Tube forming processes a comprehensive guide

on ManufacturingET.org March 1, 2012 TH6711 . M55 2003 Tags: Tube Bending Tube Formation Processes, Comprehensive Guide is a thorough guide with the latest developments in the field, the text discusses the best materials for bending and techniques and equipment for bending, cutting, branching, rationing and joining pipes. The book is suitable for beginners or advanced tube manufacturers. Information from leading industry experts covering the basics and guidelines for pipe manufacturing, pipe manufacturing and other areas. There is information about secondary operations required by typical manufacturers. The book also addresses management issues such as identifying appropriate tools and equipment, weighing costs and quality, and knowing the options available. 1 Pipeline Processes Comprehensive Leadership of the Society of Manufacturing Engineers GREG G. MILLER Association for The Formation - Technology Manufacturing / SME 2 Pipeline Processes: Comprehensive Guide i 3 4 Pipeline Processes: Comprehensive Leadership by Gregory Miller Society of Petroleum Engineer, Michigan Association for the Formation and Manufacturing Of Technology/SME 5 The publisher has not claimed any responsibility for the use of the information contained in this. Although every precautionary measure has been taken in the preparation of this book, the publisher is not responsible for errors or omissions. The publication of any data in this book is not a recommendation or endorsement of any patent, ownership or product that may be involved. Library of Congress Catalog Maps Number: International Standard Book Number: X Additional Copies Can Be Obtained By Contact: Society of Manufacturing Engineers Customer Service One SME Drive, P.O. Box 930 Dearborn, Michigan SME Employees Who Participated in the Production of This Book: Cheryl zupan, Editor-in-Chief Walter Kelly, Editorial Consultant Rosemary Csizmadia, Production Manager Frances Kania, Production Assistant Katie Kwirk, Graphic Designer/Cover Design John Newberg, Production Editor Printed in the United States 6 For a tubaologist in all of us this book is dedicated to the hard work, perseverance, perseverance and perseverance of 7 Pipeline Processes: Comprehensive Guide to 8 Confessions of an Attempt to Be Accurate in All Areas of this book. Without their contribution, this book would not have been possible. There is no substitute for first-hand experience and knowledge, the next one Michael B. Cohn, Advanced Tubular Technologies, Inc., Waterford, Michigan; Ron Duvall, SMT Industries, Inc., Sidney, Ohio; Bill Holyoake, T-Drill Industries, Inc., Norcross, Ga.; Joe Ivasca, Tower Ail and Technology, Chicago, Illinois; Wally Jenson, Engelhard Joining Systems, Daytona Beach, Florida; Jeff Johnson, Finn Power USA, Inc., Schaumburg, Illinois; Dale Miller, Manchester United, North Manchester, IN; Todd Smith, J and S Machine, Inc., Ellsworth, WI; Ron Stange, Bend Tools, Denver, CO; and Bob Want, Tools for Bending, Denver, CO. Organizing the sheer volume of information in this text was a difficult task. Without the help of Carolyn Ghiglione, it would have been another 34 years before the book went to print. I thank her for bringing her highest efforts and many skills to this project. vii 9 Tube-forming Processes: Comprehensive Guide viii 10 Table Content : Comprehensive Guide xii 14 Foreword The purpose of this book is to meet the needs of beginners as well as advanced pipe manufacturing operators. I've included a lot of data on pipe manufacturing and various other cross-sections, because I to solve much more than just making a tube. In addition, there is a lot of practical information that falls into the category of secondary operations required by a typical manufacturer. The book is located in 10 chapters, with information presented in a sequence that reflects the typical flow of manufacturing. The application consists of an appropriate physical theory that applies to many areas of metal formation, as well as diagrams and data that manufacturers will find valuable. The pipe manufacturing has advanced tremendously since packing the sand to keep the tube bending from the collapse. When I began to investigate the available written references to the manufacture of pipes, it became clear that the last real reference with any detail was The Cold Bend and Formation of the Tube and other sections written in most of this text, was adapted from this book, which is still very accurate in technical theory. Although the laws of physics have not changed, the technologies and processes that existed then have changed a lot. 133 16 Planning Process 1 The planning process planning process for systematically identifying the methods by which a product should be manufactured economically and competitively is an intermediate stage between design and production. It synthesizes factors such as: the functional requirements of the product; The amount of production required; Operations Necessary tools, materials and equipment and estimated production costs. Process planning contains specifications for the proposed production line on the process sheets, which in appropriate detail indicate the most effective sequence of operations, objects, and tools needed to produce the product. No method of planning processes is appropriate for all plants, and many methods are discussed in various other reference books that specifically address this aspect of production. However, in bending and shaping operations, certain steps are being taken in the planning of processes that deserve to be discussed in connection with the specialized nature of these steps. MATERIALS SUITABLE FOR BENDING machines are now widely used for: cold bending extrusions; hard rod and bar; moldings and rolled-up shapes; and tubes and pipes. 1 17 Pipe-forming Processes: Comprehensive Guide Typically, the most common metals can be cold bent, provided they have sufficient lengthening to reach the desired angle and radius before reaching their final strength. Metals usually formed easily include low-carbon and stainless steel, aluminum, brass and copper. Simple formation operations can also be performed on magnesium, titanium and some copper-nickel alloys. Special toolkit and bending techniques allow you to bend some of the so exotic and fire-resistant metals. Steel steel is the most common material formed on the bend of the machine, and those types of steel with a carbon content of 0.35% or less are the most practical for production work. With C The content is above 0.35%, the work solidifies going fast as the bend progresses. The loss of scrap due to the breakdown can be significant. As the carbon content increases, the bend radius should be increased and the angle of the piece should be as low as possible. The second determinant of suitability for a particular application is hardness. Steel with a Rockwell rating or less on a B scale is best prepared for production. Tougher materials usually do not have enough lengthening to bend before breaking. The American Institute of Iron and Steel (AISI) and the Society of Automotive Engineers (SAE) have developed specifications covering so-called standard steel as well as carbon and alloy steel. AISI designation system for standard carbon and alloy steels: 1. The first two digits of the four-digit series indicate the grade of steel. The last two figures indicate (as far as possible) the approximate middle of the carbon range. However, it is necessary to disassociate ourselves from this and to interpolate the figures in the case of certain carbon emission ranges, as well as for variations in manganese, phosphorus, sulfur, chromium and other alloy elements. Table 18 of the 10xxx 11xx 12xx 12xx Table 1-1 1-1 shows an abbreviated portion of the standard code of AISI carbon and alloy numbers. AISI Standard Carbon and Alloy Steel (Courtesy of the American Institute of Iron and Steel) Types and Classes Basic and Acid Open Hearth and Acid-Freememer Carbon Steel Steel Classes, Non-Ulfurgic and Non-Phosphorized Basic Open Hearth and Acid-Free-Die Classes, resulphurized and rephosphorized Basic, open source carbon steel classes, rephosphorized and resulphurized 13xx manganese % 23xxx Nickel 3.50% 25xx Nickel 5.00% 31xx Nickel 1.25%, Chromium 0.60% 32xxx Nickel 1.75% , chrome 1.00% 33xxx nickel 3.50% , chrome 1.50% 40xx Molybdenum 41xx Chrome-molybdenum 43xx Nickel-chrome-molybdenum 46xx Nickel 1.1. 65%, molybdenum 0.25% 48xx Nickel 3.25%, molybdenum 0.25% 51xx Average chrome 52xx Chrome, High carbon 61xx Chrome-vanadium 86xxx Nickel 0.55%, chrome 0.50%, molybdenum 0.20% 87xx Nickel 0.55%, Chrome 0.55%, Chrome 0.55% 0.50%, molybdenum 0.25% 92xx manganese 0.80%, molybdenum 0.25% 92xx manganese 0.80%, silicon 0.80%, silicon 0.80% 2.00% 93xxx Nickel 3.25%, Chrome 1.20%, molybdenum 0.12% 94xx Marganese, nickel 0.45%, chrome 0.2 40%, molybdenum 0.12% 97xx Nickel 0.55% , Chrome 0.17%, molybdenum 0.20% 98xx Nickel 1.00% , chrome 0.80%, molybdenum 0.25% Letters attached to the full series of numbers of this steel to indicate the metallurgical process used are: The main open air of alloy steel; B acid-free carbon steel; C basic carbon steel with an open hearth; and E electric steel oven. 3 19 Pipeline Processes: A Comprehensive Guide to Simple Carbon Steel Based on Carbon Content, Simple Carbon Steel can be divided into three groups as follows: low-carbon steel with a carbon content of between 0.05% and about about 2. Medium-carbon steel with a carbon content of 0.30% to about 0.70%. 3. High-carbon steels containing 0.70% to about 1.30% carbon. Material in which carbon is not distributed evenly, such as corners or strengthening grates, re-rolled from the rail, should be bent to the most generous radii possible, and at the slightest angle. There will be a significant scrap because the high-carbon areas have insufficient lengthening to bend. Such material should be avoided, if at all possible. Alloy elements of the alloy are added to ordinary steel to change their behavior during heat treatment, which in turn leads to improvements in mechanical and physical properties. When choosing alloy steel for a specific application, the selected steel should contain no more than necessary for satisfactory satisfactory satisfactory maintenance of operating conditions. Low-alloy steel. Low-alloy steel varieties can be divided into two separate groups: 1. High strength of structural steels, where fusion elements serve mainly to strengthen ferrit. Such steels are used as a rental state without heat treatment other than normalization or annealing. 2. AISI or SAE have become of higher quality than conventional structural varieties, where alloy elements primarily serve to improve mechanical properties over equivalent carbon steel, as well as to enhance steel response to thermal processing. Structural assessments. Highly strength structural steel is used mainly in the transport and construction industry for 4 20 process planning applications where steel with moderately high strength is not required and where weight loss may prove beneficial. The carbon content is usually less than 0.15%, although, in some of the higher-elastic varieties, steel can contain up to 0.30% carbon. While these higher carbon varieties have improved strength, they are less ducts and harder to form. Corrosion resistance, which is an important factor in reduced weight structures, is slightly superior to the resistance of equivalent carbon steels. This additional corrosive resistance is attributed to phosphorus and copper. AISI or SAE ratings. Low-alloy machine steels are usually characterized by high strength, good ductwork and excellent strength with proper heat treatment. AISI alloy steel is used, in particular, in the automotive and aviation industries for highly stressed members and moving engine parts. Some combinations of different fusion elements can, after appropriate heat treatment, give a certain steel unique and specialized characteristics for use in a particular application. For example, carbon-molybdenum and other steels have good creep characteristics and therefore find useful use for moderately high-temperature maintenance, where oxidation is not too serious. Typical applications are in pipelines steam and refineries. Nickel-chrome steel, as a group, demonstrate excellent hardening, high strength, good wear resistance, and durability. Various combinations of nickel-chromium, properly treated with heat, have tense properties, equivalent to the entire range, available with alloy steels. Chromium-vanadium steel, after heat treatment, show remarkable strength and good resistance to fatigue. Super-high-strength steel alloy. Several steels have been specially designed and applied at a strength of 200,000 psi (1,379 2,068 MPa). Examples are types 4140 and 4340. Modifications of these SAE varieties containing higher silicone have been commercially used, usually in a certain range of strength of 220,000 psi (1,517 1,724 MPa). Types 4130 and 4140 are used for bending operations when higher strengths are desirable. Both are high carbon steel that should be used with the most generous radius possible. Since both work-harden quickly as the bend is done, the bend angles should be reduced by a small to keep the scrap to a minimum. Of the two classes, Type 5 21 Pipeline Processes: Comprehensive Guide 4140 will prove more difficult to operate and will require a larger radius than the same size piece of type that is due to its higher carbon content. Stainless steel. This family of steel is described by composition as containing 4% or more of chromium, usually more than 50% iron, and perhaps such alloys as nickel, molybdenum, Colombian, titanium, manganese, sulfur and selenium. These alloys give specific characteristics to increase resistance to corrosion and scalability, mechanical properties and formation at sub-zero, room and elevated temperatures. Stainless steel, in most common varieties, is usually bent without problems. There are three broad metallurgical classifications that have a noticeable effect on their usefulness of martensit, ferrit and autonetic steel. The most common autonetic scores of the 300 series are formed; examples are types 304 and 321. Austenitic stainless steel is relatively easy to manufacture and weld. They are tough but ductile. They cannot be tempered by heat treatment; cold work alone can increase their strength. Ferrit steels are easily cold formed. However, low work hardening and relatively high yield strength combine to encourage localized thinning or neck down under strenuous stress. Therefore, caution should be exercised in cold formation operations, which include stretching. Since stainless steel usually has more elongation than soft steel, it can usually be formed for larger angles and on smaller radii than comparable carbon-steel material. Like all metals, the more bending, hardness should be considered when showing the work of stainless. The best results are achieved when the blanks are between full soft condition and 1/4 difficult. When the surface of the surface appears Bending is paramount, a small amount of hardness must be present to eliminate the appearance of stretch marks (sometimes called orange-peeling state) on the outside of the bends. Evidence suggests that stabilized stainless steel has more homogeneous characteristics and is thus less likely to be broken. Since stainless steel is often used where the highest quality bends are required, a tool is often used that gives maximum control over the flow of metal through a close material conclusion. The material for such work, especially for the ultra-thin walls of the aircraft tube bend, must 6 22 Planning process must be carried out to close the measure tolerances. Pipes with walls of about an inch (1.24 mm) or heavier can be attracted to size. Lighter wall tubes should be purchased at-size, since size operations work-harden such material excessively and produce minute wrinkles, rather than changing the diameter of the metal stream. Stainless steel molds should be produced on a roll-forming machine if there is more than one break in the part. Roll formation produces more homogeneous forms. Heat-resistant super alloys. Many heat-resistant superalloys designed for use at temperatures of 1000 2000 F (538 1093 C) have high-calorie strength properties that surpass those of low-alloy steel and stainless steel. The three most important requirements of the alloy for high temperature maintenance are strength, surface stability and structural stability. Autonistic stainless steel was used as the basis for the development of high-temperature superalloys. The three main metal systems from which beneficial alloys have evolved are iron, nickel and cobalt. Because of the outstanding high-temperature strength of superalloys, they are inherently difficult to warp hot work, and many are sensitive to cracking during hot work. They also cause significant wear and tear on the die and roll materials. Alloys are also quite difficult to cool form. The Type 19-9 super alloy is used in the production of aircraft components. It will bend in the same way as the more common stainless varieties, but with its higher strength, it resists compression on the inside of the bend. Instead, it tends to form to wrinkles. Careful attention should be considered by bending the machine with adequate power to form bends using the installation toolkit, which provides maximum stretch over the circumference of the bend. The tooling should be precisely set on the blank and exceptionally difficult so that it is not marked by the blanks should the wrinkles develop. Aluminium and Aluminum alloy is another widely formed metal. Unalloyed aluminum has many desirable characteristics, including its light weight, pleasant appearance, malleability, shapeability, and resistance to corrosive attack of industrial and marine atmospheres, 7 23 pipe-forming processes: Comprehensive guidance of many chemicals, and and Products. It has good electrical, thermal and reflective characteristics, but has a relatively low level of strength and hardness. Three methods are used to enhance its strength and hardness: the addition of other elements for the formation of alloys; Thermal treatment of some types of alloys; and the strain of hardening cold work. The alloy designation Aluminium and its alloys are marked on a commercial basis in the United States by a series of numbers or numbers and letters assigned by the manufacturer to indicate the composition. Group 1xxx is classified as 99% minimum aluminum. The last two figures are the same as the two digits to the right of the decimal point in the minimum percentage of aluminium, when it is expressed to the nearest 0.01%. The second digit indicates a change in the limits of impurities: 0 indicates a lack of special control over individual impurities; and 1 9 (appointed sequentially) indicates special control over one or more individual impurities. 2xxx through 8xxx alloy group are assigned the main elements of the alloy: copper, manganese, silicon, magnesium, zinc and other elements, respectively. In these groups, the last two digits are randomly assigned to determine the different aluminium alloys in the group. The second digit indicates alloy modifications: 0 indicates the original alloy; and 1 9, assigned sequentially, indicates modifications of the alloy. The temperature designations for the temperament of aluminum alloys are based on the sequence of basic mechanical and thermal procedures used to produce temperament, but only those operations that are recognized as significantly influencing product performance are specified. If some other changes in the same sequence of core operations are applied to the same alloy and lead to different characteristics, additional numbers are added to the designation. The temperament designation follows the designation of the alloy and is separated from its dash. 8 24 Planning process Depending on temperament, all alloys are extruded as molds or tubes, or rolled and welded into a tube, suitable for bending. The nature of thermal alloys should be T6 or less; cold should be H-18 or softer. As with all metals, the more complex, less airborne alloys will require large bend radius for successful formation. Alloys usually bent include, H-12, H-14; 5052 in state 0; and T-6. The alloy 6063-T832 is usually bent, but on the radii at least once the diameter of the tube, and in the wall the thickness of an inch (0.89 mm) or more. While it may seem that alloys in a very mild condition are best adjusted because of their greater lengthening, bending tools are easier to note very soft metals. A relatively long clip length is necessary to distribute the clip force over a wide area and eliminate the distortion of the blank and the traces of the tool. COPPER AND COPPER ALLOYS WROUGHT copper and Alloys are available in a variety of different different hardness or mores such as spring, hard, half-hard, and quarter-hard, designed with an appropriate amount of cold working after the last. In an annalized or soft state, manners are based on the specification of grain size, and grain size is the determining factor in the success of the formation. Strength tensions, yield strengths, and lengthening vary somewhat depending on the shape of the section. For flat products, the section is taken in .02 mm thick if possible. For the rod, the section is taken at 1.00-in. (25.4-mm) diameter, or if that is not available, to the closest diameter for which the data is available. The strength of profitability is a stress that corresponds to an increase of 0.50%. The data is in a mild state for an inch (0.05 mm) grain size or, if not available, the nearest grain size or annal is available. Commercially pure copper is available in several varieties, all of which have essentially the same mechanical properties. The three most commonly used (all the same purity, but different in some respects) are: electrolytic hard copper pitch, decontaminated copper, and oxygen-free copper. 9 25 Tube-forming Processes: Comprehensive Guide Copper Tubes are as extruded or extruded and drawn bent by many manufacturers. When considering copper for its formation, hardness is an important factor. Pieces in the range between fully annealed and semi-hard are commonly used for small bend radius, such as radii of about 1.5 times the diameter of the blank and larger. A tougher material will require bending radii two to three times the diameter or larger. The hardness of the skin is attached to a single light draw or size after the final anneal is considered most appropriate due to the risk of possible labeling of the tool in temperaments 1/4 difficult or less. When creating critical small bend radius in a thin-walled material, such as those used in U-shaped capacitor tubes, grain size is important. Copper-based alloys of binary alloys of copper and zinc are known as brass, and alloys of copper and tin - bronze. Some true brass, just because their color is similar to copper-tin alloys, are called bronze. Similarly, the term bronze is also used in modern metallurgy to refer to copper, exhibiting a characteristic bronze color to which elements other than tin are the main fusion materials. Figure 1-1 plots percentage of lengthening and tense strength of different brass chemical compositions. Brass is widely used in bending, especially for the production of plumbing traps and elbows. The fully annealed material is best suited to bend the light-wall brass tube for central radii that are one to two times the diameter. Often the need for anneal just that the material is actually bent, leaving the length of the hard To clamp against bend to die. Large bends of radius in all brass classes are usually made without annealing, and without any difficulty. MAGNESIUM AND MAGNESIUM The main characteristic of magnesium is lightness. While magnesium can be cold bent in some simple forms with large radii, formation has improved so much at high temperatures that most working magnesium is made hot. Small bends of the radius were made by heating the work to slightly elevated temperatures before forming. For example, tubes made of alloy A31B were bent at room temperature within a four-fold radius of 10 26 process planning drawings 1-1. The effect of the composition on certain mechanical properties of analt wrought brass. Diameter. The work of the same material in dies heated to 200 F (93 C) made possible bends three times the diameter of the radius. Heat ranges F (C) are widely used. TITANIUM AND TITANIUM ALLOYS The strength-weight ratio of titanium exceeds the ratio for most other engineering metals. As a result, titanium is increasingly used in the aerospace industry, where this ratio is a critical design factor. For convenient differentiation of various titanium and titanium alloy compositions, available commercial classes can be classified as commercially pure titanium, all alpha (single-family) welded alloys, alpha beta (two phase) welded alloys, and alpha beta in-verove alloys. The fifth group, alloys allbeta, is available in the form of a leaf. 11 27 Pipe Formation Processes: Comprehensive Guide To Commercially Pure Titanium is an unalloyed composition containing more than 99% titanium. The remaining percentage consists of carbon, oxygen, nitrogen, hydrogen and iron. The amount of oxygen and nitrogen determines the strength levels. Various ratings are listed in the app of this book. All varieties are available in blanks, bars, wire, sheet, strip, tube, and some in extruding. In the group of commercial alloys there is one all-alpha weld alloy. It is 5% Al, 2.5% Sn alloy is available as a sheet, bar and wire. Alpha-beta weld alloys make up the majority of titanium alloys. They are warm-willed; They are all available in bars and blanks, and almost all in sheets. Titanium alloys containing 6% Al and 4% V have been designed for forging and are available in wrought-iron mill shapes. Alpha Beta, indigestible alloys are not cooked by thermonuclear welding; Flash or slick welding can be practical for some. They are available in bar, wire, extrusions, sheets and foreceers. Although only a limited amount of titanium has been formed on the bend machine, experience shows that certain varieties of titanium pipes can be bent. For best results, titanium for bending must be fully annulled, commercially pure alloy A-40. The process of annealing is very critical and can vary between pipe suppliers, individual blanks, and even between sections of the same tube. In diameter more than 3-0 (76.2 mm) the best results were obtained by bending titanium at elevated temperatures F (C). It's This. on the bend of the machine itself electric heating pressure to die and mandrel the body. The pressure accelerator dying is applied in many cases. By implementing careful material quality and temperature control, manufacturers have now formed thousands of bends. These include curves such as: 1.50 inches (38.1 mm) diameter; (1.25 mm) walls by 2-1 (50.8 mm) central line radius to 90; 1.25 inches (31.8 mm) in diameter; (0.89 mm) of the wall by a 1.50 inch (38.1 mm) radius of the central line to 110. NICKEL AND HIGH-NICKEL ALLOYS All nickel and high-purpose alloys have nickel as the main element, with the exception of Incoloy, iron-nickel-chrome alloy, and Ni-O-Nel, a nickel-iron-chrom alloy. High-purpose alloys 12 28 Process Planning are designed for specific service applications associated with high corrosion and/or resistance to oxidation in a wide range of temperatures. In addition, moderate anti-galing characteristics are developed in several cast alloys. Nickel alloys are divided into five main groups with the following typical characteristics and applications. Group 1 is a commercially pure nickel for chemical equipment, electrical use, high temperatures and corrosive resistance. It is also produced in cast form. Group 2, Monel, is a nickel-copper alloy for general use requiring corrosion resistance in addition to strength and high strength. The Monel is quite suitable for bending and is usually suitable in a way similar to common stainless steel varieties. Group 3, Inconel, is a nickel-chrome, heat-and-corrosion resistance alloy capable of withstanding temperatures of up to 2200 F (1,204 C). It has a high hot force, is resistant to progressive oxidation and fatigue, and is not magnetic. This alloy is also produced in cast form. Group 4, Incoloy 901, is an age-old nickel-iron-chrom alloy used for aircraft and industrial components requiring low creep and high rupture properties in the temperature range of 1000 1400 F (C). Group 5, Incoloy, is an iron-nickel-chrom, oxidation and heat-resistant alloy that also resists moderately sulphide atmospheres, green rot, molten cyanide salts, and fused neutral salts at high temperatures. The average room-temperature mechanical properties of forged high-keel alloys commonly used for subzero, room, and elevated service temperature are given in the appendix of this book. The cold working characteristics of nickel compared to other metals are shown in figure 1-2. COLD-BENDING SUITABILITY When considering any material for its cold-bending suitability, the general rule is to use the next equation as a guide to determine the lengthening needed in the metal to make a given bend. 13 29 Tube Formation Processes: Comprehensive Guide Pattern Increase the hardness of various metals and alloys with cold work. 0.50D E and R Where: (1-1) E - required extension, % D - external diameter diameter material, b. (mm) R bend radius to the central line, V. (mm) Then compare the calculated elongation factor with the published elongation factor for this metal, either in the application of this book, or similar tables found in other references or reference books. It is quite common to make qualitative bends where the calculated lengthening exceeds the published figure. However, it is unreasonable to exceed the 14 30 process of planning published figures too far, such as trying to bend requires approximately 50% lengthening in metal having only 10%. MATERIAL SHAPES AND FINISHES In addition to material specifications, you should consider the shape of the blank. In the tube, the welding tube is often preferred to a seamless mechanical material, as closer tolerances remain between the outer diameter and the diameter of the pipes. This is especially important in lighter walls, where pulp should be used inside the tube to support the walls during the bend. Formed sections formed by hot rolling are preferable to cold materials, because hot working leaves have a higher percentage of elongation and thus allow bending to smaller radii and larger corners without excessive break. Bending machines are capable of producing a wide range of material forms. Tubing Tubing is the most often curved form of material. For the quality of bends and long life of the instrument, round welding tubes in steel or aluminum should be purchased as close to the specified diameter and as round as possible with modern processes of the pipe-rolling plant. Carrying out such quality control standards will result in consistent accuracy, no mar bends, and lower scrap rates. A welded flash should be considered if the inner pulp is used to support the tube during the bend. For critical bends, either flashremoved tubes must be used or mandrel should be grooved to accommodate the flash. Flash-in tubes are most commonly used and mandrel is done under size to accommodate the flash. You can expect a bend equal to the pulp gap. In addition, length tubes that have heavy burrs or dimple to the left of cutting surgery may require the ends to be deburred or de-dim, depending on the pulp gap and the number of burrs. 15 31 Pipe-forming processes: Comprehensive guide pipes should be free of abrasive dust, such as those left by an abrasive wheel. This is especially true for abrasives left inside the tube to be bent over the mandrel, because such dust will wear this tool excessively or cause pickup and breakdown. Excessive rust or dirt inside steel pipes can cause the same problem. Because of its physical properties, the aluminum tube can have a layer of oxide both inside and 24 hours. Pipes with only minimal oxide should be because oxide is extremely abrasive and will significantly shorten the life of the tool. Square or rectangular welded tubular area or rectangular rectangular Tubes, in steel or aluminum, should get almost the same attention as a round tube, but with an extra accent. Good material is held in uniform sizes. It is almost certain that mandrel be used in this work, and that it corresponds to the internal dimensions of the tube with only a few thousand days of inch (micrometer) clearance in general. Thus, the angular radii of the tube must be homogeneous. If any welded flash is present, mandrel should be grooved to take the flash. Since the musrel cannot be rotated from the plane, the tube must be purchased with a welded flash, consistently running along one point of the tube, preferably in the center of one side. Seamless tubes made from steel, aluminum, copper and brass, seamless tubes must be selected for bending based on the criteria of material uniformity and freedom from scale or surface oxide. In seamless steel pipes, the thickness of the wall often varies greatly, resulting in a varied interior diameter size. This condition makes it difficult to get the maximum efficiency from the use of the inner mundrel, if necessary. In addition, the concentricity of the internal and external diameters of seamless steel is usually not consistent, which can lead to sporadic appearance of wrinkles, excessive flattening or inconsistent accuracy of corner bending. Finally, the 16 32nd process of planning seamless steel pipes sometimes varies in hardness, leading to broken or incompatible springback bends. Seamless aluminum tubes are produced during the extrusion process and must be tested for the same differences in the thickness of the wall and/or inside and outside diameter concentrism as steel. Usually aluminum, as extruded, has a homogeneous hardness. The pattern after extrusion produces seamless aluminum. This eliminates inaccuracies and produces uniform tubes that do not present particular bending problems. Of course, such tubes should be free of tubular dimples and burrs, and have a minimal surface oxide. Copper and brass are most often bent like tubes that have been brought to their final shape by drawing. This presents several challenges to how to shape. The best life of the tool is if the tubes are used with a minimum of surface oxide. Often, brass tubes must be annealed, either in general or in a specific bending area, to make it suitable for bending. If this annealing is done in a gas stove or salt bath, the resulting film of oxide should be removed by nitpicking. This minimizes friction as the material is drawn over mandrel or through other stationary dies. The Lock-stitch Tubing Lock-stitch tube requires closer control than a seamless or welded tube, but is easily formed on a bend machine. Attention to two factors in the production or purchase of the specification lockseam greatly facilitates the bend. First, the seam should be rolled up to as dense a lock as possible. To check the seam tightness, grab about 3-foot 3-foot length of material at both ends and twist the tube. If the seam lock is loose, it will produce a creaking or crackling noise or a shift felt. Such tubes align significantly more and produces a higher rate of scrap than the quality of the material rolled up to a tight lock. Second, changing the outer diameter of the tube increases the bending problem because the oversized or oversized material does not match the bend of the instruments close enough to allow the dying to control the flow of the metal into the quality of the bend. This factor is usually controlled at the point of cutting the steel stock before it is rolled into the pipes. 17 33 Pipe-forming Processes: A comprehensive guide to stainless clothing and butt-stitch or open seam tubes stainless-clad and butt or open seams two relatively unusual types of pipes formed on the bend machine. A stainless pipe is usually made by a roll forming a stainless steel sheet over an open seam, a soft steel tube. The stainless steel is held on the site of the castle seam rolled in the open area of the soft tube. This material is sometimes used where the production of large volumes compensates for the additional complexity of bending the stainless ocaping tubing. When used, the best results are obtained with a material having a layer of stainless inches (0.51 mm) in thickness or heavier, and where the two layers are rolled together as sturdy as possible. While this is not a direct consideration in the selection of material, it should be borne in mind that the bend of the stainless cladding tube usually requires the use of windshield wipers to die from aluminum-bronze, pulp, and unusually high pressure tools. These factors, combined, can lead to high cost of tools. In addition, the locked seam in the tube should be located directly inside or outside the bend, thereby limiting the use of this material. The material from the butt is formed from a strip of broth, rolled into a tubular form, but without welding or other seam alloy. To get the best results, such material must be free of scale and rolling within close tolerances on the diameter. Mundrell is almost always required, and an open seam should be positioned either on the straight inside or outside of the bend, limiting the plane in which bends can be made. Often the additional difficulty in bending this material more than offsets any material cost savings compared to comparable welded steel pipes. Decorative finishes Some finishes are often applied to the material (most often aluminum, welded steel, or lock-stitch tubes) before bending. Most pre-dressed or other pre-coated tubes can be bent without overshadowing the finish. Almost all paint or coating material used has enough elasticity to withstand cracking or chipping as the metal stretches or in a bend. Pre-anodized aluminum tubes (plus extrusion or shapes) are also usually bent without overshadowing or disfiguring the finish, or adding any special tools or processing problems. 18 18 Planning the process While not normally considered a decorative type of finish, the pregalvanized material is also easily bent without scratching the zinc coating. No greater degree of success has ever been achieved, however, with preplated material because the coating is usually marked, cracked, or chipped in the bend area. The Pipe Common Tube in all graphs of weight and size is one of the most common and easily curved materials formed on the bend machine. For the longest period of instrument service, the pipe should be received with as little scale or dirt, both inside and with the day as possible. This is especially important when you need pulp. Excessive scale can bind to the pulp to the point where the bend of the machine will stall or break the pipe. The genus and bar almost all materials suitable for bending are now somewhat formative problems, provided they have sufficient extension to bend in the desired radius and angle without breaking. In non-ferrous metals, the hot-rolled bar usually has a better elongation and thus withstands more serious bends. Such material, however, may have an excessive scale, a condition that should be avoided if possible to extend the life of the machine and tool. The cold bar has less surface oxide, but, due to the stresses left over from cold rolling, can creep or distort after bending. In addition, the cold-rolled bar is usually somewhat hardened work and therefore does not withstand as serious a bend as comparable hot work material. Form sections and sections in many configurations are usually bent. Examples include T-shaped rolled sections used as sink rim water seals, garage door traces, and a standard steel canal used in truck frames. For the best results, shapes and sections must be clean, free of excess scale or other surface oxides and homogeneous when made. Uniformity between different parts and material lots is important because the blanks must match the bend of 19 35 pipe-forming processes: The Comprehensive Guide dies in close tolerances to produce smooth, wrinkle-free bends. Because of their greater homogeneity, the shapes formed on the roll-forming machines tend to be bent with less difficulty than the braking shapes. Most extruded forms are suitable for bending, provided that the main segments of the form are roughly equal in length and thickness. Both stretch formation and draw bend can be used to bend extruded sections. Larger, irregular shapes tend to stretch, while the draw bend handles a little smaller, more symmetrical extrusions. DESIGNING BENDS The correct design of tubular parts, including bends, can greatly contribute to efficiency and low unit costs. Choose a reasonable radius Usually a reasonable radius means a central line tilt radius, which is even multiple of the outer diameter of the tube. Radium will be selected as 3 D, 2 D, or 1 D, where D is an outer diameter Diameter For example, in a pipe with a diameter of 2 inches (50.8 mm) 2D bend will be made in a radius of 4 inches (101.6 mm). Sometimes a slight deviation from this rule of thumb will help keep the bending of the radii simple, as in the case of bends in 5/16-inch (7.9 mm) of the outer diameter of the tube in a 3D radius. It is only common sense to specify a 1-inch (25.4 mm) central radius instead of a 15/16-in (23.8 mm) central radius, thereby keeping the tools, production and accounting operations as easy as possible. Choosing a radius, which is even a multiple of tube diameter, reduces the amount of money invested in instrumentation, avoiding the possibility of having multiple sets dying for the same diameter tube, each of which is made to obtain a random radius. In addition, there is less chance of an error in the manufacture of tools. Maintaining a design sequence will reduce the time it takes to develop or purchase the right tools. 20 36 Standardized process planning tools are also important from the machine operator's point of view. The profession increases as the operator gets used to the performance of certain tools. Purchasing a different design of the instrument will require another period of trial and error regarding tool alignment, exposure to material, etc. These firms are standardized within a 2D center radius. With today's precision bending machines, product bends are often made on 1D radii in many materials. However, a 2D radius is a reasonable balance between the production rate, the cost of the tool, and the assembly space required by the bend. With this minimum practical radius, there is less chance to redesign the product with outdated existing tools and need new tools for additional costs. Bends over large radii, such as 3D, 4D, 5D or more, may be preferable in terms of design or production. Larger radii require less lengthening and take a little less material. For example, as shown in Figure 1-3, a bend radius from 4D to a central line in the 2st (50.8 mm) tube requires 1.71 inches (43.4 mm) less material than a 2D bend. This savings are often more than offset by the additional space required for a larger radius bend shown in Figure 1-3. Whatever multiples are selected for radii, it is more economical to design by standards at every opportunity. Figure 1-3. Larger bending radii use less material. 21 37 Pipe-forming Processes: Comprehensive Guide to Point Bend Radi in Metro Centerline It is a common practice to indicate bending radii on prints or drawings in the center of the circular pipes pipes, or round solid stock. The radius for a square or rectangular tube or solid strap should be shown in the inside of the bend, or the main face line of extrusion, casting or other section. This procedure can help avoid errors when ordering tools from vendors. Make all the bends in the same workpiece at the same radius if possible, making all the bends in the same blank in the same radius, usually allowing the machine operator to produce the completed part with rapid progression bends. Installation and processing time is kept to a minimum, production increases, and unit costs tend to be lower with this method. Often one bend of a large radius can be replaced by two bends with a smaller overall radius with savings more than offset by the cost of the machine's additional cycle. Allow sufficient clip length between bends, when at all possible, to avoid connecting the bends. The bending compound is one designed so close to the adjacent bends that it does not allow enough direct material to clamp between the bends. Consequently, the material slides into the clamp during the second bend. This almost always leads to wrinkles. The amount of clamp length required to distribute pressure over enough area to prevent the tube from collapsing or collapsing depends on the type of material and class, diameter, thickness of the wall, surface state and radius of the desired bend. Other factors that help determine the length of the clamp include: the marking of the work due to the high clamp pressure distributed over the minimum area; The amount and speed of wear and tear of the tool; Type of mundrel and use; Number of balls used on multi-ball mandrels; and the loss of scrap due to the extreme length of the clamp. 22 38 Process Planning In some cases, special provisions may be required to prevent the tube from slipping. Such provisions include the use of a jagged or knurled death clip (and clamp bend insert to die). Other methods include inserting resin, abrasive dust, or abrasively-soaked cloth in the clamp area. These tools increase the friction factor between the tube and the clamp dies with minimal work marking. In some extreme cases, even the longest practical clamp length and inserting additional friction elements into the clamp area do not prevent slippage. This is often the case in the bend of thin-walled stainless steel pipes such as the 6-in (152.4 mm) outer diameter. (0.50 mm) tube walls up to 120 by 12-c (304.8 mm) central radius. Here, cleats are used in both clamping bend parts die and the clip dies. Solid, knife-like cleats penetrate the tube as the clip dies close, eliminating slippage. This method of minimizing the length of the clamp and/or stopping the slippage is only used if the length of the tube can be extended to grip with the glue is later cut off. It is obvious that so many variables and special conditions govern the amount of direct material required for a clamp that it is not appropriate to publish a complete or untouchable clip length. Table 1-2 is the starting point for determining the length of the clamp in the table. The short-term diameters represented in this table are not absolute, but are conservative conservative The length that gives the quality of the bend. Specific clip-to-die lengths for this tube of outer diameter, wall thickness, and central radius can be found in table 1-3. If the bending tangents should be so close together that a straight clip of sufficient length cannot be used, then the part can be manufactured into one piece using complex tools. The clamp die incorporating a groove curved in the form of a previous bend (radius, angle, and plane), as well as a bend to die with a similar curve in the clamp insert, to be produced. These tools are much more complex and expensive to manufacture than standard tools with straight clamp sections. They can usually only be used at work for which they were specially designed, and need to process the tube separately for each bend compound, thereby increasing production costs. 23 39 Tube Formation Processes: Comprehensive Guide Table 1-2. Guide to the clip length of the central wall Thick Radius bending tube, inch (mm) Clip length from 1D to (0.89) 4 to 5 diameter () 3 to 4 diameters Above (1.65) 2 to 3 diameter 2D to (0.89) 3 to 4 diameter ( ) 2 to 3 diameters over (1.65) 1 1-1/2 to 2-1/2 diameter 3D Up (1.65) 2 to 3 diameter Above (1.65) 1 to 2 diameter Find minimum radius of the central line Minimum bend To which the tube can be bent is a function of lengthening the material. If the outer part of the bend is stretched beyond maximum lengthening, it breaks down. The formula that follows should only be used as a guide to the minimum bend radius possible. It does not take into account the friction between the tube and the instruments. The lengthening percentage used comes from a dough that is not quite the same as stretching the outer periphery of the tube during the bend. Equation to determine the minimum bend radius: 0.50D R (1-2) E, where: R are and minimum radius of the central bend line, B. (mm) D - outer diameter of the tube, B. (mm) E - lengthening of 2 inches (50.8 mm), % For example: 2-1 (50.8 mm) outer diameter type 321 stainless steel tube, 40% lengthening R No. 40 25 Table 1-3. The clip die lengths Outside the diameter and walls are all thick, in. 1/2 to 5/8 3/4 to 7/8 Radius of the central line, /2 2-1/2 2-1/ /2 1 3/4 5/8 2-1/ /4 3/ /2 1 3/4 3/ /2 2-1/ / /2 3/4 3/4 5 / /2 2-1/ /2 3/4 1 5/8 1/ /2 2-1/ /2 1-1/2 1 5/8 5/8 1/ /2 2-1/2 -1/ / ///8 5/ / // /4 5/8 1/2 2-1/2 2-1/ / / / /4 1/2 2-1/ / /4 1/2 2 2 2-2-2 2 //2 3/4 1/ /2 2-1/ /4 / / / / / ///// 2-1/ /2 1-1/ /2 2-1/ / Process Planning 41 26 Table 1-3. (continued) Outside the diameter and walls all thickness, inches from 1-1/8 1-1/4 to 1-3/8 radius of the central line, in. /2 5/8 3/4 7/ / / / / / / / / / / / / / / // // Comprehensive guide 42 27 Table 1-3. (continued) Outside and the walls are all thick, v. 1-1/2 to 1-5/8 1-3/4 to 2St The radius of the central line, in. /2 5/8 3/4 7/ /8 1-1/ / CP CP CP CP CP CP CP CP CP P CP/CP CP CP CP P-8 P Planning Process 43 28 Table 1-3. (continued) Outside Diameter and Wall All Thickness, in. 2-1/4 to 2-1/2 2-3/4 to 3 Centerline Radius, in /2 5/8 3/4 7/ /8 1-1/4 1-1/2 1-3/4 2 CP CP CP CP P-10 P CP CP CP P-10 P CP CP CP P-10 P CP CP CP P-10 P CP CP P-8 P CP CP CP P-10 P CP CP CP P-10 P CP CP CP P-10 P CP CP P P CP CP P P-10 P CP CP P P CP CP P P-10 P CP P-10 P CP CP P P-8 P CP P-8 P P-10 P P * For all materials except soft aluminum and dead soft copper. Key: C - clamp clip, P - clamp plug, CP - and cleat, and plug Note: 1 inch - 25.4 mm Tube Formation Processes: Comprehensive Guide 44 Planning Process This example shows that 2.50 inches (63.5 mm) to the central line is the minimum radius that can be reached. However, actual experience has shown that bends can be made very successfully on the 1D center of the radius (a radius equal to the diameter of the tube). Many bend machines are now forming bends on a production basis in a less-than-stated elongation factor, such as making 1D bends from stainless and soft steel, copper and brass. Despite the non-operational equation 1-2, it gives a practical guide. It is not recommended that the radius, attempts to bend production, was much less calculated. Find a reduction in the pipe wall after bending the (thin) amount that the outer wall of the tube decreases or thins in the bend area depends on the ratio between the central bend radius and the diameter of the tube. In practice, these relationships are directly affected by friction and the amount of flattening is allowed in the bend. Friction is injected as the tube is stretched onto the pulp or the windshield wiper die. The force exerted by pressure to die, the method of mounting this die, the fit of tools to the pipe, the type and surface of the tube finish, and the use of lubricant on the tools or tubes directly affect the amount of friction. Friction is always present in different quantities in any installation bending machine and tends to increase the amount of thinning experienced. Flattening (the tendency for the tube to take a few oval shapes) is also experienced to some small extent in all bends, and its presence tends to offset the friction factor. The alignment depends on the type of material and class, the thickness of the wall, the angle of the bend and the radius, as well as the introduction of different types of internal support of the mundrel. Thus, it cannot be mathematically calculated in advance. Ignoring friction and flattening and using measurable factors of the thickness of the starting wall, the diameter of the tube and the radius of the bend Table 1-4 can be used as a general guide to the number of thinning walls that can be expected in this bend. Because Table 1-4 doesn't address friction or flattening, it should only be used as a starting point. Elements friction in the installation of the toolkit, as well as factors that reduce or compensate friction, should 29 45 45 Formation Processes: Comprehensive guidance will be reviewed once the percentage of wall reduction has been determined. The final thinning range can be estimated with these points in mind. If the bend radius considered is not represented in table 1-4, you can use the following equation to calculate the guide or starting point for the reduction of the wall: X , where: R R and D 2 W (1-3) X and the reduction of the wall, % R - radius to the central bend line, B. (mm) D - the outer diameter of the tube before the bend, B. (mm) W - the thickness of the tube wall before bending, V. (mm) In real practice, the reduction of the wall due to bending is rarely an important factor in determining the feasibility or acceptability of a bend in a pipe or pipe. Exhaustive tests have shown that the loss of wall thickness on the outside of the bend is more than offset by an increase in the strenuous strength of the bend hardens. For example, the bend of the 4-inch (101.6 mm) outer diameter (0.64 mm) stainless steel tube wall at 6-inch (152.4 mm) central radius reduces the outer wall to an inch (0.51 mm), but this increases the metal strength yield from 66,000 psi (455, .4233 kpa). In this case, the reduction of the wall by 20% was more than offset by a 66% increase in strength. A comparable increase in strength occurs in all materials, including aluminum and other non-ferrous metals. The only cases where thinning walls become a factor are those special applications associated with enough heat to allow annal bend, or where severe corrosion or erosion conditions are present. These conditions exist in high-pressure steam boilers and sometimes in pipelines for the chemical and aviation industries. One of three solutions can be used in these cases: 1. Specify as many bend radii as possible, reducing the pattern and shrinking the walls. 2. Indicate the heavy enough thickness of the starting wall to keep thinning below minimum requirements. 30 46 Process Planning Table 1-4. Reducing the wall based on the radius of the bend and diameter of the Tube Bend Central Wall After bending radius (in multiple tube fraction % of the original % Wall Outside Diameter, D) Original Wall Reduction 1 D 2/ /2 D 3/ D 4/ /2 D 5/ D 6/ /2 D 7/ D 8/ /2 D 9/ D 9/ D 10/ /2 D 11/ D 12/ /2 D 13/ D 14/ /2 D 15/ D 16/ /2 D 17/ D 18/ /2 D 19/ D 20/ Use booster-type bender, to help move the neutral axis and reduce thinning. In practice, any or all of these methods can be used in combination to solve a particular problem. 31 47 Pipe-forming Processes: Comprehensive Guide To Determine the capacity of the machine as a whole, the ability of a particular machine to bend the part can be determined by comparing the section of modulus part with the modulus section for the largest size of the same shape and the same material that the machine is estimated to bend. To define the section module bend the tube, use the equation: equation: D (1-4) D, where: - module section for bending D and tube of external diameter, B. (mm) d - tube inside diameter, V. (mm) This comparison is valid for angle, channel, barstock, etc. The method has its limitations. It does not take into account variables such as friction, lubricant use, required bend quality or expected production. Friction is produced as a piece (with possibly a surface scale or oxide) drawn over the pulp, through the windshield wiper to die, or against any other stationary die or guide. These conditions reduce the maximum power of the machine. Applying lubricant compensates for this friction somewhat, allowing more energy to be used to actually bend the metal. Releasing or eliminating one of the stationary dies also reduces friction, but can affect the quality of the bend, allowing for more flattening or the appearance of wrinkles. Finally, the machine can usually bend a little heavier material than its maximum nominal power and can be used for this if only a few bends are required. However, the power of bending parts above the top rated maximum accelerates the wear of the machine and can cause serious damage to the machine. The comparison method is only a guide to maximum capacity. Typically, manufacturers of flexible machines publish tables that show maximum opportunities for different materials and forms. These tables take into account friction, etc., and are a reliable guide to the capacity of the machine. 32 48 Process Planning Determines the developed length in all types of bend, the neutral axis (where the part is not stretched and compressed) moves from the center line of the shape to the inside of the bend. Ideally, the length of the part developed should be calculated using a neutral axis. Since it is impossible to pinpoint the location of a neutral axis without extensive experiments, the length is calculated along the center line of the shape. One of the methods of calculating the material used in the bend is to obtain the length of the arc described by the central line. Equation along the length of this arc: where: L A and RA (1-5) L A - arc length, V. (mm) R - central bend radius, B. (mm) A included bend angle, total arc length and straight lengths to determine the developed length of the part along its central line. It will always be a little longer than the actual length. After bending several parts, the actual length can be easily determined and enough material can be reduced to such lengths as to complete the production lot (see figure 1-4). The shortcut method for determining developed length is to use arc degrees from table 1-5 and add it to straight sections. For example, figure 1-4 shows a typical part with a 2-in. (50.8 mm) straight length tangent to the first bend, which has 2-1 (50.8 mm) radius. Referring to table 1-5, the reader should estimate the normal amount of tube needed in a bend of 90 tangent, and move to the second bend, which has a 3-c (76.2 mm) radius of the central line. Continue in this way until the end of the work is reached and the approximate length of the tube is obtained. To find the length of the circular arc with a radius of 1 inch (25.4 mm) and angle : 33 49 Pipe-forming Processes: Comprehensive Guide Figure 1-4. Determine the developed length of the curved part with three different radii. 34 50 Process Planning 1. Opposite 45, find inches (mm); 2. Opposite 20 find inches (0.147 mm); 3. Add these two digits, conceding an inch (mm) amount as the length of the arc. If the radius is 2 inches (50.8 mm), multiply the lengths in the table 1-5 by two. Identify the plane bending the face dial in figure 1-4 corresponds to the circumference of the tube to be bent, and graduated clockwise. The top of the tube is 0 for the first bend, and the bend plane is horizontal. The plane of each successful bend is measured in relation to the first bend. On machines that have tight dials mounted on the tube, adding or subtracting the desired amount of rotation to the first reading of the dial will give a direct reading on the face of the dial, indicating the bend plane. If the plane of the second bend should be at an angle of 90 to the first bend, the tube rotates 90 out of 0, and the dial readings will be either 90 or 270, depending on the direction of the tube rotation. If the third bend should be in the same plane as the first, adding 90 to 270 will give a set of reading 0. Subtracting 90 out of 90 will obviously give a set of reading 0. Identify Springback and the Springback distortion section in the pipes, usually quite constant in a particularly much material. When creating a 90 bend, if the first bend is missing 3, you need to adjust the machine to an inflection to bend to 93 to perform a 90 bend. After releasing the tube from the machine, the radius of the central line is somewhat larger than the toolkit on which it was formed. In most cases, this does not go beyond the tolerances of the part. However, if the type 4130 heat-treated tube is manufactured to 90 bend, the springback may be as much as 15. Therefore, it is sometimes necessary to use the shape of a smaller radius to obtain the desired radius. 35 51 Pipe Formation Process: Comprehensive Guide Table 1-5. Length of arcs in degrees and minutes Lengths of Circular Arcs to Radius of 1 in. (25.4 mm) Degrees Length, in. (mm) (0.000) (0.445) (0.887) (1.331) (1.773) (2.217) (2.659) (3.104) (3.546) (3.990) (4.432) (4.877) (5.319) (5.763) (6.205) (6.665) (7.094) (7.536) (7.981) (8.423) (8.867) (9.309) (9.754) (10.196) (10.640) (11.082) (11.527) (11.969) (12.413) (12.855) (13.299) (13.744) (14.186) (14.630) (15.072) (15.517) (16.403) (16.403) (16.845) (17.290) (17.732) (18.176) (18.618) (19.063) (19.505) (19.949) (20.394) (20.836) (21.280) (21.722) (22.169) (22.609) (23.053) (23.495) (23.940) (24.382) (24.826) (25.268) (26.154) (26.599) (27.043) (27.485) (27.330) (28.372) (28.816) (29.258) (29.703) (30.589) (31.031) (31.476) (31.918) (32.362) (32.804) (33.249) (33.693) (34.135) (34.580) (35.022) (35.466) (35.908) (36.794) (37.239) (37.353) (38.125) (38.567) (39.454) (39.898) (40.340) (40.785) (41.229) (41.671) (40.340) (40.785) (41.229) (41.671) (41.671) (40.785) 2.116) (42.558) (43.000) (43.444) (43.889) (44.331) (44.775) (45.217) (45.662) (46.104) (46.104) (45.217) (45.662) (46.104) (46.104) (46.104) (46.104) (46.104) (45.217) (46.548) (46.990) (47.435) (47.879) (48.321) (48.766) (49.207) (49.652) (50.094) Table 1-5. (continued) The length of circular arcs to a radius of 1 inch (25.4 mm) length, in. mm) (50.538) (50.980) (51.425) (51.867) (52.311) (52.753) (53.198) (53.640) (54.084) (54.971) (55.415) (55.857) (56.302) (56.744) (57.188) (57.633) (58.075) (58.517) (58.959) (58.959) (58.959) (58.075) 59.403) (59,848) (60.289) (60,734) (61,178) (61,620) (62,065) (62,507) (62.951) (63.393) (62.065) (62,507) (62.951) (63.393) (62.065) (62,507) (62.951) (63.393) (62.507) 3,838) (64,280) (64,724) (65.166) (65.611) (66.053) (66.497) (66,939) 37 53 Pipe Formation Processes: Comprehensive Guide Table 1-5. (continued) Lengths of Circular Arcs to Radius of 1 in. (25.4 mm) Degrees Length, in. (mm) (67.384) (67.828) (68.270) (68.712) (69.157) (69.601) (70.043) (70.488) (70.930) (71.374) (71.816) (72.260) (72.702) (73.147) (73.589) (74.033) (74.478) (74.920) (75.364) (75.806) (76.251) (76.693) (77.137) (77.579) (78.024) (78.466) (78.910) (79.352) Minutes Length, in. (mm) (0.000) (0.008) (0.015) (0.023) (0.031) (0.038) (0.043) (0.051) Minutes Length, in. (mm) (0.058) (0.066) (0.074) (0.081) (0.089) (0.097) (0.104) (0.112) (0.119) (0.127) (0.097) (0.104) (0.119) (0.127) (0.127) (0.112) (0.119) (0.127) (0.127) (0.119) (0.127) (0.027) (0.104) 132) (0.140) (0.147) (0.155) (0.163) (0.170) (0.178) (0.185) (0.193) (0.201) (0.206) (0.213) (0.221) (0.229) (0.236) (0.244) (0.252) (0.259) (0.267) (0.274) (0.274) (0.274) (0.2 (0.274) .282) (0.287) (0.295) (0.302) (0.310) (0.318) (0.325) (0.333) 38 54 Minutes of Length Planning Processes, in. (mm) (0.340) (0.348) (0.356) (0.363) (0.368) (0.376) (0.384) (0.391) Table 1-5. (continued) Length of circular arcs to a radius of 1 inch (25.4 mm) Minutes, V. (0.399) (0.406) (0.414) (0.422) (0.429) (0.437) 0.445) Design Bends So Remain Ends Square As outside the bend is energized and inside under compression, Designing a bend too close to the end of the tube or similar blanks will cause it to distort and be pulled out of the square, as shown in Figure 1-5. Typically, the distance between the tangent end and the end of the tube (shown as x in figure 1-5) should be at least 1.5 times the outer diameter of the tube. This varies somewhat; less x distance is needed as the thickness of the wall and radius increases, more as the bends approach 1D radii and Walls. Figure 1-5. Bends too close to harvesting will draw the end out of the square. 39 55 Tube-forming Processes: Comprehensive Tube Oval Specification Guide Avoids directing close tolerances to tube or pipe oval at tangent bend points. Even with the most accurately made bend dying, such tolerances are difficult to achieve and maintain. This is mainly due to the change in the size of the material that will bend. Even the best tubes available has some dimensional differences between parts or lots. This may be necessary for the size of the tube or pipe after bending if it is necessary to have close oval tolerances on the bending tangent. Bending Guide on the previously bent section Avoid designing overlapping bends, i.e. bending on top of another bend. Such bends are almost always difficult and expensive, if not impossible, to manufacture. In almost every case, one of the bends can be turned onto another bend plane, as shown in Figure 1-6, to achieve the same result. Avoid spec holes in the curved section Difficult to design and/or build a die set to produce punctured holes in the bend in the pipes or pipe. To pinpoint the location of the holes, drawing 1-6. Avoid bending in the bend. 40 56 Planning the die set process should be designed to accommodate the small distortions present in the bend, and a change in the distortion pattern occurs between individual bends. In addition, because the tube is out of the round, the impact sometimes break when they hit the center of the tube. For these reasons, you should avoid the specification of holes in the curved section. Drilling should be considered if holes are needed. The bending of the part with the holes is pre-punched or drilled in the bend area is considered from time to time. It is almost certain that a metal flow like a bend did distort the hole considerably. More importantly, the presence of a hole often leads to a bend to collapse or rupture. Bending parts with holes in the formation area should be avoided if extensive tests are done prior to the production of the bend to ensure success. DIMENSIONING DRAWINGS OF BENT PARTS Many editorial and dimensional drawings do not contain adequate information for the machine operator to perform optimal bend operations. Many bends should be dimensional in two or more views on the same pattern. A number of things that facilitate interpretation by the operator, tool manufacturer, external supplier or machine manufacturer and are less prone to errors are discussed in the following sections. Always show true tangents on all kinds of work, specify the direct part of the work as attaching a bend on a tangent to the radius of the bend. This is especially true in the representation of these bends not in flat plane drawn. The line of intersection should be shown between the tangents on both sides of the bend. the degree of bending, the bend radius and the angle of the bend the actual angle of the included angle of each bend should be shown in degrees and if if minutes, as shown in Figure 57 Of The Tube-forming Processes: Comprehensive Guide Figure 1-7. Dimensional drawings of curved parts. Show Bend Radi's Centerline Show all radii to the central tube line, pipe, or round stock on those illustrations showing the actual shape of the part (as opposed to drawings that indicate only the central tube line, the technique is discussed later). In the case of a rectangular or square stock, show the radii of the inner part of the bend, and on the formed sections, specify the bend radius to the main line of the face. 42 58 Process planning to checkpoints and tolerances show specific points at which the curved part must match the checking device, and tolerances are allowed at these points. Provide critical measurements specifically to determine the measurements that need to be taken, and these tolerances differ from the general tolerance for the part. One method of specifying these sizes is to enclose the shape in a box. Show the calculated length of the developed Knowing the total amount of material used in the final curved blank helps the operator adjust and shorten the material to length. Details of the sequence of operations on the process sheets The full process sheet should include the following: 1. 2. Part number; 3. The diameter of the tube and the thickness of the wall; 4. the length of the piece; 5. material aluminium, steel, copper, etc.; 6. Operations: a. Reducing the actual length developed (including a b, if necessary allowance), b. square, dedimpling, and deburring if necessary; Specify allowable tolerances and an acceptable finish of the end; Give the necessary finished length if finishing finish processing is required, c. cleaning, if necessary, and type, d. bend; specify applicable: drawing numbers, main part number and/or location, as well as part shape, check of fixtures by number and/or location. e. end formation or fittings such as burning, bending, extension, type fittings, end plugs, etc., and f. cleaning, coating and packaging (as needed). 43 59 Tube Formation Processes: Comprehensive Guide Figure 1-8 illustrates the normal layout of the CAD curved tube. This format is very common and provides the necessary information for both engineers and production staff. Further discussion of this topic can be found in Chapter 9. REFERENCES Springbourne R.C., Ed cold bending and forming tubes and other sections. Dearborn, MI: American Society of Instrument and Manufacturing Engineers. Lange, Kurt, Ed' MetalworkIng Handbook. Dearborn, MI: Society of Manufacturing Engineers. 44 60 Process Planning Figure 1-8. Typical tube/mock pattern. 45 61 Pipe Formation Processes: Comprehensive Guide Figure 1-8. (continued) 46 62 Main Pipes Techniques 2 Basic Tube Cut-to-length Tube Cutting Techniques to Length is the primary operation required to ensure the tube is empty to be processed into the finished component through bend, end formation and/or form formation. While there is a wide range of cutting methods, no one particular method can reduce the wide range of tubular materials and forms produced by industry. The decision on which method and type of machine to use is determined by assessing the following requirements: the production figures needed to meet the needs; Requirement for final conditioning; Tubular material; Production range of diameters and cut lengths; and if the material comes in coils or straight lengths. Each process reflects the needs of users, reflecting the inherent advantages and disadvantages for each situation. Table 2-1 collects information on various tubular and pipe-cutting equipment. This is a guide to choosing equipment. SAW CUTTING Sawing is one of the most versatile methods for cutting, using a rotary (cold saw) or saw strip to achieve the desired incision. It is a simple process, and can be adapted to a wide range of cutting systems from a simple chop saw, to a complex multi-headed system based on the desired level of production (see figures 2-1 and 2-2). The cold sawing uses the same principles as turning or milling, where the material is removed by cutting with positive angles of the rake on the blade (s), and the cutting area is cooled to minimize the softening of the teeth. The main design of the saw strip is shown in Figure 63 48 Of The Saw Table 2-1. Opportunities/Limit Cut-to-Long Processes Lathe Cut Shear Cut Supported by Shear Rotary Cut Laser Cut Cost $$$$$$$$$$$$$$$$$$$$$$$$1.50 /$Speed - 2 4 2 Pipe Shape All Round Most Round End End Burr Finished Burr-Free Small Cone Finished (If er.) (some tempering) Unlimited range size up to 8st to 5 inches to 4.5 inches to 3 inches (203.2 mm) (127 mm) (114.3 mm) (76.2 mm) Automation machine Machine Working Cell Work and Pollution Chips/Grease Slug None Material Loss Significant Inch 0.140 inches. None None (mm) (3.6 mm)/cut per cut Material Type All Hard, All All Soft Raw Material Stick, Stick Stick, Stick Coil/stick Stick Form a Limited Coil Coil Coil Pipe Process: Comprehensive KEY$ Relative Equipment Cost 1 5 Relative Production Speed (maximum 6000 pc/h) - High speed (6) per 1 inch. (25.4 mm) or less in length, moderate (3) above 1 inch (25.4 mm) in length and range based on the type of equipment used by 64 Basic Tube Cut-to-length Drawing Techniques 2-1. Typical chop. Solid HSS Blades Solid high-speed steel (HSS) blades are mainly used on gear-driven clipping machines. These blades are made of high-quality high-speed steel (M2) with specially hardened teeth and a special evaporated coating. They don't have to at any speed over 350 feet/min (107 surfaces m/min). The dark blue, evaporated coating produces a layer of iron oxide that sticks firmly to the surface of the steel. Because of this, 49 65 pipe-forming processes: Comprehensive Guide Figure 2-2. He drank a lot. dark stream and improves through spongy fluid absorption by evaporating treatment. Pickup/accumulation on the cutting edge and sides of the blade is significantly reduced, providing a longer blade life, up to 15% longer than the un avaporized blades. Segmental circular saws Blades Segmental circular blades of the saw are often used on heavy segments. Typically, segmental blades have a larger width/kerb and more head pressure can be applied, resulting in greater cutting efficiency. Tungsten-carbide tipped circular Tungsten-carbide blades tipped with circular blades for use on the belt, high in rpm, colored clipping saws. These blades are generally not recommended for cutting ferrosy material. The number of teeth varies depending on the diameter of the tube. The goal is to have the maximum number of teeth in contact at 50 66 Basic Tube Cut-to-length Methods Figure 2-3. The design of the band-saw. tube, to achieve optimal production speed, and minimize vibration in cutting operations. Too many teeth in contact with the tube can cause the chips to clog your teeth, seriously reducing the effectiveness of the saw. Table 2-2 lists the number of teeth on the blade in relation to the field. Tooth step and blade performance following guidelines recommend for sawing a tooth blade step. For medium-gravity cutoff: Use a 0.12 inch (3 mm) step to cut ferrossive materials with sections up to an inch (1.50 mm). 51 67 52 Table 2-2. The number of tooth blades in relation to pitch step, inches (mm) (2.0) (2.5) (3.0) (3.5) (4.0) (5.0) (6.0) (7.0) (8.0) (9.0) (10.0) (11.0) (12.0) (12.0)) (14.0) (16.0) (18.0) 8.0 (203) (254) (279) (305) (305) 318) (356) (368) (381) (457) Pipe Formation Processes: Comprehensive Guide 68 Basic Methods Cut To Length Use 0.16-in. (4 mm) field for cutting ferrosv materials with sections of inches (mm). Use a 0.20-inch (5 mm) field to cut ferrosy materials inches (mm). Use a 0.24-inch (6 mm) field to cut ferrossive materials with sections of inches (mm). Use a 0.32-inch (8 mm) step to cut ferroso-like materials for sections over an inch (28.58 mm) as well as for colored materials. The 0.39-inch (10 mm) field is commonly used for cutting materials detailed under a 0.32 inch (8 mm) pitch and is used on heavy machines or those with automatic feed. The move is also used to cut aluminum profiles on cut-off machines that run at 900-1100 rpm or faster. For heavy cut-offs: Use a 0.16-b(4 mm) step to cut ferrossive materials with sections in. (2.03 mm). Use a 0.24-inch (6 mm) field to cut ferrossive materials with sections of inches (mm). Use a 0.32-inch (8 mm) field to cut ferrossive materials with sections of inch (mm). Use a 0.39-, 0.47-, or 0.55 inches (10-, 12-, or 14-mm) step for ferrossive materials for sections over an inch (28.58 mm) and for color materials. The inclusion of specialized cosques in the design of the tooth ensures the rupture of the chip when cutting the medium- and thick-walled tube. Teh Teh The angle varies from 10 to 20, with rakes decreasing as material hardness increases. The blades of the saw are mostly built of high-speed steel (M2) and are available with a variety of coatings to enhance performance, based on the material being cut. It is important in all cases to keep the blade cool to maintain firmness (Figure 2-4). Flooding the work area with soluble oil emulsion, or synthetic oil, keeps the blade difficult, cooling it and lubricating the face of the tooth. A typical blade is (mm) thick. However, some of the new coating blades have a thickness of an inch (mm). In addition, some applications have 53 69 pipe-forming processes: A Comprehensive Guide successfully used carbide-tipped blades to improve performance. The recommended speeds for different materials and cutting speed for different blade diameters are given in tables 2-3 and 2-4 respectively. LATHE CUTTING Lathe-cutting principles are mentioned in many guides on standard machine processing practices. A typical barstock installation (tube) uses a standard turn current on which the tube is fed through the Chuck-type clamp system. The tube then rotates, cross-carrying the tools part of the tube installed and, if necessary, provide other operations such as chamfering (outside and inside diameters). The second mechanism uses a stationary tube, and rotates up to four cutting tools around the tube to make part of the tube, and provides the end of finishing operations inside and out diameters (see Figure 2-5). The method is ideal for a tube with heavy walls where the final configuration can only be achieved by removing the metal. ROTARY CUTTING Like many traditional cutting techniques, rotary cutting as a production system has been around since the early 1950s, using a sophisticated version of a typical hand tool used for part of the pipes. It involves one or more angular blades rotating around the tube to make part of the tube. Opposite each of the cutting blades is a backup roller to supply support for the parting process, and to control the outer diameter of the tube. The penetrating blade displaces the material instead of removing it, and the pressure of the roller redistributes the material to maintain a permanent external diameter. Cutting blades have an inclusive angle of 15 40, depending on the thickness of the material and hardness. The optimal situation is to use a minimum angle of practice (e.g. 15) and increase it to more complex materials to get a better life of the tool. As a result, the incision has half a angle at the end of the tube, which is acceptable for most end operations. Special blade designs are available to meet specific requirements, such as a flat-end incision, or a specific root radius. Clips support the tube at 54 70 55 2-3. Recommended speeds for various materials Stress Strength, Cutting Speed, Material psi (Pa) Surface Ft/Min (Surface m/min) Standard Class Steel C 1010 48000 48000 48000 ((C 1020 50000 70,000 ( ) C 1030 75000 80,000 ( ) ( ) C 1040 75000 90000 ( ) High tense steel C 1050 90, .000 ( ) (C 5120' 98, 000 ( ) C 6140 110, 000 ( ) C 4140 125, ,000 () (C 4150 140, (000 ( ) Steel tubes, lightweight gage 40,000 50,000 ( ) Stainless steel 70, ,000 ( ) ((Structural steel shapes 48,000 62,000 ( ) Clitor steel 50,000 60,000 () ( ) ( ) Non-Ferrous Metals Aluminium, 000 (33.5 3,962.4) Bronze ( ) Brass Copper 1,300,000 2,000,000 ( ) American Institute of Iron and Steel / Society of Automotive Engineers (AISI/ SAE) Basic Techniques Cut to a Length 71 56 Table 2-4. Cutting speeds of various blade diameters Spindle Blade Diameter Speed, 8 in. 10 in. 11 in. 12 in in in. rpm (203.2 mm) (254.0 mm) (279.4 mm) (304.8 mm) (317.5 mm) (349.3 mm) Cutting Speed, surface ft/min (surface m/min) (6.4) 25 (7.6) 28 (8.5) 31 (9.5) 32 (9.8) 36 (11.0) (12.8) 52 (15.9) 56 (17.1) 62 (18.9) 64 (19.5) 72 (21.9) 78 (23.8) 84 (25.6) 93 (28.4) 96 (29.3) 108 (32.9) (25.6) 104 (31.7) 112 (34.1) 124 (37.8) 128 (39.0) 144 (43.9) (38.4) 155 (47.2) 168 (51.2) 185 (56.4) 192 (58.5) 215 (65.5) (51.2) 208 (63.4) 224 (68.3) 248 (75.6) 256 (78.0) 288 (87.8) (64.0) 260 (79.3) 280 (85.3) 310 (94.5) 320 (97.5) 360 (109.7) (76.8) 312 (95.1) 336 (102.4) 372 (113.4) 384 (117.0) 432 (131.7) 1,700 5 , 345 (1,629.2) 5,568 (1,697.1) 6,124 (1,866.6) 3,400 10,690 (3,6,258.3) 11,136 (3,394.3) 12,248 (3,733.2) Трубообразующие процессы : Comprehensive Guide 72 Basic Tube Cut-to-length Methods Figure 2-4. Cold configuration of the tooth saw-blade. Figure 2-5. A stationary tube with rotating cutting tools. 57 73 Tube Formation Processes: Comprehensive guide on both sides of the cutter. Most machines used standard ground and polished, vertically-opened clamps with a pipe from the outer ground diameter in them. However, recent events provide self-centering, segmented clips. Vertical clamps are subject to changes in the outer diameter of the tube, and therefore the central tube line changes as the tube changes. As a result, the incision is outside the center, and can affect the quality of the incision. Using self-centered, segmented clips ensures that the center line is maintained throughout the cutting process, providing the best quality. A normal end-to-end incision provides some roll of material as the blade penetrates the tube (see Figure 2-6). This is acceptable for most cutting applications where the end of the formation or mandrel bending are not a consideration. It can be improved by using a cutand-break/cut and pull system that has a lateral moving exit clamp. The tube is cut 95% of the way through and then pulled or broken into pieces. The operation provides a minimum reduction in the internal diameter and results in a part suitable for the formation of the end (see picture The decrease in internal diameter varies depending on the material being cut and the diameter. With the help of additional rolls of backup use, use, Can be transferred to the tube during cutting surgery to provide grooves (see figure 2-8), hose thorns, and other molds. This is done during a cutting cycle, and is limited to a maximum length of about 1 inch (25.4 mm) longitudinal from the incision. Since cutting without chips, and in most cases ready by the end of formation, modern rotary weeding can be organized with a line-to-line end formation to finish one end of the tube while the system has control over the tube. The end formation line is available from one to four impact-forming stations, some with an adjustable position to allow one of the strokes to be the final forming part simultaneously with the cutting sequence. Consideration should be given to limiting the number of end operations to ensure that the benefits were not offset by slower production speeds. See Figure 2-9 to illustrate typical end tubes. DUAL-BLADE SHEAR CUTTING The use of cutting blades for cutting pipes has been used since the 1920s, starting with the single blade method, and then improved on 58 74 Basic Tube Cut-to-length Drawing Techniques 2-6. A typical rotary cutting system. 59 75 Tube Formation Processes: Comprehensive Guide Figure 2-7. The cut-and-pull/cut-and-break system provides minimal reduction in internal diameter. Figure 2-8. Typical fluted tubes. with a double blade system. Figure 2-10 illustrates a typical double blade system showing a horizontal blade, removing the notch from the tube and then the vertical blade that the scissors tube up to the length. Using the original horizontal cutout of the scarf allows the vertical blade to penetrate the wall with minimal tube dimples. Because of the nature of the haircut process, the system is better suited for solid materials such as carbon and alloy steel. 60 76 Basic Tube Cut-to-length Methods Figure 2-9. Typical end pipes. As a result, the incision has some burrs and sharp edges, the size of which is determined by the thickness of the wall and the diameter of the tube. The brush deburing system can be integrated with discharge equipment to complete the finishing of both ends of the tube. The components of the machine frame and haircuts must be robust enough, and are usually cast to provide the precision needed for a quality incision and long life of the tool. As with the rotary cutting process, clip quality and stiffness are essential for getting cut tolerances. Cutting tools are usually made from the hardened steel tool M2, and are often TIN coated for a longer life. During the cutting process, the horizontal blade cuts out of the tube a small 61 77 pipe-forming processes: Comprehensive Guide Drawing a Double Blade Haircut System. bullets that the vertical blade directs into the tube (see Figure 2-11). Bullet then under the vertical blade and pushed through the bottom of the tube. Figure Typical double-blade haircut machine. 62 78 Basic Tube Cut-to-Length Methods SUPPORTED SHEAR CUTTING Supported Supported The system was developed in the 1950s to ensure burrs are less cut on all types of metal pipes (see figure 2-12). Basically, the cutting action is similar to a pair of scissors, cutting through the material between a fixed and moving blade. Two sections of instruments are used, one stationary and one mobile, consisting of internal impact and external death. The stationary toolbox section supports a hollow tube interior with an internal punch, and supports the exterior with a closely-fitting exterior die. The mobile tool holds, moves and scissors of the desired segment of pipes (see Figure 2-13). The haircut begins when the length of the mill pipes is loaded onto the machine through the outer dying of both sections, and over both internal blows. The pusher pushes the tube to the stop-finger, adjusted along the length of the incision. When the tube to cut hits the stop mechanism, or the programmed length, the haircut cycle begins. The mobile section of the toolkit moves against the stationary section of the toolkit, causing the material to be cut. In some drawing the haircut method is supported. 63 79 Pipeline Processes: Comprehensive Figure Guide Supported by Haircut Toolkit. methods, the movable section first moves vertically, then horizontally. In other methods, the movable section performs elliptical loops to complete the incision. At the end of the cutting cycle, the mobile section returns to a fixed position concentric with a stationary section, and the next tube to be cut is advanced. This throws out the cut segment and the process repeats itself. The cutting cycle is very fast. The incision is made without material losses between the parts (see figure 2-14). LASER CUTTING The use of lasers to cut the tube in relative terms is the most modern of the technology. It uses an energy source to generate a beam of electromagnetic (EM) radiation to cut out the tube. The beam has a certain wavelength, and these wavelengths are homogeneous, parallel and are in phase with each other. The two most popular laser tube cutting systems are CO 2 and Nd:YAG (Neodimius, suspended in yttrium gar- 64 80 Basic Tube Cut-to-length Methods Figure Typical supported shearing machine. , or a plethora of consistent procedures such as drilling, stamping, and milling that will require a series of different machines to complete the part. If the requirement is to produce a finished product on demand, or to produce small batches with various modifications, laser cutting can be practical. Because of the inherent laser system, the rationale must be based on process, and maintenance costs need to be addressed. Figures 2-15 and 2-16 show typical Applications. 65 81 Tube-forming Processes: Comprehensive Guide Drawing Laser Cutting Parts. 66 82 Basic Tube Cut-to-length Methods Figure Typical Laser Cutting Machine. BIBLIOGRAPHY Bannish, Alec Tube clipping techniques and equipment. TPA (Seminar, July Technical Document). Dearborn, MI: Society of Manufacturing Engineers. Holyoake, William H Cut the tube more efficiently. Formation - Manufacturing, February application rotary Cut-to-length Technologies. Pipe technology, May/June Integration of tube-forming operations into cut-off systems. TPP magazine, Winter Room. 67 83 84 Basic methods of bending 3 Basic Hollow bending techniques and solid sections can be bent in one or more planes, at least one of the main bending techniques if they maintain a single transverse configuration for a long enough length to provide sufficient clip area. All the methods used for the curve of straight sections have a common feature: they make the ediling surface of the bend longer than the concave surface. This difference in the length of the contour can be obtained by: The bending of the outer fibers is lengthened or placed in voltage while the internal fibers are compressed or shortened. Stretching, forming external fibers, is stretched to a greater extent than internal fibers. The basic methods of bending are divided as follows: bending the turning draw; Bending compression Bending the roll; and stretch the formation. Each type characteristically has certain applications and limitations regarding the types of bends it produces and the maximum bend angle as indicated in table 3-1. The choice of the process of bending the pipes depends on: the quality of the bend and the speed of production is required; and the diameter, the thickness of the wall, and the minimum radius of the bend desired. You can use two graphs to choose the method. The ratio of diameter and dotency is determined for the first time in figure 3-1. Crossing this value with any desired bend radius value, as shown in figure 3-2, indicates the bending process is likely to result in 69 85 pipe formation processes: Comprehensive Guide table 3-1. The ability to bend the methods of bending types of bends Maximum angle of the process is usually carried out by the draw single band, Multiple, connection to 180 Compression Single Less Than 180 Ram and Push Series of Different Angles Bending Up to 165 Manual Single, Connection, Spiral 360 Roll Circular, Spiral, Spiral, Spiral 360 Stretching Linear Variable Curvature of 180 Radial Circles, Ovals, Rectangles, Spirals 360 Figure 3-1. Nomograph to determine the ratio of D/t. bending is high quality. The following sections discuss each method in detail, providing their own applications, advantages, and limitations for different cross-geometric configurations. Instrumentation is also discussed because the choice of bending method depends on the quality of the desired bend, and this, in its own depends on the types, accuracy of measurements and surface finish of the instruments involved. 70 86 71 Figure 3-2. Minimum bending expected from different bending processes. Basic methods of bending 87 pipe-forming processes: The Comprehensive Guide to ROTARY-DRAW BENDING Draw is the most common method used on rotary bend machines that can be fed (hydraulic, pneumatic, electric/mechanical), manual or numerically controlled. These machines handle about 95% of pipe-bending operations. An important tool for bending draws is the rotating shape of the bend, the clamp death, and the pressure dies, as shown in figure 3-3. In the bend of the draw, the blank is fixed to the shape of the bend by the die clamp. As the bend die rotates, it draws a blank against the pressure to die and, if necessary, to prevent the collapse of the wall, over the inner pulp. The pressure to die may remain fixed or move with the blanks to eliminate the friction of the sliding contact. No one's bending is the most versatile and flexible method of bending. It is used to make single bends up to 180 using standard tools and multiple or connecting bends using special tools (such as mandrel). It also provides close control of the flow of metal needed to bend the small and thin-walled tube. Single bends are easily made in. (0.25 mm) stainless steel pipes. However, the thickness of the wall should be no less than an inch (mm) when multiple or compound bends are provided. This limitation is due to the complexity of the required toolkit and the hardening of the tube walls behind the tangent point of the first bend. Figure 3-3. Rotary is a draw bend. 72 88 Basic bending techniques The manufacturing process determines which of the five types of bending no one is selected. The choice depends on the diameter and thickness of the wall of the blank and the radius of the bend required by the drawing of the part. Method A (Figure 3-4) uses a complete set of bending tools and is the most expensive. Methods B, C, D and E (discussed in the following sections) require gradually less toolkit with the E method, using only bending form, pressure to die, and clamp to die. Method A bends large diameter pipes, thin wall, stainless steel pipes on radii up to 1D. Method E usually applies only to a bend of a much smaller degree of severity. For example, stainless steel pipes can be bent to central radii 1 10 times larger than the outer diameter, depending on the method of wall thickness and bending used. Method A Method of Bending Draw requires a complete masculine kind of tools shown in figure 3-4. The rotating shape of bending or bending is the main tool, as it determines the radius of which the blank is bent. It contains a groove tube that corresponds to the outer profile of the blank and provides external support along the inside of the bend, like Die Figure 3-4. Tooling for the method of turning bend. 73 89 Processes Tube: Comprehensive guide rotates. The stationary windshield wiper dies provides additional external support just beyond the point of tangent Bend. It works in conjunction with the pulp to prevent wrinkles on the inside of the bend. The multi-ball mandrel gives the inner support of the tube, both behind and in front of the tangent bend, as the tube is wrapped around the bend to die. The length of the necessary support of the pulp (the number of balls) depends on the force of the pipe collapse, the radius of the bend and the degree of bending. The pressure dies finds the tube in a bend position and holds it against the bending shape during the bending of the operation. The clamp die mates with a clamp section bending shape to produce the restraints needed to keep the tube from sliding. When thin-walled pipes bend to shallow bends of radii, a split clip can reduce the length of the retained surface (see figure 3-4). However, part of the indentation from the cleat must be disposed of. The clamp plug, also shown in Figure 3-4, prevents the thin-walled pipes from collapsing, providing internal support in the clamp area. Method B Method B drawing bending tools are similar to those shown in Figure 3-4, except the plug clamp is not used; The standard clip is usually replaced by a shown type of cleat. Thus, the B method of drawing bending can be used on the power of benders to bend heavierwall tubes than method A. Method C draw bend uses bending shape, pressure to die, multi-ball mandrel, and standard clamp die, but no windshield wiper die. Consequently, large bend radii should be specified for this method to avoid wrinkles when the tube is bent. The D Method Method bending draw is widely used because of its simplicity and economy. It requires the same tools as method C, except for 74 90 basic methods of bending the plug or shape mandrel is replaced by a ball mandrel. The mandrel fork is used when the tubes are bent to large bend radius. The front part of the plug is usually well rounded to provide a non-anchor surface. Connect mandrels designed to be about an inch (mm) smaller than the internal diameter for a seamless or flash-removed tube to allow for tube diameter tolerances. For the heavier thickness of the wall, gaps of up to an inch (0.38 mm) or more can be specified. The shape of the mandrels is used to bend the thin-walled pipes to medium bend radii (R/D No. 5) and for parts where average tolerances are acceptable. The E Method E bending draw eliminates mundrell, reduces cost, and increases production for many processes. It is practical for bending large radii where the angles of the bend are not large, where the pipes have relatively heavy walls (approximately 10% of the diameter of the tube or more), or where the ovality and wrinkles are not undesirable. When bending a draw without flesh on a small radius, bending the shape around which the tube is wrapped should have a deep groove. This is to make sure that the tube is fully supported on the sides bending load. When the radii are as small as 2D to 3D, the bottom bottom is bottom The groove is trained so that the cross section of the tube is more or less pear-shaped. The small neck is focused on the inner part of the bend so that the metal flows without excessive wrinkle. Drawing a bend without mandrel is also used in the bend of the barstock and certain channels and angular sections. Tooling bending shape bending shape or bending the die is the most important tool used in bending the draw because it determines the radius of the bend of the tube. The bend-die tube groove gives external support to the blank along the inner part of the bend as the die rotates, and provides 75 91 tube-forming processes: A comprehensive guide means limiting the compressed voltage incurred in the material during the bend. The straight section of the bend shape clip holds the tube when the opposite clamp dies applies pressure. The length of the clamp part of the shape bend should be equal to the length of the clamp to die. The length of the clamp depends on the thickness of the wall, the diameter of the tube, the bend radius, the degree of bending and the strength of the pipe yield. It should be long enough to contain ball segments of pulp and plug clamp if necessary. For some applications, the clamp surface can be enlarged by adding an extension block with the diameter of a single tube or longer. Important considerations in design-bending shapes are the length of the clamp required, the springback harvesting factor, and the degree of accuracy that the die must maintain. In most cases, the angular spring is compensated slightly by the inflection of the part; Radial spring does not count. Where the radial spring is of concern (e.g., the manufacture of 180 reverse bends, where the ends of the tube must correspond to fixed centers), the radius cut into bend shape should be slightly less than the desired radius of the final bend. The bends from a smaller size die then spring open a little in the desired radius. Since the amount of springback depends on the material hardness, the allowance in death must be determined ultimately by the trial and error. Deaths are often tested in a mild state. Any necessary processing is completed before heat treatment for production. The choice of materials for bending forms is regulated by the production expected of the form and the capacity of the available equipment for its machine. A low-carbon steel or alloy steel tool is commonly used where production works in thousands of bends per month. Forms of any steel harden during heat treatment. The steel tool is commonly used for small bend forms, the entire shape is shredded from a single block. The steel tool dies hardened Rockwell C (R C), depending on their end use. Mildsteel forms are high in carbon and hardened to R C. Large molds can be turned from low-carbon steel casts and then hardened. The clamp insert on these forms is often shredded as a separate and welded or bolted into the radial part of the shape shape Heat treatment. The accuracy of the basic bending methods of 76 92 depends on the shape of the material and the finish of the surface. For most round pipes, pipes or other blanks, where the surface trim is not of paramount importance, bending the shape with a charred finish is used. Only grinding or polishing is done, usually for the sake of appearance after heat treatment. Where the surface finish is crucial, such as on a decorative stainless steel finish or polished aluminum, the groove in the shape must be polished by hand. On forms formed into square tubes, extrusion, etc., manual resurfacing and polishing are often needed to match the groove to the exact configuration of the work. The clamp-paste groove should not be ground, except on the rare occasions when the finish of this part of the die leaves traces at work. The groove is usually a rough machine and is often jagged, carbon sprayed, or knurled. Grinding only reduces frictional retaining the effectiveness of the clamp die and can cause the work to slip through the clamp. The bending of the shape should be made accurately and installed on the bend of the machine. The tubular groove of bend or block shape should be concentric with the mounting hole. To prevent the instrument from mismatching, the central line of the groove holding the tube must lie in a plane parallel to the machine's bending boss. The bend shape is set hard to the death boss (usually part swinging arm at power-operated benders) and turns with the boss and arm, drawing the material, which will be bent into a groove to die. On a modern, power-bending machine, die studs and nuts hold a bend shaped like a die boss. The driving force is transmitted through one or more keys to the drive between death and the boss. To maintain concentricity with the spindle, the well-designed shape of the bend involves a deepening for the hardened ground placing a ring that extends between a hardened insert in the die boss and die yourself. Figure 3-5 illustrates the most common bend-die designs. The correct die is determined by the bend of the machine, part configuration, desired flexibility (inserted removable clamp section), and economy. Good tool providers will recommend a bend-die type based on customer criteria. The invention of the wheel is the least desirable option. 77 93 Tube Formation Processes: Comprehensive Guide Figure 3-5. Types of band-die. The 78 94 Basic methods of bending the Die Clamp to die are usually straight to die with a groove cut on one face, in shape to fit the outer blank configuration. This die is set so that it can be pushed under pressure to mate with the clamp section bending shape. The die clamp provides the retained force needed to prevent the blank from slipping when the bend dies On the power-bending machine, a death clamp is set on the face holder to die key to slide into a swinging arm The movement of this slide clamps and unclamps die as part of the automatic machine cycle. The length of the clamp die is an important area of tool design. This should be enough to keep the blank firmly, not allowing slippage through the die or marking work. This length is determined by the characteristics of the blank, including the diameter (or available clamp area on non-prickly pieces), the thickness of the wall or section and the type of material, hardness and surface finish. In addition, you need to take into account the radius of the bend and its relationship with the necessary clamp pressure. Guidelines for determining specific clip lengths are given in Chapters 1, Tables 1-2 and 1-3. In unusual situations, the clamp design is significantly different from the usual straight, contour groove shown in Figure 3-6. When the ultra-thin walls of pipes are curved at diameters of approximately 1.75 inches (44.5 mm) of external diameter and larger, there is almost no possible length of direct clamp to die prevent the material from slipping through the clamp or as a result of wrinkles. Increasing clamp pressure only distorts the tube. This also increases the ability to actually clamp the tube onto mandrel balls and break the mandrel as the bend of the arm begins to rotate. In these cases, you can use a clamp plug or a combination of cleat and plug. When bending a heavy wall pipe or a solid bar where some markings can be allowed, die is sometimes used that is about once a tube with an external diameter in length. To perform the bend can be used rough, soaked carbide, clamped with a knife or jagged clamping surfaces. This death is used with a high-pressure clamp to effectively hold the work in the form of a bend. 79 95 Tube Formation Processes: Comprehensive Guide Figure 3-6. Pressure and clamp die construction. 80 96 Basic Methods of Bending Figure 3-6. (continued). 81 97 Tube-forming Processes: Comprehensive guide to clamp dies, usually made of low-carbon steel and hardened to resist wear. A steel tool can be used if a high pressure clamp is required or a very long lifespan is required from a small die that can deform in heat treatment. Machine trim is used, but in no case the groove is not polished. The plugs of steel, which have hardened in the hull, are made to the minimum allowable tolerances of the inner diameter of the tube. The same die clamp can be used with multiple bend forms having different radii as long as the size of the tube or harvesting shape remains constant and the length of the clamp is enough to prevent slippage during the bend. The design of the piece should always try to have enough straight material between the bends to avoid clamping on the early bend (the bend of the link). Special clip to die (and clamp inserts to bend shape) be provided if this is not possible. The tube groove is shaped to fit the previous bend and finds the next bend in the correct position position rotation plane. Figure 3-6 illustrates standard and complex death clips and general design criteria. The Pressure Die To Die finds the blank in the correct position and applies the reaction force to the free end of the blank. This causes the metal to take a bent shape as the bend and clamp die to rotate. The pressure exerted by death must be adjusted to balance the tense and compressible bending stresses. Even 5 pounds (2 kg) can make a difference on critical bends. Pressure dies fall into three main structures: 1. moving or follower-type pressure die, the most common design, moving forward with the blanks during bending. It's basically a long straight die with a groove cut into one person, in shape to match the configuration of the piece bent. 2. The stationary or static type of pressure dies is similar to a moving type, except that it does not move forward during the bend. 3. The type of roller uses a rotating coil to die with an overtaking tube groove. 82 98 Basic methods of bending Pressure Move die. Moving pressure death is preferred for many bending operations. Its free sliding action from the blank minimizes friction resistance (thus reducing the stretching or thinning of the outer wall of the tubular bend), reduces flattening and provides better bend quality. As death moves, a certain amount of self-leveling action allows this type of death to distribute pressure-death power more evenly over the entire blanks, thus increasing the quality of the bend. Moving death also minimizes or scratches of polished or pre-painted material. For easily labeled materials such as aluminum or anodized tubes, some manufacturers use Teflon-inserted pressure to die. The insertion of the dowel is in place and can be transferred and regrooved when worn. As all pressure dies, the moving type is supported in the holder on the stationary arm of the powered bend machine. On well-designed machines, this die either relies on a series of handmade rollers or a hook mounted on a master die-mounting bar that itself relies on needle rollers in all four planes. This type of support allows the pressure to die to be precisely aligned with the job. It is important that the pressure die to move forward freely, while maintaining close parallel tolerances with the bend of the shape and convey the necessary force without restricting the forward movement of the blank as it bends. As it moves along with the work, the length of the required pressure is determined by the maximum radius and angle of the bend to be formed. The equation to determine the length of pressure dies required for the bend itself: where: 2'RA 360 R and the central bend radius, in. The angle of the bend, (3-1) The resulting figure must be increased by a certain amount to provide the developed length needed for the pressure to die. To make direct pressure die, add add length so that the die remains in its holder at the end of the bend, usually in. 83 99 Pipe-forming processes: Comprehensive guide (see). For the master bar is set to pressure die, add a length equal to 2D from the blank to give die enough length to maintain the restraint pressure at the end of the bend. Moving pressure dies are usually made of soft steel, barstock for smaller sizes, or cast steel for larger works. Machine finish is usually sufficient. The steel tool is sometimes used where the wear rate of the tool will be high, especially when the die groove is cut into a developed shape that gives a special shape for the work. Instrumental steel can also be selected for high-production jobs with highly abrasive material. Moving pressure dies is usually not tempered, except for accelerated wear and tear applications. The same pressure to die can be used with different forms of bending, as long as the blank diameter or shape remains the same. In addition, the death should be long enough to provide the maximum required angle of the bend, with enough extra length to stay in or on the death holder. Hospital pressure is dying. Stationary death pressure is used primarily when the specified bend radius requires moving pressure to die, which is excessively long, difficult to handle, and difficult to maintain in proper alignment on the machine. The stationary type is also used from time to time in those applications where additional stretching of the outer bend wall is desirable. When a machine or tube installation jamming is likely, it may also be helpful to use stationary pressure to die. Stationary pressure dying produces more friction between the moving material and the hard-set die. It has a lack of scratching or marking the tube more than a moving type. Hospital pressure dying usually causes more flattening and/or wall thinning in tube bends than moving die. For these reasons, inpatient deaths are used only where material finish and structural appearance is of secondary importance. The stationary death design is generally similar to the moving style. The length of death required will depend on the surface of the finish work, the radius of the bend, and the pressure exerted on and through the die. The final length is the balance between the maximum bearing area for the harvest to avoid overshadowing, and friction generated by death. For most works, this length varies from two to five times the blank with an external diameter. Vellum is sometimes used to prevent bile. 84 100 Basic methods of bending the material for stationary type die can be soft or the steel tool when bending soft steel or colored blanks. The steel tool is used more often in this die than in the moving type. Both soft and tool-steel dies hardened to slow down wear, incurred by sliding from the blank along to die. Machine finish is often sufficient, but resurfacing resurfacing The polishing of the groove is usually determined to reduce the overshadowing of the work. Dies for stainless steel bending are usually made from a solid grade of aluminum-bronze alloy. This material eliminates bile or pickup between die and stainless steel blanks. Uretan or various plastics are also used quite widely because of their low friction properties. Roller-type pressure dies. Third, a pressure-type roller die can be used. A roller-type pressure die is set in a holder equipped with rollers that rotate like a blank bent. It is often used when bending a heavy wall tube or pipe to generous radii where the length of a moving die will be ungainly. Rollers, usually made of soft steel and trained finishes, are usually enough. The depth of the tubular groove carved in the rollers is just under half the outer diameter of the tube or pipe. This allows a gap between the edges of the rollers and the lips bending shape when the pressure is applied through the rollers. In many cases, the shape of the roller groove is specially designed to pinch the outer part of the tube in an elliptical form. The resulting flattening of the bend action tends to force the distorted section back into an almost round state. Soft steel or tool-steel rollers incorporating a pinch into the groove are often hardened after being turned to give a longer life of the tool in high temperature. If special provisions are not made, roller pressure dies does not limit the material at the point of tangent and more distortion of the results of the cross-section bending, when the rollers are used, than when using moving type of pressure die. Auxiliary tool mandrels. The bend of the tube has advanced far from the packing tube with firmly packed wet sand. Once upon a time, high tech was a 20-foot (6th) packaging booth complete with ram sand and water. Cable 85 101 Pipe-forming Processes: Comprehensive guide to mandrels with bending, nested saucer segments were used in the late 1950s. Since then, mandrel choice has been versatile, flexing the steely mandrel bond in various forms including regular, close pitch, and ultra-close pitch. Single planes, bends, and rough mandrels are still used. Figure 3-7 illustrates different configurations. Figure 3-7. Mundrel types. 86 102 Basic mandrel bending techniques is a tool inserted inside a tube, tube or other hollow section in the area of the tangent bend. His goal is to support the outer wall of the blank as he is pulled around the bend shape and reduce the amount of flattening in the bend. In addition, musrel helps prevent the formation of wrinkles on the inner wall of the bend. Mandrel sometimes has a secondary function as a size tool on extremely close tolerance work in thin-walled tubes like this is used in the aviation and aerospace industries. Wrinkles can be smoothed during bending hesitating mandrel. On most curved machines, the mundrell is attached to the core anchored in the back of the machine. The rod includes the ability of the lateral and longitudinal adjustment of the mandala position in relation to the bend radius and at the point of tangent bend. The required amount of support length is determined by the strength of the collapse of the blank, the radius of the bend and the degree of bending. Connect. The mandrel fork is the simplest type and is used for the least critical bends requiring mandrel. It's just a cylindrical death with one end, a trained radius. All mandrels have a tapped hole or some other type of locking device in the back so they can be attached to the supporting rod. The mandrel fork is located from its end 1/16 1/8 inches (mm) past the tangent point of the shape bend. This supports the outer curvature wall at the point where the yield strength of the metal is exceeded and the bend is actually formed. Form. The shape of the mandrel is a refinement of the type of plug, with the outer edge of its tip outlined to the outer radius of the blank. It is usually located with all the contouring tip in front of a tangent. Thus, it supports the outer wall of the material a little deeper in the bend area than the plug. The formed tip of this mundrel usually does not exceed the length of more than half of the outer diameter tube. Connect and form apps. Connect or form mandrels for use with soft steel or any non-ferra material almost always made of steel tool and hardened to resist the wear caused by materials drawn over them. The steel of the tool chosen should not be distorted during heat treatment. Once hardened, the mandreli is usually ground and polished so that their smooth finish will cause as little resistance as possible. 87 103 Pipe-forming Processes: The comprehensive Mandrels guide used to bend stainless steel must be made from a solid grade of aluminum-bronze that resists pickup and galling under the heavy pressure required in stainless work. Such mandrels usually only need light polish after handling to achieve a suitable surface finish. Connect and form mandrels are made with a certain amount of gap between the internal diameter of the work and the mandrel to facilitate loading and unloading the blank. The amount that is unsaltable depends on the type of material and the physical qualities of the bent tube and the radius of the bend. For most bends in seamless or flash-remote tubes in sizes up to approximately 1.25 inches (31.8 mm) of external diameter and wall thickness up to an inch (2.41 mm), the gap of an inch (mm) between the mundrel and the internal diameter of the tube is MIDDLEPART maximum grip or thrust to the pipe. This allows much more pressure and relief, thereby minimizing the thinning of walls and collapse. To bend the tube or pipe, the inner wall must be compressed. How To Pressure dies, empty bend die has a true radius and several groove radii (see Figure 3-15). The multi-needle groove causes the tube to take over the configuration, which causes the compression of the material and eliminates wrinkles in the bend of the heavy-walled pipe. The design also provides space for the material to thicken. 107 123 Tube Formation Processes: Comprehensive trend of bending directional shape. Drawing The Empty Bend of a true and multi-thousand groove. 108 124 Basic bending techniques Although the use of mandrel will hold the tube in a more concentric cross-section, the non-mandrel configuration tool eliminates the need to load the tube over the mandrel and rod. Reducing wall thinning, better ovality, and no lubricants to clean other benefits. It is important to remember that methods other than mundrell are not the same, and the laws of physics still apply. Non-mandrel methods don't work for every application. The formula in Table 3-4 can be used as a guide to determine the feasibility of the Empty-Bending method. Folded dies. Folded deaths can be used to increase production; Reducing processing costs and/or significantly reduce installation time in many cases. Sometimes it takes two or more different bend radius to form a completed part, and no compromise radius can be used. To achieve this by conventional methods, bend machines must be configured and work processed through it for each different radius. To eliminate this rehandling, as well as the installation time for the second, third, etc. bends, different radius bending shapes are stacked on top of each other, as shown in the picture the appropriate clamp and the pressure dies are also stacked using special die holders. Different bends of the radius can be made gradually in part with this installation. In other cases, bend machines can be used for single or small work, such as maintenance jobs or low-production piping in two, three or more different parts of diameter or on different radii. In such cases, a single set of stacked tools can often be configured to cover almost all bend requirements, eliminating the need to customize individual die sets for each different diameter or radius. Multiple bend. Multiple bend on the rotary-bending machine refers to the bend of two or more of the same part during the same machine cycle. This method can significantly increase production by bending solid rods, where you often don't need a groove bending the shape. Multiple bending is easily achieved, making dies high enough to take multiple parts at once. When bending the tube or other forms, there should be a groove in the shape of a bend for The parts to be bent, along with the appropriate grooves in the clamp and the pressure dies. 109 125 110 Table 3-4. Applications with an empty bend (outer wall diameter and wall factor) (central radius of the outer diameter tube) diameter) factor Outside Centerline Empty- Diameter, Wall, all, Radius, Bending Collapse, Thin Out, Industry in. (mm) in. (mm) in. (mm) Material Factor % % Aircraft (6.35) (0.51) (19.10) 321 S.S AL 2.5 Ti (6.35) (0.71) (19.10) 6061 T (9.53) (0.48) (28.60) 3AL 2.5 Ti S.S (9.53) (0.51) (28.60) S.S (12.70) (0.71) (38.10) 321 S.S (12.70) (0.89) (38.10) 6061 T (15.90) (0.81) (47.63) 321 S.S (15.90) (0.89) (47.63) 6061 T Tube Forming Processes: A Comprehensive Guide 126 Table 3-4. (continued) 111 Industry Outside Centerline Diameter, Wall, Radius, in. (mm) in. (mm) in. (mm) Material Empty-Bending Collapse, Thin Out, Factor % % Air conditioning (9.53) (0.86) (19.05) Copper and refrigeration (12.70) (0.71) (19.05) Copper (12.70) (1.14) (19.05) Copper (15.88) (0.89) (28.58) Copper Automotive (7.92) (0.71) (11.99) Mild steel (9.53) (0.71) (14.00) Mild steel (12.70) (0.89) (19.05) Mild steel (19.05) (1.24) (38.10) Mild steel Boiler tube (50.80) (5.77) (50.80) 321 S.S (50.80) (4.06) (63.50) Steel (50.80) (2.79) (76.20) Steel (53.98) (4.57) (57.15) Steel S.S. = stainless steel, Ti. = titanium, AL = aluminum Basic Bending Methods 127 Tube Forming Processes: A Comprehensive Guide Figure Stacked dies. (Courtesy Cambridge Machines) Split dies. Split dies, or a bend of the form, which is divided into horizontal halves so that it can open and close vertically, used in two common instances. First, when the blank has a foot, section or plane of the person that lies in a horizontal plane, such as square or rectangular tubes, angular iron, and many forms of extrusions. All parts of such blanks should be closely limited to prevent unwanted distortion of sections stretched by thin walls, and avoid accordion-style wrinkles on the inside, compression side of the bend. If a solid, one piece of bending shape has been used, compressed parts and/or distorted elements will wedge into the die groove and the piece will become virtually impossible to remove from the dies. Therefore, divided deaths are used. These die open to easily load the piece into a bend shape, the clamp is closed to limit the piece during the bend and then open to easily unload. Figure 3-17 shows the split-die app. The second usual use of a split bend shape is when the shape of the part or the frame configuration does not allow the use of a conventional clip to die. Examples of these parts are the double displacement of heat expansion cycles; single-fruit hydraulic fittings with nuts installed; 112 128 Basic Methods of Bending Figure Split dies. (Courtesy Cambridge Machinery) and refrigeration fins bent to 180. Here the bending shape and the clamp die are made as one piece and then split horizontally. In operation, the two halves die close on the blank and the bend is done in the usual manner. When the necessary bend was two halves open to allow to allow This type of die is used in the rare cases where the shape of the part does not allow sufficient movement of the usual sliding type of clamp to die or when the joints bends not all in a horizontal plane. Clip on end forms and fittings. Sometimes it may be necessary to bend the tube, which is in direct immediate immediate need to the flank, beads, flash or otherwise formed tubular end. You can turn on the shape of the flank, ball, etc. as in the clamp die and clamp inserts bend the shape. The tools are actually sandwiched at the formed end, as shown in the picture that saves material or costly secondary operations. This special toolkit should be treated with caution. The force needed to bend can distort the formed end or pull the flank out of the square. In addition to the formed or flanged end, there should always be a straight clip length equal to at least 1D blanks. A clamp plug. Sometimes it is difficult to distribute the necessary clamp force over enough area to hold the tube without sliding or overshadowing the surface. This can be a problem when bending an ultra-thin wall of stainless or aluminum ducts used in 113,129 Pipe-forming processes: A Comprehensive Figure Tooling Guide for End Forms and Fittings. (Courtesy Bend Tools, Inc.) Aerospace. Often, straight clamp lengths over five or six times D are indicated, adding significantly to the value of the tool and, if the clip length is later cut off as a crowbar, to the total cost of bending. In such cases, a clamping fork is often inserted at the end of the tube. This fork fits tightly into the inner diameter of the tube and acts to transfer the necessary clamp force into the tube without distortion and with a much smaller amount of tube used in the clamp length. Lubrication. While the use of lubricant or compound patterning is not strictly a technique, it is a necessary part of many draw bending operations. Typically, stocks are bent on ram benders, roll benders, and some compression bends should not be smeared. It is also not usually necessary to apply lubricant on the metal formed on hand bands. This is largely due to machinery and equipment, as well as large radius bends usually produced. However, some of the most serious stresses in formation occur in the bending of the draw, the bend of stretching and in numerous compression bending operations. 114 130 Basic bending techniques with a great emphasis on bending the thinnest sections and making radius bends to 1 D, 1.5 D and 2 D, all influencing factors should be carefully considered and the lubricant becomes very important. For example, it is necessary to ensure proper lubrication both inside and out when bending the thin-walled tube. Metal should be easy on the surface of mandrelsupporting. Lack of lubricant or improper lubricant can easily easily Bending. The type of lubricant to use depends on the severity of the bend. Typically, for medium to medium bending operations, water-soluble paste is satisfactory. Not all lubricants react the same way to bend surgery. Experiments are needed to determine the lubricant best suited for the job. In practice, bending some materials may not be possible with one type of lubricant, but another lubricant does not present any difficulties. Grease tightening should always be used on a rotating curved machine whenever there is sliding contact between the material formed and die or material guide. Lubricants should also be used when bending with mandrel, especially the flexible type of ball. Grease reduces mandrel galling, pickup, and friction resistance between moving blanks and stationary mandrel. Reduces the slippage of the clamp, the flattening of the bend and the crowbar due to the breakdown. The lubricant should also be applied to reduce friction and wear on the wiper to die, and to help prevent scratches at work. The type of lubricant used varies depending on bent materials and working conditions, such as cleaning method, etc. Water-soluble plant compounds are often used in the formation of steel. Accurate lubricant for any work and/or working environment is best defined by experimentation and experience. Lubricants can be applied inside the tube or hollow blanks by dipping, smearing, or spraying, depending on the length and size of the material. Mandrel web lubricant can be used where length lengths must be lubricated, or where work requires the highest production. Pumping and vodka installations installed on the machine, cloud the lubricant through the hollow mundrel rod and through the outlets in the hull of the Mundrel. Such units are available as machine accessories from some manufacturers. 115 131 pipe-forming processes: A comprehensive lubricant manual on the outside of the blank can usually be applied to work or dies with a tampon or brush. Neither in the event that the outer lubricant should be allowed in the clamp area, because slippage can cause. The curving-shaped sections of the Tube Area Tube area used in office furniture and outdoor furniture tend to be harder to bend than comparable circular tubes. The circular tube is a good cross-section to transmit pressure clamps from the clamp to die bending to die without distorting the tube or allowing the material to slip through the dies. In most cases, the circular tube allows the metal to flow evenly in all directions during the bend. None of these good characteristics refers to commercial square pipes. The corners of most commercial square pipes are slightly rounded; thus requiring carefully designed bending. Successful bending of the square tube requires that the clamp and pressure die properly their strength through the walls of the tube without unwanted distortion. During the bending, the inner wall is compressed so that its metal tries to expand vertically and flow horizontally along the surface of the tube. If uncontrollable, it will result in a bend to take over the shape of a cornerstone with a series of wrinkles along the inner face. Particular attention should be paid to three areas to control problems and successfully bend square tubes: material, instrumentation and the use of lubricant in the bend. Material. The angular radius of the square tube is the main factor of successful bending. Corner radii are often quite inconsistent in commercially produced pipes. Running around the tube through the turk's head produces a square tube, but this production method gives little control over the angle radius. To avoid distortions, wrinkles, etc. clamp and pressure dies, bending shape, and mandrel must match the shape of the tube closely to give maximum sharpening and metal control. It is especially important that the clamp dies and the pulp fits the angular radii closely and consistently. Thus, one of the rules of square bending 116 132 The basic methods of bending the tube is the large sequence in holding a single radius at all corners of the tube, and on all the tubes that will be bent, the better the quality of the bend operation. The second important consideration is the number and position of any welding flash on the inside of the tube. Because the mandrel must match the inside of the tube in very close tolerances to achieve good quality bends, it cannot be done in insufficient size to allow for welding flashes, as is often done with round pipes. In order for the flash to be kept close, the mandrel is often grooved along one or more faces. Many manufacturers specify that the weld is located along the center of one face tube. The third factor in the specification of the material is the purity of the tube. On more than one occasion, the bending difficulty and accelerated wear of the mundrel were traced into the mud, scale, or abrasive dust left in the pipe. It is not always necessary to clean square tubes before bending, but the use of fairly clean pipes leads to less wear and maintenance of the machine. In addition to previous selection factors, conventional considerations of lengthening, etc., as in chapter 1, apply. Tools. As mentioned earlier, when the square tube is bent, the inner or compression side of the bend tends to expand vertically, thereby falling into a series of wrinkles along the inner side of the bend. Without support, the outside bend is always destroyed inwards. Special tools should be provided to prevent these conditions. Vertical pressure should be applied to minimize the expansion of the inner half and for convenience in loading and unloading the bend of the machine. This is achieved by separating the bend die horizontally, so that the top half can be raised and lowered as needed. In operation, either fast-acting nut or cam clamps can be used to drive the split dies. Most often, the hydraulic controlled split-die drive is used to automatically open and close the split-bending shape within the machine cycle (see figure 3-19). Whatever method used to work split dies, bending shape: 117,133 tube-forming processes: Comprehensive Guide To Figure Split-Die drive for square tube. (Courtesy Bend Tools, Inc.) 1. Open to easy square tube loading; 2. Closed to the use of the necessary limiting pressure; and 3. open to reposition or unload the bent part after the bend is completed. In addition to using a split-bending die with a square tube, the use of a radius angle or fillet in the die clip and mandrel in the matched corner of the tube radius should be considered. Since tube angle radius, as purchased, is rarely consistent, a compromise must be made in choosing the radius to the machine in dies. Good results were obtained when the angular radius of the clamp die made an inch (1/64 inch) larger than the actual radius of the angle of the tube. Conversely, the angles of the mundrel are carved inches (1/64 inches) less than 118,134 basic bending techniques than angular radii in the tube. Fillet angles are rarely used today in the form of bending and pressure to die. When bending the square pipes, a windshield wiper die is almost always required to prevent metal that moves horizontally along the inside of the tube from the building in unacceptable wrinkles. Unlike windshield wipers dying to bend round pipes, the square-body windshield wiper die is a simple rectangular shape that is a flat work surface against a tube. The cutting edge of the die is curbed in the same radius as the flat bottom of the groove in the shape of a bend. The janitor die cones of feathered so that this curved part approaches the tangent point of the bend of the shape. When properly adjusted, the wiper die carries against the bottom of the bend-shaped groove with about 75% contact and feathered or lip is slightly behind the tangent bend point. For example, the lip is approximately 1/16 1/8 inches (mm) per tangent when bending 1-in (25.4 mm) square tubes by 2-th (50.8 mm) inside the radius. Wrinkles begin to appear on the inside of the bend as the windshield wiper die wears. To the point, increasing pressure on the pressure to die can eliminate these wrinkles. When excessive pressure becomes necessary to prevent wrinkles, the wiper die can usually be remachined and converted into a bend shape to prolong Life. The second tool almost always required when bending square pipes is a multi-ball mandrel. Normally There will be a link and contact type with two or more balls. Smaller square pipes (3/4 13/16 inches). Regardless of the mandrel configuration used, it must fit the inside tube sizes very closely to ensure maximum metal restriction. Experience has shown that musrel's body size should be no more than an inch (0.20 mm) under the internal size of the tube; the size of the ball should be approximately inches (0.38 mm) under the size. However, 119,135 tube-forming processes: Comprehensive guidance this usually causes accelerated mint wear or pickup on mandrel. that can cause pickup, slippage material through the clamp die, wrinkles, and damage to the pulp. A good lubricant can compensate for the dense flesh fit, but it can't fix the problem. A pickup truck on the pulp is a condition in which the metal from the tube becomes bound by heat and pressure on the surface of the mundrel. The pickup quickly causes the binding between the mandrel and the tube as a result of a tube or mandrel breakdown, or slowing down and stalling the machine. In addition to the overly tight fit between the mundrell and the tube, the pickup can be caused by inadequate lubrication, abrasive dust, or dirt in the tube. Other sources of problems are excess pressure to die force against the tube, a crumb that is too soft, and excess or poorly positioned welded flash. Experienced operators can often discern when a pickup truck starts to occur by the speed and sounds of the machine bending. To correct accidental cases, filing or scraping is used to remove cabed metal. When a pickup truck starts to happen frequently, one of the previously discussed conditions is present and steps should be taken to fix it. Another common problem is the hardened case of mandrel worn through and the replacement is probably in order. Most manufacturers use mandreli, scratched hard chrome to slow down the pickup and compensate for some dirt and/or inadequate lubricant. Even with chrome, however, the pickup may appear after a long period of production. If after such pickup is removed, it appears again after the next bend, the mandrel should be immediately stripped and rechromed to avoid permanent damage. In some cases, the size of the tube has eliminated the requirement for different mandrel sizes. A commercial square pipe runs through a simple rolling mill to bring angular radii to the exact size and control the outer dimensions. Four fluted rollers are used, resulting in only one mandrel size required to bend one many tubes. 120 136 Basic methods of bending grease and purity. Proper and adequate lubricant of the pulp and the wiper die are essential for the production of quality bends in square pipes. The lubricant reduces mandrel galling or pickup, as well as frictional resistance between the blank and the mandala and the windshield wiper die. Consequently, the lubricant reduces wear and holds the clamp slippage, flattening the bend and breaking to a minimum. The immersion tube ends in grease and/or smear pulp and the windshield wiper dies before loading are common ways of applying such compounds. At no time should lubricant be allowed in the clamp area because slippage and wrinkles can result. The type of lubricant used usually depends on individual preferences, depending on factors such as the types of subsequent cleaning operations. It is generally considered practical to use the same tool to bend pipes derived from more than one source. The purity of the tube as it comes to bending the machine depends on the conditions under which the tube is produced, cut, and stored in both the supplier and the manufacturer. Even environmental conditions affect the cleanliness of pipes in extreme cases. The mud and abrasive cutting dust in the tube contribute to excessive wear, pickup, tying and breaking of the mundrel or bends. Cleaning operations on the pipe, or some many pipes, from some suppliers may be needed to eliminate these problems. Table 3-5 can be used as a guide to determine the minimum radius of the central line on which the square tube can be bent without wrinkles. (A good toolkit is a prerequisite for satisfactory results.) Wrinkle-free bends with a radius smaller than any of those shown in the table can be made. However, special tools and premium tubes (deep quality draw) may be required and bending equipment should be in excellent condition. Waveguide Tubing For years, the art of bending the tube has not been advanced enough to make economically possible the extremely close tolerances needed in electronic wave waves. It has become apparent that the previously used bend technique should be improved as much as 121,137,122 Table 3-5. The minimum draw is the bend of the central radius line for a square tube size in an inch square, (2.11 mm) Wall (1.65 mm) Wall (1.25 mm) Wall (0.89 mm) Wall of inch (mm) (14 Gage) (16 Gage) (18 Gage) (20 Gage) (12.70) (41.28) (44.45) (47.63) (50.80) (19.05) (19.05)50.80) (50.80) (63.50) (76.20) (25.40) (76.20) (76.20) (8 8.90) (101.60) (28.58) (76.20) (76.20) (88.90) (101.60) (88.90) (101.60) (38.10) (114.30) (114.30) (127.00) (44.45) (44.45) (114.30) 152.40) (165.10) (145.10) (152.40) (165.10) (165.10) (14.45) (152.40)40) (165.10) (165.10) (165.10) (152.40) 77.80) (50.80) (177.80) (215.. 90) (228.60) (63.50) (228.60) (266.70) (76.20) (304.80) (381.00) Tube Processes: Comprehensive Guide - For welded soft steel tubes 138 Basic methods of bending increased power, higher aircraft speeds, and rocket applications have made undulating requirements more demanding. First, it was necessary to find a faster method of bending, because it took about 30 minutes to make one bend. Second, to reduce transmission losses, the new method had to produce bends that met closer internal transverse tolerances. Third, much smaller radii, more closely marked connection bends and curves adjacent to pile and florid sections had to be bent to meet the new design requirements. In addition, uniformity of production is needed to ensure quality control. One solution was a modified drawing-bending process developed by Western Electric Co., Inc., which maintained internal transverse accuracy despite material flow due to changes that bending creates in the outer dimensions of the pipes. Previously, the distortion of pipes had such extreme forces on the links that the breakdown was a problem on all but very large radius bends. The thin walls of the wave guide are wrinkled in almost every case, and no mandrels were available to make compound bends. Another more pronounced problem when bending the draw was the breakdown of the tube on small bends of the radius, where pulling the action exposed the tube to more tension. One way to prevent this rupture was to use a booster to compress the tube axially as it was bending. However, the increase, while reducing the tense forces, the increase in the construction of the wall, as shown in the picture Since the distortion of the wall can not be eliminated, the bend of the tools have been changed to create a wall so that the exact, the inner section of the tube can be preserved, as shown in the picture of the inner wall of the tube, which lies against the windshield wipers to die and bend the shape , tends to thicken due to the force involved in the bend. The design of these tools is crucial as they should prevent buckles under great pressure. The upper and lower walls of the tube thicken to the inner radius and become thinner in the outer radius. Thus, the upper and lower plates should prevent the inner part of these walls from bucking, even if they do not touch the plates on the outside of the walls. The outer parts of the bend are in suspense and pull against the mandrel, which must be strong enough to withstand the forces involved and accurate enough to keep the size. 123 139 Tube-forming Processes: Comprehensive Guide Figure Effects of Tube Enhancement During Bending. Figure Altered bending tools for wave guides. When investigating bend samples, a certain pattern of distortion By cutting and measuring the thickness of the wall at various points in and around the curved part. Distortion does not end with tangent lines, but extend outwards along straight ends in an elliptical form. Walls of the Wall varies within this model. These wall changes seriously distort the cross-section of the tube when using unalmeted death. Thickening the inner wall 124 140 Basic bending techniques pushes the muenrel outwards, thus opening up the space behind the stem of the pulp and allowing the tube to widen. The inner upper and lower walls thicken against the plates, moving them away from the shape of the die and allowing these walls to bulge away from the mandrel. Mundrell is badly crushed by the thickening walls of the wave guide if, as is often the case, the toolkit and mechanism are made extremely rigid in an attempt to prevent wrinkles and bulge. Flexible links, limited in strength, can then break. If the tools are carefully contoured to ensure the construction of the wall, then the tube can maintain its internal section and simply grow in the recesses provided in the dies. Collapsed steel shapes of the shape bend, such as an angular iron or canal, may present difficulties not found in a round, square or rectangular material unless special methods are used. Problems arise because cross-sections are not symmetrical, but unequal loads, installed in the material in the manufacture of bending. Consequently, the various legs attempt to deform from its original position, or the whole piece can wriggle out of the plane. The roll-pulling or bending processes discussed later in this chapter are usually used to bend these sections. The rotary-drawn method of bending these types of parts is reserved for stricter radii requirements. The key to bending the most rolled form of rotary-drawing method is to make the material flow where required by using heavy, durable dies to properly restrict it. There is only one exception to this rule of concluding the bending angle of the iron with the foot on the outside of the bend. The angle of the iron leg Bending the angle of the iron leg (one foot in compression on the inside of the bend) can be achieved with speed and efficiency through a draw bend with proper instruments. The bend form used should be split to allow for easy loading and unloading of blanks, but at the same time provide heavy limiting force on the inner leg during the bend. This force prevents wrinkles of the compressed penis. The pressure to die is a flat surface against the outside of the corner and is usually designed with a position to support the angle and prevent it from cocking out the square with a die groove as the bend progresses. 125 141 Pipe-forming Processes: Comprehensive Guide Third Special Position for Bending the Corner of the Iron Foot in is the use of material guidance. This component of the tool is set behind the bend form in a position usually occupied by wipers. Material guidance, however, does not no force to harvest, serving only to guide the work right into the grooves as the bend is made. When bending all folded shapes, material guidance is used. It's This. The strain of the action bends from throwing one leg or segment shape out aligning with the die groove as the work is sucked into the die. The structural channel of the foot inches Bending the structural leg of the channel in represents almost the same situation as the angle of the iron. A shape bend is used, which is divided into three segments. When the fast-acting nut on the stud is tightened or, more often than not, when the hydraulic drive has force on death, both flanks of the channel are put under the proper limiting force. In addition, the right material leadership is used. Canal with a curved leg. The curved leg channel is usually handled in much the same way, except that the clamp and pressure dies are designed to expand into the U, rendering the force against the channel's network. The split to die then exerts limited pressure on the legs. Thus, the legs are in a position on the sides of the clamp and the pressure dies. The channel in Plane H. Bending the channel in Plane H (legs up or down) is a different situation because a proper conclusion cannot be reached by developing a bend of shape, clamp, and pressure to die. The space between the legs of the canal should be filled with pulp, usually the design of the connection and pin with multiple segments. Munrel prevents the outer leg, which is in suspense, from collapsing inside. In addition, it transmits the pressure force on the inner leg to prevent the compression of the forces acting on this segment from the buckle of the foot in a series of wrinkles. The typical curve of the channel is illustrated in the figure using munrel in combination with separated dies and material guidance usually leads to good quality bends. The angle of the iron leg. The bending angle of the iron leg is usually best carried out by the rotary bend machines by squeezing the bend (sometimes called bending of the napkin). The one napkin will form the necessary bend if the material is ductile enough. Usually, however, the material behind wiping shoes distorts. Using special circuits in the car, wiping shoes returns to its original position at the same time in contact with the work. This action swipe back presses the foot angle back to the shape of the bend to produce a smooth, good Bend. Once the piece leaves the conclusion of the pressure-die bending shape at the tangence point, the unequal stresses set by the bend are usually a strain of 126,142 Basic methods of bending the figure of a typical channel bend. (Courtesy Bend Tools, Inc.) angle from the shape bend. Compression bending is used to counteract this trend. Here, stationary death pressure is used to clamp the angle of the iron against the stationary shape of the bend. Instead of clamping die, wiping shoes are brought into contact with work. This shoe wipes or compresses the material within a curvature radius of the shape as it rotates around the circumference of the mold. One napkin will form the necessary bend if the material is ductile enough. Usually, however, the material behind wiping shoes distorts. Using special circuits in the car, wiping shoes returns to its original position at the same time in contact with the work. This action swipe back presses the foot angle back to the shape of the bend to produce a smooth, good Bend. The manufacturer of the machine should be consulted when this type of bend is first considered because the work requires special dies and may include modifications to the machine, depending on the type of bending machine in use. 127 143 Pipe-forming Processes: Comprehensive Manual Unusual part forms the same principles as for bending the angle of iron and channel, usually can be applied to other similar forms and sections. The possibility of a slight distortion of the shape in the bend should be taken into account whenever the shape bend is considered. The number of distortions varies depending on the bend required by the radius, as well as the number and type of limiting pressure applied to the work. Imposing specifications that are tougher than necessary on bending quality can noticeably add to cost tools and/or slow production without adding to the final quality of the product. Serpentine coils. Serpentine coils often have parallel legs so close together that space is not enough to accommodate the usual clamp to die or give a place to die to open and close. In this case, the clamp die should be changed to work between the legs of the coil. Two methods of handling such works are a camoperated death clamp or modified vertical head bend machine with a split dying. Camera tools are often used when a conventional tube is formed into a serpentine coil. The tool includes a raised bend shape and a low-profile clamp holder with a hinged clamp (see figure 3-23). The clamp dies and the holder is placed below the bend plane. To clamp the Figure Cam tools for the serpentine bend. 128 144 Basic methods of bending the tube, the swivel clamp die rises between the legs of the coil, traveling up the sloping camera in the leg bend to die. Figure 3-23 also illustrates how the pressure to die can be cut off to complete the bends that will be arranged behind the bend-die tangent. Modified pressure die holders or bolsters are also very common. Figure 3-17 shows a typical serpentine instrument installed. Sometimes it is advantageous to use a split dying on a vertical head bend machine to produce a serpentine coil. This type of modified machine uses a combination of bending shape and clamp to die split horizontally. Die is open and closed by a drive mechanism in a vertical head. Such a machine offers the maximum possible clearance for processing the blank. Also, there is no waving arm. The absence of a hand makes it easy to process with maximum production speed. This method of producing coils is used, especially in the bend of pipes with fins attached at intervals. It is a purpose-built special machine that is considered secondary in relation to fist tool. Folded coils. Folded coils include both cylindrical and oblong types. Often circular wound coils on a fluted cylinder on foam or a special device. Sometimes they are formed on roll benders when a generous radius is acceptable. Acceptable. Drawbending machines can be used for circular coils by forming successive bend shapes and repositioning the tube between the bends. Making round coils on the bend machine may require use as a curved, clamp-to-die compound and bend-shaped insert to allow the clamp die on the previously curved section after the first bend. In other cases, when a slight clouding of the surface is acceptable, a completely round bend shape can be used in conjunction with a straight die clamp). This results in the contact of the clamp to die from the tube after the first bend, but keeps the value of the tool to a minimum. Elbow and fitting. Elbow and fittings are common parts formed at high speeds on bending machines. Usually only the bend itself is required, and several methods are used to reduce the length of the direct clamp between the bends to usually save material. The tool to form 180-return bends in copper tubes involves a raise or cam-like die clamp, which includes cleat to preserve the material. The distorted section is later cut off when the form of serpentine is cut into separate bends. 129 145 Pipe-forming Processes: A comprehensive guide to high-production fittings, machines are available that power the tubes, bend, and cut off the finished bends in a continuous automatic loop. Depending on the angle required, two different principles are used. Compression bending is used for 180-return bends, while 45 and 90 Ls are made on the principle of gravity bending. 180 bends are rubbered around the bend shape and then cut off, as these fittings do not have acceptable direct lengths behind the tangent points. The connection of the clamp dies and the cutting between the finished bends make a smaller angle fitting. Using any method, the recycled material is less than 1%, and the production of over 1,500 finished bends per hour is common. Depending on the diameter of the tube, one cycle of the machine makes up to three bends. This type of machine only handles colored tubes, however. Other types of fittings, such as plumbing waste traps or sink traps, require a certain minimum direct length outside the bend zone. When the straight length required on the finished part is less than required for the clamp, you can save the material by bending two elbows in the same piece of material. Once one bend is done, the piece reverses the end for the end and is re-inserted into the dying bend to form a second bend at the opposite end. Pieces are later cut into separate elbows. When a brass tube is formed for a sink trap, it is usually necessary to anneal part of the tube used in the bend. The part used for the clamp remains difficult to prevent the clip markings from dying. High clamp pressure is needed to prevent slippage through dies on the large bends of small radius. The chosen method of annotation should produce a bright, clean finish, free of scale. A A this method produces welded fittings in stainless steel pipes. Wiper dies and close fitting, all-around mandrels are required because of the close tolerances usually required from such bends. To preserve the material, Ls are made by inserting just enough pipes into the bend to form one bend and then cutting that bend out of the tube. The process is repeated after removing the burrs from the incision end and washing the abrasive dust from the tube. The bends are made until there is only enough material left to clamp the last bend. This method reduces the loss of scrap to less than one time the outer diameter of the tube. 130 146 Basic Machine Bend Techniques Accessories Modern rotary bend machines have different accessories. Each of them is designed to expand the versatility of the device, increase its scope of application, increase the operational speed or more closely adapt the machine to the requirements of this bend work. The new equipment has these accessories, but many can also be added to the machines already in the field. Booster Booster applies power to the back of the blank to push or force the fast forward of the blank as it draws in the bend dies. Boosters are practical in three different cases: 1. reducing the thinning of walls; 2. Allowing the use of a short clamp length to die; and 3. overcoming a small lack of material elongation. As mentioned earlier, thinning of walls is usually observed in any type of cold bending, usually compensated by the work of hardening, which occurs in the bending area. In conditions where anna temperatures are present or where there are serious problems with erosion or corrosion, it is advantageous to minimize thinning of walls. Thus, accelerators are used in the bend of seamless boiler pipes, and sometimes in the formation of electronic wave guide and ducts. The amount of force that can be applied and the results achieved depend on the strength of the work column, the method of application and the bent material. When the seamless low-carbon boilers are curved, typical diameters range from 1.75 inches (44.5 mm) of external diameter to 3st (76.2 mm) of external diameter. The thickness of the wall runs from an inch (mm). The force of the boost is applied to bends with central radii of 1 2.5D. 1D bending usually results in 30 35% thinning, but applying a pre-programmed force boost can reduce this to a 13 17% range. Similarly, 1.5D bends that are usually thin from 25 to 28% can be held up to 12 15% wall reduction. These heavy pipes can be bent at pressure to 20 tons (276 MP) forces. Because such heavy force can push the work away from 131,147 Tube-forming processes: Comprehensive guide dies, special sequence controls are usually used for changing force as the bend progresses. One pressure is usually sufficient when bending the lighter wall material. The second case where increased strength can be helpful is bending work where there Insufficient clip lengths are available. Without help, the work slips and wrinkles develop. With a few hundred pounds of forward thrust added, a clip length of up to one-third of the usual length can keep the job running. Applications for this method include a clamp at tape lengths, on a threaded section, or simply avoid connecting bends. Another case is when increased strength helps bend materials that have borderline elongation characteristics. In materials such as solid varieties of aluminum, copper or brass, 500 1500 pounds / in 2. (3,447 10,342 kpa) forward strength can reduce tube breakdown. Booster's design depends on the app. Some types can compress the tube anywhere along its length and apply a variety of power determined by the tracer, servo control, or switching settings. Other designs vary down to the simplest type, which is a hydraulic cylinder and a needle valve type control. It is important not to confuse the booster with the more common option of pressure machine die to help. Pressure to Die Assist Help is based on the booster concept. Instead of clamping and pushing the tube, the pressure dies pushed by mechanical, hydraulic, electric servos, or pneumatic means. Pressure-die help counteracts drag pressures dying, mandrel, and windshield wiper die. It pushes the tube into the bend area. This prevents excessive thinning of the walls, reduces the length of the clamp and improves the ovality. Figure 3-24 illustrates the most common configuration of death pressure help, as it relates to the installation of tools. Without pressure in advance, it is generally expected thinning is about 75% of the lengthening of the outer wall. Thus, the 2-in (50.8 mm) tube is bent to 3-0 (76.2 mm) the central radius thins about 25%. Since the stress of profitability is usually higher than the voltage value, a neutral axis (that part of the tube that is not stretched or thinned) will be inside the geometric axis of the tube. Since the distortion is proportional to the distance from 132 148 the basic methods of bending the Rotary Figure-figure bend the instruments. 133 149 Tube Formation Processes: Comprehensive guide to the neutral axis, thinning the outer side of the bend may be more than thickening inside. Moving the neutral axis to the outside of the bend reduces thinning. Putting the tube into compression before bending alters the distribution of stress in the section, as shown in the picture electronic bend-corner selector electronic bend selector allows you to bend the angles that will be installed using electronic methods, usually programmable logic controller (PLC). The input of the compensatory value provides the inflection necessary for the springback correction. The selector works on the principle of conformity of electrical impulses from bended to the head. The selector reduces the time it takes to install the machine and switch. Direct Acting Pressure Die Direct Acting Pressure Dying Replaces Switching the pressure motion work to die with a hydraulic cylinder directly in line with the central line tube, as shown in the picture Direct use of force allows the pressure to die to float, moving in or out slightly to compensate for small changes in the material or instrumentation. The precise hydraulic pressure used can be read and recorded out of gage for use on subsequent machine installations. This accessory is applicable where jobs require precise pressure adjustment, such as bending thin-walled pipes for ducts. It is also used to reduce installation time in short-term jobs. Overhead Tie Bars Overhead Tie Bars are used to add another degree of stiffness to the installation tool, and insure the opposite resistance to the pressure to die (see figure 3-26). Automatic mundrel-genus lubricant Automatic mundrel-birth lubricant is available on most bend machines. They increase production by eliminating the need for 134,150 basic methods of bending Figure Effects of Pressure to Die Care. 135 151 Pipe-forming Processes: Comprehensive Guide to Figure Direct Action Pressure to Die and Overhead Tie Bar Supports. (Courtesy of Cambridge Machinery) for hand-grease inside blanks. These blocks consist of a pump that forces a dosed amount of grease through hollow rods and outports at the end of the hollow pulp. Units are available to handle almost any type of liquid lubricant. This accessory is especially beneficial when bending long pieces that require lubrication along the entire inner length. Such projects include the formation of copper pipes in serpentine coils and making bends near the center of boiler pipes. The Aircraft Bend Selector plane bending the selector unit is an accessory that reduces installation time on a short, small amount of work, eliminating the need for a mechanical bend plane and the distance between bend stops. Several types of units are available. Figure 3-27 illustrates a simple version. It consists of a collet for chucking a tube or other round section to be bent, and a series of stop drives adjusted to determine the plane of each bend, with roller crews. The whole block rolls down the track above the car. Small cameras on the track are adjusted to determine the distance between the bends and free the device to rotate to the next bend plane. In operation, the device is pulled forward manually to each stop chamber, and the part rotates until the selector snaps into position, determining the correct position and plane for successive bends. 136 152 Basic methods of bending the figure of the plane bending the selector. (Courtesy EBM America, Inc.) Modified and special rotary-drawing machines In addition to standard bend machines, most Deliver modified machines and perfectly special units to meet such requirements as extremely high production, maximum material savings, unusual parts shapes, etc. it will be less flexible for other works or future applications. Such units almost always bring much less money than standard units if sold as ready-made equipment. The Precision Aircraft Bending Machines Precision Aircraft Bend Machine includes mechanical, electrical and hydraulic refinements to make possible high quality 137,153 pipe-forming processes: Comprehensive guide bends in ultra-thin walls made of stainless and aluminum pipes. Plane machines are essentially improved standard benders with special accessories. Improvements included on such machines include hand-scratching paths and slides, calibrated scales, special controls for each movement to die, and a long-stroke mandrel extractor. A more detailed discussion of computer numerically controlled (CNC) bend machines can be found in Chapter 4. Fixes for bad bent tubes There is no substitute for experience when it comes to fixing problems with a curved tube. Factors influencing the bending process are numerous and should be approached methodically. Figure 3-28 is the starting point for correcting poorly curved pipes. Guidelines, data can be valuable timers. COMPRESSION BENDING Compression Bend uses a group of tools very similar to those used in bending the draw (see figure 3-29), except the bend shape is stationary and the movable wiping shoe replaces the die clamp. When the compression bends, the blank is clamped to a stationary shape, and the wiping shoes rotate around the shape, wrapping the material against the bend of the shape. This method is not practical for the production of bends requiring mandrel when there is more than one bend in the blank. In some cases, when two or more bends in the same blank are in direct contact, this method can avoid the compound dying that would be required if a method of bending from the draw were used. However, the compression bend does not control the flow of the metal as well as the bending of the draw. Compression bends can be powered or manually controlled. Manual benders can be either rotary or compression type. Since the rotary noch bend has been described in terms of the powered machine on the previous pages, the rotary-compression bend will be discussed in terms of manual or manual bender. Hand-bending Sometimes small parts can be formed faster and at a lower price with handmade benders, providing production volumes of 138,154,139 Figure Rotary-drawing bend correction for poorly curved pipes. (Courtesy Bend Tools, Inc.) The basic methods of bending 155 pipe-forming processes: Comprehensive leadership figure (continued). 140 156 Basic methods of bending the compression bend pattern. do not require powered equipment. The range of bend operations required to a significant extent determines best-suited bender. The hand bender does not fit if the work to be performed consists of one specialized operation such as bending the thin-walled tubes on the on Basis. All-destination side bender is the best choice if the jobs are short-term and so varied as to include bending multiple cross sections of pipes, canal, angle, extrusion, and bus bars, in addition to solid sections. Manual bending machines simply provide a means of using manual power to perform bend operations and supply attachments to bend the tools. These tools consist of: bending shapes that have the same shape as the desired bend; clamping block or locking pin, reliably compressing material during bend operation; and forming a roller or pressure die, which moves around the bend of the form. The bend is no different from any other metal processing operation in that the results will be in direct proportion to the care taken in the proper bender tool for the work to be done. When bending materials with an open section of pipes, channel, angle, and extrusion, the shape bend must exactly match the contour of the material to provide support during formation. This also applies to clamp die and the formation of the roller, because only a completely limiting material can the perfect bend be obtained. 141,157 Tube-forming processes: Comprehensive guide is usually the smallest recommended radius for hand-bending tube, measured in the center of the tube, 1.5 times the outer diameter of the tube, provided that the inside of the mandrel is used when bending. This minimum central line radius should be increased by at least 2.5 times the outer diameter of the tube if the bend is to be made without the inner pulp. If the tubes are bent without internal pulp, heavy practical walls should be used. As a rule, in non-ferrous metals from a quarter to half of solid pipes provides the best results. Connections of bends or adjacent bends in different planes should be avoided, if possible, due to a conflict that may occur between bends that require special tools. This is especially true in pipes, but also applies to hard materials. When creating a bend at the end of the tube, a straight length equal to at least the diameter of the tube should go beyond the bend. If a bend is required to the very end of the tube, the straight length should be allowed and trimmed after formation. When bending channels, angles, moldings and extrusions, the radius of the central bend line should usually be at least three times the width of the flank to be formed at the edges. The elasticity of the material, which causes it to spring back after it has been bent, should be considered because it may be impossible to form a closed eye or a full circle in some alloys. Since all metals are somewhat elastic, they return to varying degrees after their formation. For this reason, the bend form should usually have a smaller than the required bend. The number of springs depends on the type of material, its size and hardness, as well as the radius of the bend. It's This. You usually need to experiment to determine the exact size of the shape of the bend. The forming-roller (compression) Tube bend forming method is recommended for large bends where the center radius is at least four times the outer diameter of the tube. It is also successfully used to bend pipes or heavy pipe walls to smaller radii, and is the most practical method of bending small diameter pipes. Forming a roller and bending the shape as shown in Figure 3-30 should be grooved to precisely fit the tube. The tube should not be allowed to slip during- 142 158 Basic methods of bending the Figure Form-roller method. ING bending the operation because even a small amount of slippage will cause distortion. Bends larger than 180 sometimes open enough, so they can be sprung from bending shape. A bend much larger than 180 can be removed if two-thirds of the bend shape segment is used. Then the part should be formed into two operations. If the formed part cannot be released by these procedures, the bend form must be split horizontally so that the top part can be removed to free the tube. RAM BENDING Ram bending is one of the oldest and simplest methods of bending pipes and pipes. It uses the principle of compression of the bend of the tube, as if it were a beam. Two supporting transfixing hold the tube and sufficient force is applied with the help of a hydraulic ram to the center of the blank. This process bends the tube to the desired angle and bends the radius. 143 159 Tube-forming Processes: The Comprehensive Guide to the Baran Bender uses a die or forming shoe mounted on the hydraulic piston rod of the machine, as shown in the image of the groove in the die being processed up to the desired tube contour and bending radius of the proposed bend section. Auxiliary blanks are also outlined to fit the outer surface of the tube. These die turn or rotate on their mounting pins, so they follow the tube and maintain external support throughout the operation. This method does not require a clamp during the bend. Forming die determines the radius of the part bend when full running is used. However, the tubes can be bent into a larger bend radius, limiting the ram's advance and thus putting a smaller amount of bending in the part. Then the part moves and the formation cycle repeats. The ease of bending the ram limits the types of work being processed. Pipes can be bent through corners up to 120; however, this method cannot provide bends with close tolerances. Ram bend is best suited for bending heavy pipe walls approaching the size of the standard pipe sizes. The process works well where support mandrels are not needed and where some flattening drawing Ram Bender. (Courtesy bentec/Kiffer Industries) 144 160 Basic bending methods are not undesirable. It can also be to straighten the damaged pipes. Baran Bender Bender a low-production machine. Ram bend is not recommended for bending stainless steel tubes with unsupported walls if the desired bend radius is less than six times the diameter of the tube. PRESS BENDING Vertically-hydraulic bend press is a modification of a simple ram type bender. It works in the same way as a bender ram (see figure 3-31), but much faster and more flexible. A tube or pipe is placed on top of a neighboring type wing of a dying set at the same levels (see Figure 3-32). Dies simultaneously to separate and rotate with the tube as it deviates and bends from the pressure exerted by the downward ram to die. Pillow cylinders to maintain constant torque on the wing dies. This cushioning force limits the blank in dies under proper pressure, precisely controlling the flow of metal. The almost constant force of depreciation is the key to preventing wrinkles and producing precise bends with minimal distortion of the cross-section. In fact, two compression bends simultaneously form at two points of contact between the ram and the wing dies. Making the ram die a little smaller than the size of the tube eliminates tube wrinkles on the inner bend of the radius. A small pinch effect is produced as bending is done to prevent wrinkles from forming. Drawing the basic principle of vertically bending the press. 145 161 Pipe-forming Processes: Comprehensive Guide to the Ram Moves Down in Direct Motion Against the Lower Wing Dies. As the ram exerts pressure down, the wings rotate on the spindle arm, which exerts pressure up against the cushion cylinder mounted on each side of the pressure. The machine has a stop depth that provides multiple positions to vary the ram's course and thus the angle of the bend. The toolkit is changed by machine, allowing you to form different forms of parts. The press bend machine is capable of high production, forming pipes and other cylindrical shapes, as well as some rolled up shapes, channels and extrusions. The bend quality made on this type of press is usually not as good as the bend made by the method of compression and drawing on the rotary equipment. The thinning diameter on the inside of the bend is common. The advantages and limitations of the main advantage of bending the press is its high production capability. Bends can usually be made three to four times faster than conventional equipment. Bend the presses use a simple tool and quickly and easily adjust. Their wide working gaps make it possible to efficiently produce complex, multi-flexible parts in a single installation. In the press bend, it is not practical to use an internal mandrel. Because of this limitation, a slight reduction in the diameter of the work on the inside of the bend leads. The bend angles, large about 165, are impractical to form on the press equipment. Pipes, pipes, and some formed sections are easily bent, but rolled up shapes or or parts are usually processed on rotary-bending machines. Bending on a hydraulically controlled bend press can produce bends on radii up to about twice the outer diameter of the tube in the tube, pipe, or other round stock. On a production basis successfully formed a pipe of 0.71 mm thick. Formation bends one at 146 162 Basic methods of bending one length of material is known as progressive bending. The operator moves the blank after each bend until the desired shape of the part is formed. In practice, a single toolkit is set up, and the work goes through the area of death in one direction. The presses automatically produce different angles of bending in sequence. Positioning work against bar stops determines the plane and location of the bends. Another processing procedure used to bend the presses is to repeatedly bend two or more bends at the same time in one blank or in two or more blanks with each press stroke. This procedure gives the highest rate of production, but less flexible than progressive bending. All bends are made in one plane. The work can be done with several different angles and bend the radii in the same part. The angles and distances between the bends produced by the toolkit can be varied. Once the angle of the bend and the distance have been set, each impact of the press produces identical parts. The technique of the tool as shown in Figure 3-32, the instrumentation for a typical hydraulic bend press consists of a ram die and a double wing dies, all having a tube groove. Limiting or compressing the tube wall produces good quality bends. This is why press bends usually have a certain amount of depression on the inside of the bend, ending with what appears as a hump (see figure 3-33) for only two tangent bends. This transitional hump can be minimized by processing the distortion of the shape that occurs when the press bends. 147 163 Pipe-forming Processes: Comprehensive groove tube guide dies enough under the size to get wrinkles bends and/or by producing the washing of the ram dies. Wash die to process up to the exact angle of the bend required, as well as an inflection for springback. As the wing dies turning, they are bottomed out against the flat sides of the ram to die, mixing or washing out the end of bending humps. Washout dies to produce this effect for just one particular angle. However, they can be used to bend any angle to maximum receipt by machine. The press tools are trained from a steel tool and hardened to resist wear. When producing new tools, the groove should be trained a little less than the diameter of the tube. Size Size varies from inch (mm) to small diameters, where appearance is a factor up to an inch (mm) underneath for a large diameter car exhaust pipe The depth of the groove is usually half the diameter of the tube, smaller just enough to prevent the wing-die lips from contacting the edges of the ram to die. This results in very little compression action. If thinner tube gags should be bent, they require a bigger pinch. The upper or lip wing dies to land in progressive steps, taking no more than an inch (0.25 mm) off before attempting to bend. Before grinding dies, the operator must make sure that wrinkles or excessive flattening are not caused by the lack of wing die pressure cushions or the use of an overly greasy tube. Different tool designs and specifications are detailed in the figure If the appearance of scratches or marks to draw on the bends is undesirable, the common method is to set the wing dies on the rollers. This movable montage allows everyone to die to move with the tube as the bend is made and eliminates the movement between work and the wing dies, thereby prolonging the life of dying and preventing scratches at work. Dies are automatically focused on the spring at the end of the bend cycle. This type of wing-die installation is common on small presses of furniture-type work. The gaging of the plane and the distance between the bends of the Progressively produced multi-thin parts in different planes on the hydraulic bend of the press requires almost the same type of partshape gaging as the rotary bend. Indexing towers or electronic selectors on the press allows you to bend the angle of adjustment, but the mechanics- 148 164 Basic methods of bending the Figure Ram and Wing dies. Cal stop gages are needed to find the plane bend and the distance between the bends. The typical setting of the plane and the distance of the gages shown in the picture of the flag type stops, correctly positioned along the bar, to determine the distance between the bends, as at the end of the blank is consistently butted against the flags. The aircraft stops shown are made of available material. They are arranged so that previously curved parts of the blank can be gagged to determine the plane. Good plane-stopping characteristics allow for some adjustments and 149,165 pipe-forming processes: Comprehensive Guide To Figure Press bending the plane and distance gages. insure enough stiffness to prevent deviations that lead to scrap pieces. Detection devices should be used where they allow the operator to hold a positive location, rather than simply applying experienced guesses about the aircraft. Many bend presses are designed to allow both the distance planes and feet to be removed intact and kept undisturbed between repeated runs of the same piece shape. This greatly helps the subsequent settings. ROLL BENDING Roll Benders provide a simple means of bending a wide range of cross-sections. The principle of bending the roll pipes is shown in Figure 3, forming rolls roughly the same They are located in a pyramid in vertical or horizontal planes (see figure 3-37). Performing bends on a roll bender, just as is the case Most other Benders require a qualified operator to run the machine. Skill level requires close parallels of the complexity of the part and the problems that need to be solved in getting the machine to produce the expected results. A relative beginner can produce a very simple part with a large radius from the strong, 150 166 basic methods of bending the Figure Roll-bending principle. Figure Vertical and horizontal-flat roll benders. (Courtesy J and S machine) is a single material. But as complexity increases, so does the need to have an operator who knows how to deal with the problems that may arise. The vast majority of rolling jobs include materials that are easy to bend and radii that are easily achieved. An example would be the bending of a circular tube into a large ring. As long as the right tool is used, it's a simple procedure. Jobs become increasingly difficult when the same ring is made with an iron leg angle in or thinwalled square tubes. The natural resistance of the material to compression and stretching causes twisting and wrinkles, which must be counteracted by forces in opposite directions. This is where these special skills begin to come into play. Where to use force and how much to apply should be determined. Design 151 167 Pipe-forming Processes: Comprehensive Manual and Tool manufacturing provides one of the most likely methods to do so, but unfortunately, there are no hard and quick rules or instructions booklets for beginner guides. Most guide machine owners touch lightly on these topics and only give the new operator some basic guidelines to address the problems that may arise. The real key is a good understanding of what is going on and where it is happening as the material bends. Understanding these forces, you can find a possible solution. The only limitations of the solution are in the operator's imagination. All roll benders use the same basic principle of force applied between three rotating rolls. Different radii are achieved by changing the position of one or two of these rolls. The material enters the rolls and the pressure of the roll causes it to give way to the underside of the center of the roll. The encapsulation of the material is most important at the point where the material gives. Failure to ensure adequate encapsulation results in the material moving in other directions than where it is intended (see drawings 3-38 and 3-39). Using a circular tube as an example, if the top roll has a groove less than half the diameter of the tube, the sides of the tube are unsupported. The denser the radius of the bend, the more oval the tube becomes. It is more exaggerated as the thickness of the wall becomes thinner. On projects with exceptionally thin walls and dense bends You may need to make the groove in the top roll extra deep to get a good encapsulation. The support of the tube from within is difficult and once unnecessary. However, there are applications where the internal sup- figure pipe is sufficiently supported by rolls. 152 168 Basic methods of bending the pattern insufficient support on top of the roll. No port required. This can be achieved by filling the tube with the material that can be removed after bending. The procedure has many drawbacks and should be avoided in high production situations. It is time-consuming, time-consuming, can be dirty and sometimes dangerous. For one part or prototype bend, filling the tube may be acceptable. The roll bend moves to another level of skill when the project involves multiple radii, multiple planes, and bending complex shapes. Aluminum extrusions commonly used in the window and furniture industries are an example. The square and rectangular shapes of the area and the rectangular shapes present problems when tilted into a dense radius: the inner surface develops waves as a result of excess material forced into a shorter length (see figure 3-40). The instrumentation should push the material to the inside of the tube and not allow the bulge of the material to move to the radius of the inside. This can be done by producing a roll with a crown on the surface of the tube (see figure 3-41). Grooves should be made on each side of the roll to cause the crush bend to develop in cases where the radius is exceptionally tight (see Figure 3-42). 153 169 Tube-forming Processes: Comprehensive Guide Drawing Irregular Waves on the Inside Surface. Figure Roll-bending tools with a small crown. Roll-bending tools with concave. 154 170 Basic methods of bending the channel with legs to the inner radius requires very good encapsulation to eliminate any wrinkles on the legs (Figure 3-43). In cases of dense radius of bends on the channel, it is necessary to leave a small space in several thousand days inches in the roller grooves, so that the material thickened as a result of compression of the legs. Another solution may be required if the wrinkle restraint starts to push the excess material back into the area where the feet come into the rolls. Slide block that rides on the material and contains feet before entering the rolls will solve this problem. This is typical of one solution to produce another problem. Parts with multiple radii bending parts of multiple radii on a single plane usually require numerical control. The operator can produce ovals, spirals, elliptical arches and other parts with multiple radii on a repetitive and permanent basis with a numerically controlled machine. The curves of several planes, such as spiral coils with a certain step, can be achieved by side rolls, which many benders have as standard equipment. Several manufacturers market CNC controlled bend machines that make production figure Roll tools for the channel. 155 171 Pipe-forming Processes: Complex guide to complex multiple parts of the radius is much easier, but these are these in no case eliminates the need for qualified operators. In most cases, using a more sophisticated machine requires operators with a higher level of expertise to enter the data needed for programming. This seems to go against the thoughts of many CNC buyers to roll benders. Because the machine is controlled by a computer, it does not mean that the operator can approach the machine, press a few buttons and throw it away from the other side. CNC-controlled machines have many features that allow you to accurately repeat the complex part, but it is the operator or programmer who should know how to use these functions to their advantage in the production of these parts. Once you've completed your programming and set it up, it's easy to remember the program from memory and run it. Complex aluminum extrusion shapes of bending complex aluminum extrusion shapes can require a variety of and numerous features. When extrusion has a heavy wall thickness and the bend radius is not tight, the problems are minimal and easily solved. The often presented app bends a thin shape with hollow areas that may not be sufficiently supported by rolls. In these cases, filler strips or static mandreli should be used to support support. A superficial trim profile is also an important issue to address. The very visible painted surface is of great concern to many manufacturers. The use of plastic discs supported by steel discs solves many problems, although these materials can be fragile and can wear out prematurely when working against the forces of metal bending. The longevity of the drives also depends on the radius required. The dense bend of the radius causes the inner fin to thicken, exerting wear pressure on the surface of the disk or creating a situation where the fin will ripple before entering the rolls. Once the fin is destroyed, the damage to the plastic results. Material hardness is a factor of resistance to bending. Materials in more rigid temperamental materials are not very well stretched and difficult to compress. Many times, experimenting with mild mores solves a rupture or ripple problem. There are so many varieties of potential problems as there are roll-bending applications. The key to solving any roll bending problem is to keep a close eye on what happens where it occurs, 156 172 Basic bending techniques to determine why this occurs, and decide what actions can prevent it from continuing. This is where the experience and imagination of cameramen and tool designers play an important role and ultimately determine success or failure. The deformation definitions of common terms used to describe the deformation of the blank are as follows: Helix is a deformation that puts a certain step in the blank, for example, which sometimes occurs in flat-on-flat where the ends do not match in parallel to the harvest (figure 3-44). A dish of deformation that rotates the axis of the blank from the established This is illustrated at the angle of the foot, where the angle heel rises from the floor, even if the blank is square and without a spiral. This sometimes happens to be flat on the edge of the job, and the results do the job of taking a cupped shape rather than staying in a flat plane (see Figure 3-44). Figure Examples of Deformation. 157 173 Pipeline Processes: Keystone's Comprehensive Guide is a deformation caused by the tendency of the blanks to increase the thickness of the compression deformation and reduce the thickness from the intense deformation. This happens in a flat on the edge of the job. The strain disorder caused by contact rolls on the blank as shown in the picture of the inner edge of the flat bend edge tends to swell, especially on several passages. It also describes an angle bent on the leg at the base rolled without a spacer ring, where a roll of contact upset the leg at 90 to the axis of the bend. The end of the match is a deformation, as evidenced by the inconsistency of the leading and rear ends of the blank parallel to the main diameter of the bend. Again, the best illustration is the flat-on-flat work, where the leading and rear edges show a different diameter bend. All the values given to the flat on the edge of rolling refer to hot rolled soft steel. In general, these restrictions also apply to aluminum, copper and steel alloy. Soft materials tend to fail due to the contact roll and are not so prone to buckle or column failure. Tougher materials show a decrease in upset, but tend to buckle more easily due to the higher force needed to make a bend. The pipe and pipe Rolling Rolling round or square pipes follows a pattern almost identical to flat on the edge of the work. Referring to table 3-6, the equivalent height of the blank is equal to the outer diameter of the tube h, as shown in the picture the thickness of the blank is equal to the thickness of the wall of the tube or pipe t. The failure of the column in a circular pipe or pipe will manifest itself as wrinkles of the tube wall on the internal diameter. The bend ratio of six, combined with a column ratio of 16 to 1, produces an initial buckle in a steel pipe (see table 3-7). This also applies to more difficult aluminum varieties, which can be substantially altered by heating to reduce the final strength. Very soft materials such as annealed copper tubes, do not buckle as fast as steel tubes, and column ratios as high as 24-to-1 can be bent to bend the 6-to-10 ratio. However, the soft material and thin walls combine to produce 158,174 basic methods of bending Table 3-6. Determining the column coefficient for a round or square rolling tube Blank Inside Height (h), Thickness (t), Diameter, in. (mm) inches (mm) v. (mm) Column Ratio 1.00 (25.4) 1/16 (1.1.6) 6.00 (152.4) 16 to (50.8) 1/8 (3.2) (304.8)) 16 to (76.2) 2 3/16 (4.8) (457.2) 16 to (101.6) 1/4 (6.4) (609.6) 16 to 1 Table Buckling Waiver in Round or Square Tube Column Ratio, R R The ratio of 14 to 1 or less uncritical; other factors 16 to 1 and 6; produces buckles in steel 24 to 1 (upper limit in steel No. 20 or more steel without mangle) Copper No. 12 or more 35 to 1 (upper limit in copper 30 or softer copper) Figure size values for rolling around or square tube. flattening during the rolling process. Filling the tube with sand, salt, polyglycolic or similar material can reduce this deformation. The circular rolling tube can be illustrated by the actual work involving an inch (53.98 mm) of the outer diameter of the copper tube with in. (3.05 mm) the thick wall is bent to an inch (48.3 cm) inside a coil of diameter in one pass. Here the column ratio is 17.7 to 1, the bend is 159,175 pipe-forming processes: Comprehensive guide ratio is 8.9 to 1, and the section is not wrinkles, but has been flattened by about an inch (0.64 mm). The same tube, bent to an internal diameter (40.64 cm) in rolls with a diameter of 17.78 cm, showed minor signs of wrinkles. The bend rate was 7.5 to 1. The diameter of the B. (40.64 cm) can be rolled into a large machine, using rolls with a diameter of 27.94 cm, and shows no signs of failure of the column. Another slightly larger example is the 3.00-inch (76.2 mm) curve of 80 black iron pipes with an inch thick (7.62 mm) to a 152.4 cm-diameter coil in one passage along the vertical bend of the roll. Here the column ratio is uncritical 11.6 to-1 and the bend ratio is 17.1 to-1. In the second passage, this pipe was spiraled in (63.5 cm) inside the diameter with a bend-to-1 ratio. The product showed no wrinkles and was flattened by about 0.50 inches (12.7 mm) during the rolling process. Square pipes follow almost the same pattern as round pipes, although failure occurs through deformation of the blank rather than the buckle. The production run of three sizes is shown in table 3-8 with the resulting deformation, illustrated traces shown in the I-Beams and Wide-flange Beam Rolling The column and bend ratios that can be applied to I-beam (figure 3-47) and wideform beam shape when they are bent on a hard track or flank. Actual bends are possible in table 3-9. The 3.00-inch (76.2 mm) and 4.00-inch (101.6 mm) dimensions represent minimum diameters, using 43.2 cm diameter rolls on the vertical bend of the roll. The size of 6.00 inches (15.2 cm) was bent using rolls with a diameter of 53.3 cm on a horizontal bend roll with an initial failure of evidence. The column ratio of 24 to 1 for the I-ray is the extreme upper limit. The angle of rolling Application column ratio and bend ratio to asymmetrical sections is very similar to symmetrical sections. Angles are the most common asymmetrical sections that are encountered. 160 176 Table 3-8. Typical production run of three square tube sizes Diameter, Column Bend Pipe Size inches (mm) Odds 1 in. 2 1/8 inch wall (35.6) 8 to 1 14 to 1 Good; see (6.5 cm wall) Figure /4 inches 2 1/8 inches inches 10 to 1 20 to 1 Cm (8.1 cm wall) Figure /2 in geig (0.074 inches) (66.0) from 20.3 to 1 cm (9.7 cm 2) Figure Basic Methods of Bending 177 Pipe Processes: Comprehensive Figure Guide To The Warp From Production Run summarized in Table 3-8. Table 3-9. Maximum bends for the I-rays of the Inner Diameter, Column Bend section, inside. (mm) v. (cm) Ratio 3 (76.2) I 5.7 beam (366) 17.6 to 1 3 (76.2) I 7.5 and beam 44.0 (112) 8.6 to 1 4 (101.6) I 7.7 beam 22 beam,8 (58) from 21.0 to 1 4 (101.6) I 9.5 beam (366) from 12.3 to 1 6 (152.4) I12.5 beam (1,097) from 26.0 to 1 Figure Size for Rolling I-Ray. To apply the ratios to the corners, the equivalent height must be determined. This can be done by pointing it out as twice the distance height from the neutral axis to the corner of the corner. The use of these ratios is shown in the picture the main problem of the buckle and of course this means that the definition and use apply to the leg in the bend. The neutral axis can be defined as a plane 162 178 Basic methods of bending the column ratio and bend ratio where: h - 24 to 1 t 0.12 D I - 9 to 1 h and height, b. (mm) t - thickness, B. (mm) D I - inside diameter, v. (mm) Figure Rolling 2 inches (50.8 mm) angle of shape. near the center of the beam, where the fibers are not deformed during the bending process. Thus, the concept of the plane used is identical to the concept of elastic deformation. In fact, the neutral axis shifts toward compression when bending. Because it is used as a means of comparing sections, it does not affect the immediate problem. In a 3-48 column, 24 to 1 directly categorizes it as a critical work, especially when combined with a 9-to-1 bend ratio. If it were a flat on the verge, it would be classified as a job that can only be done with special rolls to fully support the blank, and the resulting product will have some inevitable strain. This describes the result of 7.00-inch (17.8 cm) of rolls. It was necessary on a roll of this size to support the angle with the help of a specialist, to make at least five gears, and the final bend showed some signs of wrinkles. The same bend was placed on a machine with rolls with a diameter of 27.9 cm. The bend was completed in three passages without 163,179 pipe-forming processes: A comprehensive guide in favor of the astronaut, and the product showed no evidence of wrinkles, but to show deformities on the heel angle that can be corrected by a specer. The same process can be applied to 8.00-in. (20.3-cm) angle with 0.50-b(12.7 mm) feet, as shown in the figure from the data on the 2.00-in (50.8 mm) angle in figure 3-49 can be bent about nine times higher than the section. The equivalent height is inside. (29.5 cm) with in. (264.2 cm) as minimum domestic under ideal conditions. This diameter can received with several passages, but will be accompanied by an inevitable deformation. In general, the degree of deformation increases with the size of the section. A common practice is to keep the safety factor at a diameter of 10 30% to compensate for deformation in large areas. That is, the V. (345.4 cm) is the practical minimum for this 8 inch Ratio of Colum x t - 24 to D Bend Factor - I h - 9 to 1, where: h - height, v. (mm) t - thickness, b. (mm) D I - internal diameter, inside. (mm) Figure Rolling 8 inches (20.3 cm) angular shape. The angle is 164,180 basic bending methods (20.3 cm). This assumes that the size of the machine is ideal for the job and completely ignores the changes in support of the blank that occurs with the change in the size of the roll. Corner capacity tables are available for standard machines with corner rolls, and they cover more than 95% of all rental applications. The size of the machine definitely enters the picture. It is also common to provide special corner rolls to provide additional support on critical rolling applications. Bending special extruded angles and brake angles formed or a roll formed from a flat stock has become very common. Due to fluctuations in thickness and leg length, common performance tables are not available for materials in this category. However, the capacity charts for standard structural forms can be compared to similar formed sections using bend and column ratios. Brake angles are harder to roll than their structural counterparts. Support at the ends of both legs is important at all sites where the column ratio is 10 to 1 or higher. The usual type of support shown in the figure Any asymmetrical section is an additional problem because it tends to turn. The reason for this can be understood from the drawing Obviously #1 feet the angular leg has undergone a plastic stream and is compressed from the rolling process. The angle heel has an elongated voltage due to the section that exists between the #1 and the heel. The legs #2 do not lengthen to the same extent, and do not have the same tendency to lengthen as the heel. Thus, the angle of the foot from heel to toe #2 usually act as flat on the edge and bend in a plane 90 to the plane drawing the support required for the braking angles. 165 181 Pipeline Processes: Comprehensive Leadership Requires Bending. This condition is corrected by external or auxiliary rolls, commonly called leg attachments. Lengthening length is defined as: Lf Li E 100 L I (3-2), where: E - length, % L f - final length of blank, B. (mm) L I - initial length of blank, B. (mm) Since the neutral axis of the blank is not deformed in theory, we can take the length of the blank as a circular length Final length is taken as a district length The actual position of neutral neutral does not necessarily correspond to the theoretical neutral axis used in elastic deformation. In the plastic stream, the neutral axis moves during deformation towards the compression side of the blank. The amount of movement is governed by the ratio of the final compressing force and the ultimate tension in the material that was rolling. In the case of flat or flat or flat edges, where a neutral axis is thought to exist one-third of the way between the compression edge and the edge of the voltage, the extension can be calculated as follows. Dimensional values are shown in Lee's figure - 3.14 d'h 3 (3-3) L f 3.14 (d 2h) 2 (d' 2 h) d'h 3 E and d'h 3 166 182 Basic Bending Methods of Dimensional Values for lengthening. where: E 1 h and 100 x d - internal diameter of the rolled-up part h - the outer diameter of the rolled part If it is assumed that the neutral axis is in the center of the blank and its shift is ignored, the extension becomes: E d 100% h and d Minimum lengthening of material in the blank should be at least 25% more than is estimated by this method. If the material is shackled and it is necessary to roll on the shackled edge, the lengthening of the material should be 50% more than the estimated value. If you suspect an extension failure, you should do an actual rolling test. The pattern of plastic flow can be defined by marking the blank before rolling. Punch-marks at these centers give approximate results in the number of deformations. Machine-capacity machines used in rolling corners, bars and shapes are made in a wide range of sizes, with rolls of varying diameter from less than 2.00 inches (50.8 mm) to more than an inch (127.0 cm). In total, all machines are equipped with three power rolls of 167,183 pipe-forming processes: A comprehensive guide located in a pyramid or pinch-type configuration, as shown in the picture of a pyramid-like machine dominating the market. It has two advantages over a pinch-type machine. The pyramid configuration maintains contact with the blanks over the larger arc and usually retains better control over the asymmetrical sections. It also requires less tonnage on the top roll to perform the same bend using rolls of the same diameter. This reduces the load on the machine and reduces the load on the blank, thereby reducing the tendency to buckle on critical sections. The pinchtype machine has an advantage in the production of blanks with a minimum amount of flat at the end. Manufacturers of rolled machines offer equipment of different power. Estimates for this model of the machine are related to the shape and size of the material. Figure 3-53 reflects the ratings of a small roll of Bender. It is best to consult with the manufacturer when evaluating the machine for the intended use of bending. Roll-bending Tools Cataloging Tools covers more common structural and mill forms includes angular rolls, flat rolls on the edge and rolls of pipes and pipes. Figure Basic configurations of roll-bending machines. 168 184 Basic methods of bending the drawing typical roll-bender capacity chart. 169 185 Tube formation processes: Comprehensive leadership figure (continued). The angle of Rolls The need to bend corners has spawned the original concept and design of the main roll machine. The angle of rolling requires the use of overhung rolls to easily remove the blank and makes it mandatory to drive all three rolls. The bend of the foot or leg of the place places one foot of the corner in the groove formed by two sections of the roll. This groove should be adjusted for a minimum clearance to keep the angle of the square and create a state of friction and movement under intense pressure between the inner face of the roll and the foot angle. When the hot corners are bent, the presence of the scale of the mill makes the minimum hardness of 58 R C mandatory. Highly polished rolls with such hardness produce a blank free from traces or scratches on all but the heaviest bends. Where small diameters make the bend unusually heavy, it may be necessary to increase the hardness of the roll to a minimum of 62 R C. This can be done with the hardening of the flame. Lack of sufficient hardness results in scratched or marked blanks, and usually does not show how wear is on the roll. The chrome coating was also used on the surface of the 58 R C and eliminates all marks on the blank. It has two drawbacks: 1. It is sensitive to handling and can chip or peel. 2. This reduces the friction of the roll to a level where additional passages may be required on small-diameter bends. The chrome plate A. (mm) usually has a lifespan of 18 months to two years under high production conditions. When worn or chipped, it is necessary to strip the rolls and replate them, and then grinding operations to eliminate the buildup on roll radii. The 170,186 basic methods of bending flat on the edge of Rolls Flat-on-edge rolls are adjusted for any width of grooves to the tank capacity in square bars. The top idling roll and lower rolls are jagged to ensure sufficient traction. Upper bank idling is needed to avoid slippage under heavy load. These surfaces in contact with the blanks should have a hardness comparable to the angle of the roll, the 58 R C minimum. The lower rolls are oversized, with the top or rolling roll oversized to produce the slightest diameter practical. Pipes and tubes rolls pipes and tube rolls are usually furnished from alloy steel with 48 R C minimum hardness. The groove in the roll should fit the pipe or tube within 1/32 inches (0.79 mm) on small tubes, and within 1/16 inch (1.59 mm) at 3.00-inch (76.2 mm) tube diameter or larger. When the thin-walled tubes are bent, the rolls can be made of nylon, Teflon or urethane. Materials are usually used where all traces of roll contact must be eliminated. A common practice is to simply top the top and control the lower rolls. In cases where 50% or more of machine power is used, idling top roll space is a must. A small work spiraling to small diameters requires all the rolls to be controlled. Special tools and angle techniques Roll Spacers The most common form of specialized instruments is the angle of the spacer roll. These spacers are used to prevent deformation on the heel of the corner caused by a strong force on the fillet angle. The use of the spacer is usually limited to the upper roll for bending the leg, as the force on the upper or rolling roll is twice as much as on the lower rolls, and the resulting deformation is greater. The purpose of outer space is to provide contact and force directly on the note of the corner, thereby reducing the force in the fillet. Rings the size to clear the end of the corner of the foot at 1/32-inch (0.79 mm), up to a 4.00 inch (101.6 mm) angle. Large corners require large gaps. Despite the mill's tolerances, it is a commercial 171,187 pipe-forming processes: A comprehensive practice guide to use one space for a single-sized angle. Several critical applications require that the size of the cosmodrome be changed to compensate for the change in size due to the mill's tolerance. The seer is placed on the flank of a smaller section of the roll. It controls the distance or width of the groove in the roll, and also comes into contact with the end of the corner leg. Therefore, it is necessary to change the space for each corner of different sizes and each different thickness of the corner. Spacers were also used in both lower rolls, where small diameters were required, and in minimal distortions. They are usually manufactured in a shock-intensive steel tool and hardened to 54 R C for maximum strength. STRETCH FORMING Single-astrity formation is used to meet formation requirements for metals such as high temperature, high strength nickel and cobalt alloys, as well as new alloys of molybdenum, tantalum, columbus, tungsten and beryllium, which are not easily formed by conventional methods. In addition, stretching is used to form very thin materials, including titanium and Renee 41, which are difficult to form in any other process. The application part that needs to be formed stretch, usually must have a permanent transverse area along its entire length, and be free of holes, cutouts or cuts. Variations in cross-section cause the part to be separated before it is possible to create an adequate voltage to establish the curvature (exceptions to this are possible and will be described later). If cross-section variables are needed in the finished product, it is common practice to first stretch the shape of the permanent cross-section area. After forming a sprain, the operator makes the necessary routing, milling piercing to obtain the final cross-section with a variable part. All stretching operations emphasize a part up to or outside the point of profitability of the material, placing the material in its plastic range. Tensions In order for part of the contour shape to die approaching the final strength of the material. 172 188 Basic bending techniques during stretching formation, the very nature of moving the material to plastic deformation or work hardens the material, resulting in the potential to increase the yield point value and reduce lengthening. At the same time, with a stretch, the length of the part increases, and the width and thickness are reduced, because the part maintains a constant volume. Determining the ability of stretching to determine whether a part can be successfully formed, the engineer must first calculate the amount of lengthening of extreme fibers section. If the part has a permanent radius, as in figure 3-54, and the radius is known, use the equation: where: R E e E RI 100 R I E - lengthening, % R E - radius of extreme fibers, V. (mm) R I - radius of the inner fibre, B. (mm) (3-5) Example: suppose that the inner radius of the curve part in the figure 3-54 is inside. (73.7 cm) and a section 1.00 inches (25.4 mm) wide. The picture is stretched, forming a part with a permanent radius. 173 189 Pipe-forming Processes: Comprehensive Guide (30 29) E and 3.4% If the percentage of lengthening is within the allowable lengthening of the material to be used, then the part can be successfully stretched formed. Along with the bend limitations and the variations described in the formation of stretching, there is also a shift of the neutral axis. It moves from its normal position in part to the outer position to the cross section of the part, like the material of the stretchforms. As mentioned earlier, stretching part emphasizes all the transverse fibers of the part. During the actual formation of stretching, there is a condition, as shown in figure 3-55, in which these fibers (associated with the a-b-c-d area) are emphasized in different quantities. To ensure that the curvature of the part is fully adjusted, the inboard fibers are strained as indicated in the c-d line. This moves the neutral location of the y-y axis to a position specified in A and C, as opposed to the original location of the neutral y-y axis before the stretch. This situation is desirable because all strains are in the same direction (in voltage, as opposed to pure bending, where both voltage and compression exist in transverse fibers). This reduces distortion or twisting of the stretched part after the voltage is released from the blank. Shift the neutral axis. 174 190 Basic bending techniques that determine the stretching forces Of the part, which should be stretching, should have a constant transverse area along the entire effective length, which should be exposed to a stretching force. At no point should the cross-section be subject to curvature, which will lengthen the requirement between the inboard and the suspended fibers of the cross-section, which is more than the metal is capable of stretching without crashing. A simple procedure can be followed to obtain the approximate force needed to stretch the shape of any material: 1. Identify the transverse area of the part, v. 2 (mm 2). 2. Identify the metal's profitability point from a directory or materials supplier. 3. Replace the above values in: F and Y p A (3-6), where: F - stretching power, lbf (kn) Y p - metal yield point to be formed, lb/in. 2 (kg/cm 2) A - transverse area, v. 2 (mm 2) F - is the force needed to stretch the part to the point of giving way. This force is then on the straight side as a trial force stretching. It gradually changes from part to part until the exact production pressure of stretching is obtained. This is necessary because often the materials supplied by the supplier to the same procurement specifications vary in physical properties. Finally, when the part is completely wrapped about the shape of the die, the stretch force increases additionally to stretch the set part. At this time, the final force of the stretching should not emphasize the part beyond its ultimate strength (lb/in. 2 kg/cm 2) for this material is formed. Maximum strength stretching value can be determined by replacing the final strength of the material value instead of Y p in the aforementioned equation 3-6. To help determine the strength of stretching required without actual calculations, drawing 3-56 can be used as a guide. Use a straight edge to align the known value for the transverse part area and the yield force to get the necessary stretching power. 175 191 Pipe-forming Processes: A Comprehensive Drawing Guide to determine the required stretching force. 176 192 Basic methods of bending as illustration, For the aluminium part of the 61ST6 contained in. 2 (483 mm 2) transverse area, the required stretching force is 30,000 pounds or 15 tons (13,608 kg), as evidenced by the broken line in the pattern Overcoming formative restrictions Frequently, the correct formation and procedures of thermal treatment can significantly increase the percentage of lengthening of some metals. Details of the specific properties of metal at various stages can be found in brochures provided by suppliers of materials. For some alloys, heating the mold to die or part during the actual stretch work allows more critical angle bends to be successfully completed. Slowing down the rate of surgery formation, combined with different stretching pressure during cycle formation in heavy bend zones, also helps in the production of satisfactory bends. Thin from a metal cross-section occurs with all stretching operations proportionally thin of the thickness of geags. This part of the part should be formed a little oversized in width to ensure a reduction in The simultaneous use of compression and stretching techniques also leads to a temporary shift in the cross-section during the formation. However, it shifts to a much lesser extent than it does just for the stretching method of forming. The accuracy of the cross-section without distortion is possible due to this combined method of stretching and compression. This allows you to stretch the part with a reduced stretch or strenuous force and results in a reduction of cross-section thin. Controlling different contour angles, whether in the same plane or not, can also be saved with the right tools. Linear stretching techniques form linear stretching formation is a process in which the inhibitory or extruded part is changed from linear configuration to contour configuration without destroying the integrity of the original section. Theoretically, this is achieved by placing the blank under optimal initial voltage, which extends the metal over 177,193 pipe-forming processes: A comprehensive guide to its exit point, and then wrapping it around to die, from which it takes a permanent set. This places a neutral axis in the inner fiber part during formation (see figure 3-57). The main method of forming contoured corners, channels and hat sections is stretching on the linear stretching of the press of a special machine with a fixed holder to die and retractable travels stretch jaws (see figure 3-58). This press has been used to form heel in and heel from the corner and channel sections, and the heel-in-hat sections discussed in this section. The linear stretch dies subject to a wide range of contour radius for formed sections, ranging from the linear-stretching process of the shape. A drawing of a linear-stretching machine. (Courtesy Sheridan-Gray, Inc.) 178,194 Basic bending techniques (25.4 2,032.0 mm) for corner and canal sections, and v. (76.2 2,032.0 mm) for hat sections. Studies conducted under U.S. Air Force contracts have provided most of the data presented in this section. The aim of the program was to develop an analytical method of predicting the limits of sheet material formation, using only the mechanical properties of the material. Twelve formation processes have been studied, including linear formation of stretching. Equations were identified for each type of failure for each process, and methods were analyzed to draw limit graphics for any material once the corresponding properties of the material were known. There are problems with determining the definition limits for almost all processes. Most of them were explained on the basis of known answers; however, some of them can only be explained by theoretical analysis. Determining the shape of the part and geometric variables. The formation limits presented in this section are valid for sheet metal configurations illustrated in 3-59 pre-59 drawings where: t - thickness of material, V. (mm) D - web width or flank, v. (mm) h - height of the part, in. (mm) R - the radius of the inner part, in. (mm) R d - radius of the outer part, V. radius (R or R d for attachment to the other part), b. (mm) Drawing the heel from the corner. 179 195 Pipe-forming Processes: Comprehensive Guide To Figure Heels from the Canal. Drawing the heel into the corner. Drawing a heel in a canal. 180 196 Basic methods of bending figure heels in the hat section. The equation of predictability. Five types of configurations generate three different classes of formability limits: heel angles and channels, heel angles and channels, and heel sections. The following predictability equations define the definition limits for the three geometric classes. Class 1: Corners and channels for the heel. (Elastic bucking equation), where: h e q 2 R Sty (h/t) h - the height of the section part, B. (mm) R - radius of the inner part, B. (mm) E - standard longitudinal tension taken from Sty t - material thickness, B. (mm) h. (mm) (inflection line equation) h R and h t (3-7) (3-8) 181 197 Tube Formation Processes: Comprehensive Guide (Elastoplastic Bucking Equation) h E 2 and 38.2 (3-9) t Sty 5 (Cleavage Equation) h R and magazine h 2.0 t Class 2: heel in corners and channels. (Elastic bucking equation) h E 0.81 and 2 R Sty (h/t) (Cleavage equation) h R and log h 2.0 t Class 3: heel in the hat sections. (Elastic Bucking Equation) h 2 R Sty (h/t) (Cplifies) h R and log h 2.0 t (3-10) (3-11) (3-12) (3-13) Geometric variables, h, R and t are defined by geometry and mechanical variables in the list of symbols defined. E and Sty were taken from standard longitudinal voltage tests. When solving equations for h/r values, replace randomly selected h/t values as needed. Parts with variable radii at successive points throughout the bend can be stretched in one continuous operation without changing the rot or tweaking of the machine every time the circuit changes. Matching male and female dies are not necessary because the material wounds around the table die. 182 198 Basic methods of bending tubular and hollow sections with unsupported legs can be stretched with laminated flesh or snake. The laminated mundrel consists of a series of metallic leaves, similar to the spring of cantilever leaves, firmly welded together at one end to keep the leaves properly aligned. Many different types and forms of auxiliary members can be used, depending on the section to be formed. Stretching formation is used mainly in the aviation and missile industries to form complex and precise parts without springback from hard-to-work materials. Its advantages are relatively low cost and precision to die. Its application is limited application in high-speed production environments of the automotive and domestic industries due to the relative slowness of the work. Rotary Compression Formation in Compression Formation, hydraulic ram reversed to apply pressure instead of voltage (see Figure Figure The material that will be formed is formed against the background of table death either with shoes or rollers as the table rotates. The entire ram-slide-guide assembly is locked in one position to the bed by security haircut bolts to prevent the assembly from turning. Wipe the shoe or roller mounted on the frame of the face supplying concentrated pressure and arm lever to start bending a small area of metal. It also restricts the metal at the point of tangent bend being done. The principle of the formation of the Rotary-compression shape. 183 199 Tube-forming Processes: Comprehensive Guide Because of the localized action formation, which is continuous as die rotates past the shoe napkins, can be compression-shaped large parts. Rub rails and bumpers can be formed for as little as 2% of the total tonnage that will be required in press dying designed to form an entire contour in one blow. The compression method often has a great advantage in the formation of parts that include sharp bends of the radius in deep cross-sections (see figure 3-65). The reason for the improvement of the smaller radius potential is explained in the figure During the formation of the operation, the fibers in the cross-section of the part of the channel, limited by the a-o-b area, are at varying degrees of voltage; on the contrary, the fibers in the c-o-d area are, to varying degrees of compression. Thus, for all compressions- Figure Sharp radii in deep cross section. Figure Of The Neutral-axis position in compression formation. 184 200 Basic bending methods are formed in parts, the neutral axis of the cross section does not significantly change its location during the formation of the operation. The greatest voltage imposed on the fibers of this cross-section cannot be greater than the same material is able to withstand under the strenuous test load of the sample. With equal voltage or lengthening of fibers within this cross-section, the minimum compression radius is about half the minimum bend radius that can be obtained by stretching method (shown in figure 3-55). In figure 3-66, the transverse fibers did not move in the same direction in relation to the neutral axis of the section. Recovery of these fibers after the release of external forming loads is done around the neutral point of the axis in two opposite directions. This two-fiber movement of fibers leads to the spring of the contour of the part, which is about twice as much as the equivalent stretching area (in the stretching molding part is exposed only to tense voltages). Springback comes from a rotary compression formation adjusted by providing an inflection in the form of die to ensure the proper contour of the part after formation. For heavy bends made in deep cross-sections, where greater metal movement must be achieved, The re-portion can be achieved by making a second swipe of the napkin to set part of the required contour accuracy Compression formation is best performed on symmetrical cross sections. If the section is unbalanced, as in the case of the angle, the spring can create a distorted path in two planes. To help overcome this, it is necessary that the shoe napkin be heeled in the form of die as it limits the material formed. The radial-draw formation of the radial no man formation differs from the usual stretching formation in that two items are added: the table (and die) rotation and compression of the shoe acting at right angles and usually tangent form die. Because of the slip action to die passing shoe napkins, lubrication is necessary to prevent bile harvesting and to protect against the rapid wear of shoe napkins. Any of the extreme pressure oils or pigmented drawing compounds can be applied to 185 201 Pipe-forming processes: A comprehensive manual part brush or spray gun shortly before the wipe operation. Another lubricant often preferred because of its clean appearance and easier handling, is water-soluble wax. It can be applied to the number of pieces before you wipe the formation and is effective even when dried to pieces. Equally important is the choice of the material from which the napkin is made. This material depends on the material that will be formed and the size of the part. Typically, for all steel, stainless steel, inconel, or titanium-type materials, the aluminum-bronze alloy must be used because its polished work surfaces require minimal maintenance and prevent galling of emerging surfaces. For non-ferrous metals, such as aluminum alloys, several materials are suitable for wipers, depending on the size of the formed part. As the section of the part is smaller, it is vital that the more difficult wipe-shoe material be used. Smaller contact areas should carry under a relatively higher concentration load. This creates a possible wear problem for shoe napkins. Conversely, when the cross-sectional size of the part increases, it represents a large projected area of the face for contact with the napkin. You can then use softer materials to wipe the shoes. These softer materials guarantee the formation of parts with minimal surface marking, since galling and pickup trends are reduced. Wrinkles or buckles in the formed part indicate that the metal was not compressed in compressed areas. The compression can be used by making the wipe shoe strong in mass to resist internal deviations and limiting the curved metal as it plastically flows between the shoe and the form dies. Excellent cross-section accuracy can be obtained by compression method. Often you don't need to keep the accuracy of the cross-section of the brake sections of the press up to very close tolerances, because the shoe napkin will tend to correct cross-section errors during the formation of the operation. The stretching force used should not be equal to or exceed the final long force of force or the blank will be a fracture. The radial-drawing formation does not stretch all parts of the fibers in increasing the amount from the inside outside the bending radii. Instead, the internal fibers are usually moderately compressed and the outer fibers are 186,202 Basic bending techniques moderately elongated. The voltage of the yield required to adjust the part of the contour is obtained inside the part by a combination of rubbing and stretching forces. Thus, critical voltage external fibers are avoided in sharp bends of the radius. The material you are forming can be rolled up or extruded by sections, stripes, or other types of sections. In typical radial-drawn work on the material there are three working-forming forces: 1. Long-range voltage force on the material brings its fibers into the plastic range, turning the metal into a state of flow. 2. The radial-forming action generated by the turning circle, sweeps into the metal creates the necessary contour. 3. The compression force is used by the windshield wiper shoe to maintain or change the cross-section and to assist in the formation of the work. The combination of these forces seals the metal in its new form. Control of voltage output and/or lengthening is vital if the part is to be made of metals such as titanium, which tends to bile in sliding contact with other metals. Titanium has a high yield strength and a narrow margin between yield and final strength. As the capture jaws stretch the part, automatic voltage output and control are used that allows the stretching process to continue as the instrument shows exit lines and voltages parallel. When they diverge, electronic sensors detect deviation and automatically correct the stretching cycle, thereby maintaining optimal voltage throughout the formation. Although the characteristics of the same metal vary with the individual element, automatic control detects these changes over time to eliminate subtle outputs and fractures in the final formation. Once the correct force of stretching or tonnage has been applied and the metal becomes plastic, the rotating table is in motion and the part is turned into a die, taking on the configuration to die. To the ram of the second hydraulic cylinder is attached to the compression of the shoe in the form of mating with a transverse profile die (with the norm of thickness of the material). It applies pressure to limit 187 203 Tube form processes: Comprehensive metal guide to the face to die and helps with the formation. Wipe the boot of the second hydraulic cylinder usually acts at the point where the unformed part of the part makes the tangent die. This last step in the work of planning gives high precision, practically stroking the grain of the material in its new position. While it's happens, you can also insert joggles or offsets, if any, and produce reverse curves. Traverse hydraulic compression unit for the compression force can be extended or removed (to or from the center of the table) or moved longitudinally as needed. This keeps the shoe pressure in contact with die at the point of the tangent. The longitudinal movement of the unit makes it effective in stretch wiping parts, having linear radical curvatures and turns. The radial-draw exes are rated in a stretch tonnage; for example, a 12.5 tonne (172 IPA) machine would provide a stretch in that amount. The diameter of the die and the speed of the rotary table also determine this ability. The tonnage or force required to make the site exceed the point of return is supported by electronic control while the machine goes through its formation cycle. Accessories equipment allows for even more complex or different operations. With the radial-drawn formation of many products can be excluded the use of handmade. The entire formation operation can be precisely controlled and tolerances in thousands of inches (hundreds of millimetres) are now possible. Springback is eliminated or significantly reduced. Components such as a jet engine, which would be very difficult or expensive to produce by other means, are formed on a production basis. Jet engine materials are well known for their complexity for the machine or shape otherwise; and because there is no production of chips in the radial draw formation, expensive materials such as titanium are retained. Parts can often be made into one piece, eliminating or reducing the amount of riveting or another joining. Where design changes occur frequently, as in the case of aircraft programmes, the radial-drawing method provides an added benefit due to the relatively inexpensive tools and relative ease with which it can be modified or modified. In addition to creating parts such as the true 188,204 basic methods of bending circles and 360 spirals (or exceeding the full circle), the radial-drawn former produce irregular curvatures or parts in three planes. In addition, you can form standard and irregular cross sections, including sections of hats, canals, sections, corners, tubes and honeycomb. REFERENCES Lange, Kurt, Ed Metalworking Handbook. Dearborn, MI: Society of Manufacturing Engineers. Springborn, R.K., Ed is cool bending and forming a tube and other sections. Dearborn, MI: American Society of Instrument and Manufacturing Engineers. Stange, Ronald Major trumpet bending the manual. Dearborn, MI: Society of Manufacturing Engineers. 189 205 206 The rationale and choice of equipment 4 The rationale and choice of equipment companies considering the purchase of pipe-running equipment face an extensive set of alternatives. The potential buyer must exhaust their needs and affordable equipment. Manufacturer pays special attention to detail, gets a significant advantage over competition. This chapter examines some of the more popular equipment options available for tube tubes their benefits, limitations, cost and applications. BENDING DATA Buyer must understand the basics of bending the tube before you can make a reasonable decision. Instead of delving into the theory of bending, this book looks at the information that is important to know on the bend machine. The proposed equipment must have the physical and technical characteristics needed to bend the parts. The main factors influencing this are: external diameter, wall thickness, bend radius (usually measured from the central tube line), material, part configuration, and bend quality required (ovability and thinning of walls). Of particular interest in choosing the method of bending is the external diameter, the thickness of the wall and the radius of the bend. These factors correlate with each other and directly affect the type of toolkit and configuration of the pipe-bending machine. 191 207 Tube-forming Processes: A Comprehensive Guide to Modern Design Concepts tends to develop the curved shape of the tube using Cartesian coordinates. These points in space X, Y and q sizes mean nothing to the tube bending machine. Even the most advanced CNC machines do nothing more with this information than convert XY coordinates into bending data. The bend of the data can be defined as: the degree of bend, sometimes called an angle; Distance between bends, sometimes called long, feed or position; and the plane of the bend, sometimes called a turn, rotation or orientation. It is imperative that the potential buyer understands what needs to be monitored to select the right equipment. BENDING METHODS There are different types of tube bending equipment available on the market today. It is important that the potential buyer of the machine pays special attention to the bending of the data and applies this knowledge to what is available on a commercial basis. The invention of the wheel can be time consuming and expensive. Tube-bending solutions, when approached methodically, can be obvious and profitable. The manual bending of the original method of manual bending began with human strength. Although the hand-bending tube is very economical, it does not contribute to higher production rates, quality, or repetitiveness. The basic die kits with a mechanical method of producing levers have been designed to combat the adverse effects of bending strictly manually. Die sets increase the quality of the bend and raise the pace of production. They reduce the required human power. Although the machines were built with a lever to handle 2-inch (50.8 mm) pipes, hand-held benders are usually suitable for 1 inch (25.4 mm) or smaller tube. The operation of the hand hender requires that the operators place the tube in the instrument area in the correct bend position, bring the tool into position, and physically pull the machine mechanism to produce a bend. Basic machines have one dial, goij, or ad - 192 208 and the choice of equipment is a stopover capability that serves as a guide to producing the desired desired Bending. When receiving more than one bend per part, the operator must index the part to the next bend point and repeat the process until the desired second bend angle. Advanced hand-bending machines have been developed to produce parts similar to those produced from much more sophisticated equipment. Systems have been developed that allow accurate part positioning and duplication of the method and the quality of the rotary rendering bend. Physical tight stops have been built by manufacturers or rigged end users to perform the exact positioning of the part. These advanced machines are much more expensive and use customized tools. The fact remains that the operator provides power for indexing between bends, rotating for the bend plane, and producing a bend angle. Benefits of basic pipe-bending equipment: low initial investment; A short lead time for the machine and toolkit; Easy to operate (if the configuration of the part is unsophisticated); Portable and relatively safe to operate. Weaknesses: The maximum operator interface required; Limited bandwidth Can't be automated. Limited standard external diameter and central radius (CLR) toolkit; It is difficult to produce complex part configurations. and accuracy and repetitiveness are in question. Typically, hand-held benders are best used for: lower volumes, short runs, small diameters, basic part configurations, and lower labor performance. Prototype areas, short-term departments, job stores, remote tube manufacturing locations, and situations where economical labor 193 209 Pipe-forming processes: Comprehensive manual can be applied to all good applications for manually bending machines. The semi-automatic bending of the semi-automatic curves of the tube is fundamentally hydraulic or electric motors of pipes and pipes bending the machine. The equipment is available in many sizes and shapes, and with many features. The most basic semi-automatic benders have a degree of bend stops connected to the control panel. Stops are a physically set limit to either a switch or an electronic-relay logic system. These machines may require manual positioning of the toolkit or provide power positioning tool power through the control panel. The operator acts the loop with a button, and the machine bends the tube at a given angle. Once the bend is done, the operator physically indexes the part forward to the next bend position, leads the return sequence and repeats the process. Most machines come with several stops of distance between bends. The distance between the bend stops is usually an adjustable physical paddle stop mounted on the rod, running the length of the machine. Operator them to the right distance between them. The rear end of the tube comes into contact with the stop and provides a way to repeat the distance between the bend of part of the configuration of the part. Major machines require that the operator part in the plane of the bending position. This is perhaps the most difficult operation in the process of achieving accuracy and repeatability. Bubble Goij is the main method of achieving this orientation. The hard stops can then be rigged or built into the toolkit to provide a method for repeating the position. More advanced semi-automatic benders are almost like CNC-controlled machines. Bender manufacturers now offer options to alleviate the flaws of the main machines. Digital data entry details and storage of parts numbers are available features. Although the actual control of the machine is limited to sequencing the bend and spring, it provides a method of storing valuable data on each individual part configuration. 194 210 Justification and choice of transportation equipment /colleting arrangement are available to hold the rear end of the tube. This system allows the physical plane to bend stops and the distance between the bend stops. However, the operator provides the physical strength needed to position the part. Significant advantages of this semi-automatic bending equipment over manual machines are: increased capacity, less physical operator interface, more affordable options, suitable for larger volumes, standard machines are more accurate, and capable of more complex applications. The disadvantages of semi-automatic bending machines: input directly affects the accuracy and pace of production; Requires the operator's experience. Lack of accuracy and repetitiveness can sometimes be a problem; The limited complexity of the part and it's hard to automate. CNC BendIng Computer Numerically Controlled (CNC) Benders tubes have been designed to bypass problems associated with other methods. Modern computer technologies associated with servomechanical control offer an excellent method of controlling three bending a fraudulent a column. CNC-bender mechanics work in a similar way to other methods. The difference is that the servos control the distance between the bends and the bend plane. The transportation/collection system is standard equipment. The movement and sequencing of tools, partial storage of data, and other items that will be discussed later are automatically monitored by the computer. For the purposes of this book, CNC Bender is defined as a selfsequencing, tube-bending machine. The operator hands the machine a part, the activation of the start button and the machine bends 195 211 Pipe-forming processes: The comprehensive part of the manual. The operator then removes the part and includes a return sequence that repeats the operation. Benefits of CNC tube bending: maximum accuracy and repetitiveness; Low-level workforce for production sequences A high degree of control; Fast shift versatility and the complex capabilities of the piece. Weaknesses: capital expenditures; requires that the operator Familiar with the computer It may require additional water, air and electricity. And maintenance is under stress. A special Bending Special app (sometimes called dedicated or fitting) bend machines, usually purpose-built machines created for specific parts or families of parts. Configurations range from hand-powered hand-held devices to fully automated work cells. Control systems range from hard stops and air logic to advanced programmable logic management technologies (PLC). Many different reasons motivate manufacturers to use this style of equipment. The necessity was, perhaps, the original and the most logical. When there is no alternative, the best tube bending people will create a solution. Only the imagination and bank account of the company, buying it to limit this equipment. Some parts simply cannot be bent on conventional equipment due to their size, shape, configuration or any other physical factors. Previous parts operations may make them impossible to bend by conventional methods. In addition, standard commercial equipment may not be able to use the necessary tools and/or provide the forces needed to provide the tools. Custom-built equipment can handle even the most complex parts designs and accommodate more sophisticated tools than was previously possible. 196 212 The rationale and choice of equipment Another reason for the use of special pipe-running equipment relates to production requirements. Extremely large volumes of parts and a competitive economic environment can force the manufacturer to develop faster and more efficient parts production tools. In small diameters, the equipment can be built using pneumatics. Pneumatics makes dedicated benders faster than traditional machines, especially when a special machine makes more than one bend at a time. This is especially true for details with numerous bends, and seems to be true until hydraulics are needed to bend power. Then the cycle time can become a boundary difference. Pruning, pressing hose, end formation, T-branch and many other secondary operations can be incorporated into pneumatic equipment. The transfer and orientation of the part associated with the holes, T-branches, brackets and suitable places can become an integral part of the bend operation. These factors can have a beneficial effect on the economic and human needs of the production of parts in large volumes. Special application machines are usually either built in-house or custom machine builders and engineering firms. It is important that the potential builder of this equipment have experience in making pipes as well as mechanical and design capabilities to make custom machines a reality. These qualities are often imitated, but not It's easy. Manufacturers of special machines tend to be smaller companies and, due to the customs of their work, may have difficulty complying with deadlines and economic constraints, especially if they are good at what they do. Do. Beware of custom builder with amazing price and extraordinary delivery time. Custom hardware is called dedicated for a reason. The manufacturer can be left with a very expensive dodgy if the part of the machine is designed to get out of production before the end of the payout period machine. If this happens, all you can do is use the machine for spare parts. The winning period and the life cycle of the part should be carefully considered. The manufacturer should exercise caution if there is a chance of a design change. Alternative uses for the machine should be considered at the purchase specification stage. 197 213 Pipe-forming Processes: Comprehensive floor floor guidance requirements can be quite extensive for a manufacturer that bases the bulk of production on custom equipment. Machines that are not used take place. They still need to be stored or repaired to be put into operation after long periods of downtime. Part of the production contracts that require service periods after the initial large production volume run make the area a certain economic consideration. Special pipe bending equipment is best suited for multi-volume complex parts, where design changes are unlikely and production schedules remain the same. The automotive industry is perhaps the largest user of this style of equipment because of the sheer volume. Indeed, the manufacturers of brake lines have created some of the most complex, expensive and productive dedicated benders ever produced. However, with the introduction of easy-to-time flexible production methods and the realization that the area is expensive, manufacturers are beginning to give special equipment more rigorous study. Benefits of special application benders: small diameter, pneumatic machines offer maximum speed; It can usually be automated if stated during the assembly. Secondary or other operations may be included. The maximum complexity of the part Minimum input of the labor force with working machines; Automatic orientation of hoses, T-branches and equipment; and the buyer can specify the functions and components of the machine. Weaknesses: Capital costs can be high for complex machines; Minimum flexibility Difficulties in finding qualified long-term suppliers May become obsolete as a result of changes in the design of the part. Delivery times can be long and increases with the complexity of the machine; The rationale is based on a narrow range of parts. and the space requirements can be extensive. 198 214 Justification and Equipment Choice CONSIDERATIONS Capital Procedures for The Justification of Equipment vary greatly between companies. Spectrum varies from sole owner, that she or he is just going to buy one corporate accountants pouring through computer justify programs. In any case, it is easy to ignore important factors that can make a break or process. Justification The equipment is unique to every company and to every industry. The equipment manufacturer may provide relevant information about the equipment, but do not expect to complete the substantiation procedure in full. The staff of the company, which is responsible for the purchase of equipment, should have the time and resources to properly investigate the project. Team Approach Operations staff, who must work and use specialized equipment on a daily basis, can provide valuable information about which equipment will benefit the production the most. However, they may not have the accounting background needed for a modern crunch number. Conversely, what can look good on paper may not always be true in the real world. It is rare for a company to have someone with operational experience who can both fill an accounting function and realize the use of purchased equipment. The rationale should be seen as a team effort, or at least as something related to a wide range of experiences. The main factors influencing the justification of pipe-bending equipment are price, return on investment and pace of production. The price of a pipe bending machine vary in cost between manufacturers depending on features and power. It is important that the buyer is sure that he or he compares apples with apples. Table 4-1 presents a pricing chart designed solely as a guide. Variations of machines are endless. 199 215 200 Table 4-1. Труба изгиб машины ценообразования Приблизительные цены ($ 1000) Вне диаметра Основные Расширенный Основные Расширенный Расширенный компьютерный потенциал, дюйм (мм) Ручное руководство Полуавтоматический Полуавтоматический численно управляемый 0,25 (6,4) (12,7) (25,4) (50,8) (76,2) (101,6) Трубообразующие процессы: Всеобъемлющее руководство 216 Обоснование и выбор оборудования Таблица 4-1 показывает, что, чем больше машина, тем больше разница в цене. This is because the vast majority of Bender tubes are built for smaller external diameters. Thus, thanks to economies of scale, bender manufacturers are able to keep pricing more in line with the market. Large CNC machines are specially built to fill a specific need. It's not unheard of to see $1 million spending on a very large specialized machine. Very few CNC bender manufacturers offer machines over 4-in (101.6 mm) of external power diameter as a standard catalog of items. Return on investment return (ROI) is the basic accounting procedure to determine the return of specific costs the money will give. Each company has a set of available options that can be unique to its corporate philosophy and capabilities. A common argument among management that is a reasonable payback period for capital investment. Many companies are looking for a one-year payback; the other three years, and some may set long-term goals. Many foreign companies with factories in the U.S. are set for a period of five to ten years of payback. Installation is very very very Payback suggests the practice of either fudging numbers or making the project useless. In any case, time and/or money is thrown away. Most successful projects are based on a payback of three to five years. The most basic approach to justifying a new machine is to see how many more parts per hour can be produced. Many variables can affect this analysis. The shape of the pipe, size, configuration, secondary operations and operator skill, among other factors, are directly related to the actual speed of production. Before a potential buyer looks at the projected production rate, he or she should be comfortable with the data collected on current production methods. More than one project failed miserably because the current methods were under-appreciated, resulting in anemic payback. On the other hand, there is a tendency for 201 217 Pipeline Processes: Comprehensive Guidance to re-evaluate existing processes. Measuring current methods is a variable that the manufacturer makes in-house. The tubular components purchased from the outside must be selected and the exact value set. Analyzing Bender's catalogs and communicating with machine sellers gives the impression that machines with the bend of small-diameter CNC pipes make a bend every two to three seconds. At any cost, the CNC bender should be able to produce at least 1,200 bends per hour. However, this conclusion is false. When the analyst adds five seconds of load and offload time, the figure drops to 450 bends per hour, assuming the single-bending parts are being made. If the observer is watching the operator for 10 parts, it may be true, but the real world is not so perfect. Fatigue, other duties, breaks and other circumstances must be taken into account to get an accurate picture. Table 4-2 compares the traditional semi-automatic bend with the CNC bend. The Bender semi-automatic tube will be defined as a hydraulic machine in which the operator must act the degree of bend by pressing the start button. The machine bends the tube. The operator acts a return sequence, manually moves the part to the distance between the bends and turns it into a position so that the bend or turn plane is made. Positions are achieved by a series of rigid mechanical stops with which part of the soybean contact. Table 4-2 shows actual performance for employees performing a range of other functions, including packing and installing end caps. The parts were 3/8-in (9.5 mm) steel tubes produced on the 1st (25.4 mm) power of the machine with an average production capacity of 500 pieces. Part D was part configuration with tube, charge port, and another tube brazed together. CNC table 4-2. Comparison of semi-automatic and CNC-bending number average CNC Части Части изгиба степени изгиба частей (изгибы)/hr (Изгибы)/hr A (401.30) (401.6) B (362.10) (506.7) C (239.34) 89.6 (537.6) D D 69.6 (696.0) 202 218 Justification and choice equipment Bender was capable of bending parts pre-brazed in the straight. The semi-automatic bender required both pipes to be bent separately, and secondary operations were then carried out to lure them to the charge port. Table 4-2 showed that if the details are relatively simple, the production differences between semi-automatic and CNC benders are minimal. However, there is a significant difference when part of the difficulty increases. The more bends the part has, the faster the CNC Bender becomes compared to the semi-automatic machine. When the operator has to manually uns disclose the part, fatigue, attention to accuracy and clean movement time have a big impact on the cycle. Table 4-3 illustrates the labor savings between CNC and semi-automatic bending. It is based on one year of production; works two shifts 220 days a year at a working rate of $15 per hour. Table 4-3. Labor Savings Between CNC and Semi-Automatic Bend Room Semi-Automatic CNC Labor Part Art Bends Parts/Y Arts/Year Ear Parts/Y Arts/Year Savings 1,412,576 1,413,632 $39 B 3,424, .528 $21,085 C 6,140, .392 $65,798 D 10 80, .992 $106,977 Transition Time. The time transition is another common benefit of the performance of the Bendera CNC. Table 4-4 shows the transition time to the same four parts using the $15 per hour labor rate. CNC Bender is supposed to have a program for this part stored in memory. Table 4-4. Transition time for semi-automatic versus CNC-bending number Semi-automatic CNC Labor Part Bends Transition, hr Transition, hr Saving $0 B $4.50 C $9.00 D $219 Pipeline Processes: Comprehensive Guide to Short Manufacturing Works require more switch time. Therefore, there can be significant savings from CNC benders for manufacturers that produce low volumes and/or focus on just-time stocks. The more bends the part has, the longer it takes to change over the semi-automatic bender. This is due to the fact that the process of positioning mechanical stops takes a long time and may require several adjustments to qualify the part as acceptable for production. The speed of the scrap. While many tube-bending operations do not actually have an exact way of measuring scrap, this is a tangible aspect of the justification procedure. Days of scrap barrel in the corner of the store quickly ends. More and more managers are realizing the impact of scrap rates on the overall profitability of their companies. Measuring the amount of scrap produced is sometimes overlooked during the justification process. This is especially important for a company that uses expensive or exotic materials. The aviation industry is a great example. The automotive industry is constantly working to meet weight restrictions, more frequent use of aluminium. In addition, automotive engineers design stainless steel exhaust and fuel systems for durability. Durability. which have numerous components, or many of the operations they perform before bending, can be expensive to throw away. Fittings or braces brazed on the pipe before bending can be costly. End operations represent a significant contribution of the workforce, which can also be miscalculated in the estimate of the cost of scrap. The effect of the part complexity on Bender's performance has been documented in previous sections. When looking at the speed of scrap the same is true. The CNC-tube bender can be modified more to produce an accurate 10-bending part in just a few attempts. In order to produce the same part on the semi-automatic Bender, it can take 10, 20 or more attempts. The operator's expertise is directly related to this. It is a partial basis for expression, the black art of the curve of the tube. The speed of scrap will also be very different for CNC and semi-automatic methods. Outside of the failure of the machine or tool, the CNC Bender should not produce scrap metal while in production. With manual or semi-automatic equipment, operator fatigue can cause scrap or, worse, defective parts. 204 220 Reason and choice of accuracy and repeatability of the equipment. Modern tube bends must be precise and repetitive in their movements. The overall guide is shown in the table 4-5. While the CNC bending offers unprecedented accuracy and repetitiveness of position, rotation and degree of bending, it does not guarantee that the part will be measured as such. It is important that the company understands that the machine can only bend within the materials used. Physical properties such as wall thickness, hardness, strength and external diameter, if not permanent, can have a direct impact on the part produced. Worn or inaccurate tools can significantly reduce the accuracy of the machine. If the company is going to spend six digits on CNC bender, then save on the toolkit, accuracy of the part and repeatability suffers. In fact, the performance of the machine can be seriously reduced. It should be noted: to add allowances to the budget of the project for good tools. It pays off time after time. Intangible assets. The intangible aspects of the bend of the tube may be most overlooked in the justification exercise. Conversely, more than one machine was purchased for reasons unrelated to the pipe bend department. If the company's finished product is something other than a manufactured tube or assembly tube, there may be additional benefits to control the accuracy and repetitiveness of tubular components. For example, an assembly operation with significant time spent setting up pipes to fit can affect the failure rate, especially in components associated with Freon or other fluid transfers. Table 4-5. Precision and repeatability for different methods of bending Semi- Semi- Guide ±'s automatic CNC position,? v. (mm) (1.3) (1.3) (1.3) (0.05) rotation ±,? Is the bend ±?? 221 Tube Formation Processes: Comprehensive Guide Guide engineers, if they are aware, can realize increased design capabilities that can give them more flexibility. A good example is a company that is committed to developing a smaller product, but because of the limitations of accuracy should allow for a larger envelope installation than desired. The emergence and implementation of statistical control of the process and increased attention to design have forced many companies to abandon disputes about contract awards. Numerous purchasing decisions depend on the factors that the tube manufacturer must meet before she or he is even allowed to quote. Leadingedge technologies can be an effective means of marketing the company's products and image. EQUIPMENT SELECTION Choosing a Bender tube from potential suppliers can be a long, involved process. Any good marketing efforts projects that one product is the absolute best for a given company. If a potential buyer has a lot of experience with bending the tube, it can be difficult to figure out what is important and what is not. Choosing the wrong machine can have a serious impact on a company's career, business relationships and overall performance. Two broad categories can be considered in the selection process: features and intangible purchase costs. Features of the machine function can offer a specific method of comparing different pipe-bending machines. Functions can be divided into two areas: a mechanical system and a control system. Mechanical Almost all pipe-killing machines use the same basic mechanical principles. Differences occur in several areas that may or may not be patented. Differences can be separated to cover either machines or specifications. The characteristics of the machine. The machine's characteristics are functions that affect the overall mechanical operation of the machine 206 222 Justification and the choice of equipment and its ability to bend the tube. The main similarities between product manufacturers make this area more receptive to sales and/or personal preferences. Rotation. Standard bend machines can be built with a swing arm rotating clockwise or counterclockwise. The configuration of the machine's part and interference zone determines which ones are needed. The potential buyer should pay special attention to the physical measurements of Bender's interference zones. These zones dictate the machine's ability to bend complex parts. If necessary, specially designed machines have been built to allow the configuration of certain elements. However, the economic impact of a special machine may outweigh its benefits. Speed. Published catalog positioning, rotating and bending speeds are not necessarily translated during a partial cycle. All manufacturers claim roughly the same axis speeds within this but the actual speed can be drastically different. Common parts over a period of time are more important than the speed of movement of the machine's axis. It's This. it is simply impossible to bend the part at high speed because the previous bends will be deformed if the part moves too fast. This is especially true for small diameters and soft materials. In practice, few manufacturers operate axis machines at high speed when the accuracy of the part and repetitiveness are paramount. The number of interference moves, neo-axis movements, production controls, load/unloading ease, and part configuration are more relevant to actual cycle speeds than to axis speed. Capacity. The potential buyer should be interested in the capacity of the machine. Bender tanks should be estimated by the thickness of the wall, the outer diameter, the material and the radius of the central line. The yield points and other indicators of the strength of the material can be applied to the machine's mechanical lever to determine the machine's capacity. A manufacturer producing large volumes of 1st (25.4 mm) parts should not buy a car with a rating of no more than 1 inch (25.4 mm). The consequences can have a direct impact on the life of the machine, the efficiency of the tool and the accuracy of the part. Buying a machine used today at maximum capacity can lead to problems tomorrow. Hydraulic system. Most semi-automatic and CNC-bending machines, especially large ones, use a hydraulic system. Effects of heat, cold, mud, etc., documented and impor- 207 223 Pipe-forming processes: Comprehensive landmark guide. The most accurate machines should include a heat meter to maintain the temperature of the hydraulic fluid. It is common practice to provide fresh cold water. Additional water coolers and special hydraulic cooling systems are also available if water is not available. Hydraulic oil filtration systems are usually standard equipment. The quality of the filtration system, however, is not the same among machines. It is advisable to exhaust the options available. Servo drives. Servomotors to control the movement of the machine tend to alternate between current (AC) or direct current (DC). Early CNC machines used dc servos, and they have been the standard for years. AC drives provide better speed and accuracy, as well as less expensive, more compact and easy to replace. This is primarily due to the fact that they work cooler at high speeds and have a much higher acceleration and slowing ramp. They are common in most machines today. Security. Service personnel can offer preferences based on their experience and judgment. Security devices. Semi-automatic machines usually come with a safety system to protect personnel from impact or pinched arm swings. Due to limited control capabilities and general requirements for bending machines, there are not many alternatives, except built safety systems or physical light security. CNC vehicles must be equipped with a safety mat to guard the front of the vehicle during operation. Double-palm buttons quickly replace the foot pedal Standard equipment. Other security measures can be easily added to the management format. Light fences, additional mats, fences, etc. can be added as long as they do not interfere with the tool area or parts bent. Serviceability. The service parts of the machine should be easy to find and identify. The valves and cylinders must have identification tags relating to function and electronics. Chain discs and wear plates should be easily adjustable and interchangeable. Grease fittings should be clearly marked and positioned to provide easy access. Grease fittings are usually called once a month. An additional automatic lubricant system can be reasonable for many companies. This will remove the error and facilitate much faster maintenance. Modern flexible machines do not require much maintenance, longevity and consistency. 208 224 Justification and choice of power transfer equipment. An important mechanical aspect of the machine is the method of transferring power to the head for the degree of bend control. The curving head gets the greatest voltage of any movement that the machine makes. The buyer should pay special attention to rigidity, maintenance, flexibility and design. The most common and time-tested method of testing head bending is to use a gear, sprocket, and chain communication to supply the strength of the arm swing. The systems have been designed to allow independent hand swings and motion tools, shaft energy transmission, belt drives, and rotary drives. Potential buyers should be aware that the size of the head bend can directly affect the machine's ability to produce parts. Specifications. The specifications are features that affect the specific functions of the machine. Manufacturers can vary greatly in this area, and differences can directly affect the performance of the machine. The potential buyer should pay discriminatory attention to the details of current and future needs. Multiple-radius capabilities. Many design engineers today indicate more than one bend radius. The feature offered by almost all CNC-bender manufacturers is the ability to bend the part on more than one radius of the central line. This is achieved by laying the toolkit. Then the part is passed between the bend dies. Another use for this feature is to transfer the part between the connection bending dies and other special tools. This can allow the parts to be bent in a single installation that otherwise may take two or more operations. The first method of transferring pipes between dying moves is the bend of the head. The head can move up, down and from side to side. This essentially moves the toolkit into a piece. The problem with that is that the heaviest part of the machine must be precisely moved and moved. The bend head is one of the areas of the machine that requires absolute rigidity to ensure the effectiveness of the tool and the accuracy of the part. Wear related to Additional moving parts can affect the overall accuracy and maintenance requirements of the machine. The second approach moves the bend of the head and parts. The instrument area can move from side to side, and the part, by positioning with the coach, moves up and down. Conversely, some machines move part from side to side with toolkit up and down. Special Tool 209 225 Tube Formation Processes: Comprehensive Guide and/or Parts of the Configuration may arise where this may be a necessary method. Any system still requires the turn of the most severe and critical area of the machine. The third method only moves a part. The tool area remains fixed while the carriage holding the part moves up, down, left and right. The rigidity of the tool area is not compromised, there are fewer moving parts to service, and there is greater flexibility in designing tools. Regardless of how the tube is transferred to bend multiple radii, you should pay attention to the placement of the tube, which is not straight. The onion in the tube can create problems. Most CNC benders use pipe support and/or a guide to provide a tube position in tooling. Although it is not necessarily standard equipment, it is crucial to ensure the success of bending multiple radii. Help with death from pressure. Pressure assistance should be considered an option for any machine with more than 3/4 inch (19.1 mm) power. The pressure to die help offers a significant improvement in the quality of the bend and a certain likelihood that efforts to eliminate mandrels and/or windshield wiper dies will be successful. There is no increase in cycle time, the cost is minimal compared to upgrading later, and the benefits are palpable. The clip for disembarkation. The drop-off clip is standard for most CNC machines. The machine's jamming zone is noticeably improved by the angular movement of the clamp-die assembly, which is partially drawn into the swing arm. This allows the formation of a more complex part with less chance of machine interference. Colleting. All machines have some colleting or tube-toting tools. Most are a way to control how far a caller opens. This allows you to make a toolkit to understand beyond the installation or end of the form. It is important to note that some projects achieve this better than others. It is necessary to ensure that the internal diameter of the spindle is large enough to accept current and future projects. The most widely used collet in small machines includes three jaws. Four jaw systems are available for square or rectangular tube shapes. Large machines can use rubber collets or internal collets. Part configuration determines which method 210 226 Justification and choice of equipment extractor Mandrel and lubricant. Mandrel extractors and automatic mandrel-lube systems may not be used on smaller machines. Big machines should definitely have an extractor mandrel. Automatic munrel lubricant can increase the life of the tool tool improve the quality of the bend by taking the margin for an error from the hands of the operator. Numerical Control Systems Computer technologies today offer unrivalled control over a variety of machine and programming functions. Discussion of computer functions in this book is mainly applicable to numerical control computers (CNC). The control system and software have a direct relationship to the performance of the machine. Computer technologies vary between manufacturers of CNC-benders. Therefore, it is important that the potential buyer has the practical experience with as many controllers as possible. Almost all working tube bend machines use components such as relays, power supplies, and switches common to many other electrically controlled devices. There should be a series of sensors and coders throughout the machine to provide machine position feedback to the computer. You can use 1,25 command boards to control the functions of the machine. It is important that the buyer focus on the functional aspects of the machine control system. Dust and heat-controlled electronics. Exposure to heat and dirt on complex electrical components can lead to machine outages and inaccuracies. However, modern electrical systems are reliable in harsh conditions. The computer systems used in cars are a good example of improvements made over the years for this type of application. Data entry. The data is usually entered through the keyboard and can be seen on the cathode beam tube (CRT) screen. Data input can also be done either by traditional buttons included on the CRT as a touchscreen or by a membrane panel. The traditional button approach can become sticky due to dust and dirt. Plastic treads are available to minimize the impact of dirt in keyboards. The touchscreen is very susceptible to grease and dirt on 211,227 pipe-forming processes: the operator's hands are a comprehensive guide. In addition, screens can be a source of frustration and slow-motion input, because it may be unclear which area has been affected and how many times. This is especially true when you enter sequences of numbers. The membrane panel offers the best approach. It is not subject to dust, can be erased easily and provides a certain position of contact. Color CRTs, graphics and large screens should be approached with caution. Simplicity and functional design should be the rule. Storage of data. You should avoid long-term storage in the electronic memory of the CNC controller because it can lead to data loss. You should be able to provide a printed copy of the program. If the controller fails, the data may be lost. Constant storage is achieved by tape, floppy disk, data cartridge, or hard wire transferred to a secondary computer. Tape storage is probably the oldest method to date. Without Care, the tape may be damaged and the device will be susceptible to dirt. Use with secondary computers tape reader for data translation. Disk storage gives you an edge over other methods. Discs can be used on a secondary computer for additional manipulation of data. Floppies are less prone to crash due to dust and dirt. File management techniques are also simplified. Data cartridges are unique to this brand of equipment and are generally very reliable. Cartridges are expensive and require additional equipment for use on secondary computers. Linking a bender to a secondary computer is an option if the manufacturer wishes to store or manipulate data in another area of the plant. A secondary computer must have the necessary software to analyze the data transferred. Restrictions on distance from the bender and interference from high-voltage equipment should be considered. Data output. The printer in the control system allows you to get information about the part, what is in storage, and about the diagnostic functions of the machine. This is valuable information that can be used to validate data, manage storage, and improve diagnostic efficiency. Management of pedestals. Setting up the machine requires easy access to manual functions on the controller. Controllers are usually placed on a rolling pedestal or an adjustable column attached to the machine. Moving secondary pedestals 212 228 Reason and equipment selection provide start-up, stop and emergency-stop functions while the machine is being installed. This reduces the time and effort required to load and unload the machine. Production management. Some controls are not common to all CNC machines. Intermediate pressure-to-die positions, plane-bend delays, and swing-hand-return delays significantly improve machine performance. Intermediate pressure-die positions allow the open pressure assembly position to die, which will be selected during automatic cycling. This reduces the movement of the machine, thereby improving the cycle time. Half of the die position can be irreplaceable when trying to cycle pipes that are not straight. Basically, it acts as a guide to ensure that the tube stays in the bend-die tube groove. Plane-of-bending and swing-hand-return control delays act as alternatives to programming avoidance or clogging movements. These latency controls provide a method for adjusting the machine's synchronization sequence. In many cases, this eliminates the need for a separate line of data in the program. This improves programming time and machine cycle time. Serviceability. Unlike machine mechanics, the machine control system is something that service personnel are usually unfamiliar with. Nine out of 10 machine problems not solved by maintenance personnel in devices caused by a malfunction of the control system. You should identify command and control tips that are easy to replace. Repeaters, switches and related components should be available. Sensors and coders must be resistant to dirt and to avoid excessive wear and tear. Finally, an accurate machine maintenance guide and/or video recording should be mandatory. CNC software. The CNC-bender software should simultaneously and increase the control system. Convenient software should not be taken for granted. The only way to be confident in friendly software is to get first-hand experience with the machines being considered. The following sections outline the main operational and control characteristics of the CNC-bender software. Operational software. The software that guides Bender's work is considered operational software. Although it is closely related to the control system, the operational software is a vehicle that tells the machine what it should do. In addition to controlling the machine's motion sequences through 213,229 tube formation processes: Comprehensive Closed Feedback Guide, this software provides critical data entry and channel format. Simultaneous programming. Being able to program the next part without interrupting production is a valuable feature. You can build multiple parts in advance, eliminating the need for computer recycling. Benefits directly reduce the transition time and increase the portion over a period of time. Consistent production. Consistent production is the ability to produce several different parts in a row. This can be useful for the production of multifuses assembly tubes. PrB entrance. Typically, traditional position, rotation, and bending (PRB) data can be entered in the form of a diagram to create a bend program. The machine accepts information similar to that provided in Table 4-6. Table 4-6. Position, rotation and bending data of Part 1123B External diameter (25.40 mm) Material steel wall in. (1.65 mm) Bend radius in. (50.80 mm) Radius of the bend at end of bend (63.50 mm) Although the categories of material, outer diameter and walls mean nothing for the machine is useful for the machine to be stored with each part of the room. This ensures that materials are properly selected when recovering data from the store (see table 4-7). The loading position is where the wagon is when the operator gives it a part. Offset the position where the carriage moves for the table 4-7. Information stored from each part of the number 1123B Loading Position 104 Offset Position 88 Pressure-Die Point Collision 8 Bend-Die Point Collision 3 Booster Mode 5 214 230 Reason and Choice Equipment First Bend. Pressure and bend collision points are positions where the coach comes into contact with the instrument. Collision points protect the car and tools and are used as a reference for other movements of the machine. The booster identifies a stop-point for the aid unit to assist. Settings on this screen can be set numerically or by physically moving the wagon to the desired point and pressing the insert position. It is important that Note that all the bending machines are not the same here. The difficulty of entering these numbers ranges from simple keystrokes to scrap metal calculations (see table 4-8). This is where the specific bend data is entered. The dot number is automatic. The radius, the distance between the bends, the bend plane, the degree of bending and the speed of the axis for each can be entered sequentially or accidentally. Table 4-8. Bending data to enter the CNC system Distance between the radius of the process, bends the axis axis of the axis in. (mm) (Feed) Speed bending speed bending, Speed (25.4) (50.8) (50.8) Processes. Most CNC bends allow you to enter bends and clog movements on the bend. While this may seem excessive, many users have requested an additional increased capacity of more than 60 bends per piece. Manipulating and storing piece data in electronic memory allows the operator to access faster than relying on tape, floppy disks, cartridge, and so on. etc. It can also be used as temporary storage until the design part is completed. The process of debugging the new part of the program is much easier if the initial attempt can be broken down into separate movements of the machine. Interference points, tool modifications, and speed changes can be marked and corrected in this way. It is important to have 215,231 pipe-forming processes: Comprehensive guidance to note that each individual motion machine can be separated in a program to create individual bend sequences. The more difficult the part, the more likely it is. Management software calculates, measures, and records data to manipulate operational programming or to output to the operator. It can be valuable and is not always offered as standard equipment by CNC-benders. The following sections outline the main features available. XY coordinates directly from CAD drawings or projects can be entered in the same way as PRB data. The coordinates are then processed and converted into traditional bend data. Cut length, extended length, and offset position are also calculated and displayed. This feature can be an excellent time saver if the engineering department is often behind. Reverse bend calculations. Many times the bend sequence makes it impossible to bend the part as entered. However, if it had been started from the other end, it would have been a cycle of fine. Reverse bend calculations automatically flip the tube over and start bending at the other end. This feature can shorten programming time and eliminate the great frustration associated with complex parts. Diagnostics. Three areas of diagnostic function should be standard equipment on machines with cNC bending with CRT output and printer. Some have a modem connection to connect to the manufacturer's service. First diagnosis determines the current state of normal functions such as activated emergency stop, automatic mode, illegal data and manual mode. This first diagnostic area is regularly used by the operator and is the first logical step in finding the machine problem. The second diagnostic area is the machine's performance indicator, which should provide a systematic overview of every large mechanical system on the machine. All cylinders and side engines must be positioned and identified if they do not reach the target location. This identifies a cylinder or engine malfunction and the possibility that position sensors are not working properly. 216 232 The Rationale and Choice of Equipment The Third Area, I/O monitoring, should provide data on entry ports, exit ports and codeframes. Binary code readings on these systems indicate which command printed board or encoder is faulty. It is normal practice to fax this display to the central service center. Trained professionals can analyze this information much faster than most maintenance personnel. If the object is within the ride, the service technician sends spare parts at the postal service night. This approach is fast and economical. Springback and lengthening. Springback is measured manually depending on the degree of bending, then it is automatically applied on a straight basis to determine the value of compensation. Thus, a 90 bend measuring 2 springback applies to the bend program for 45 bends like 1. The extension is measured automatically or manually and applied to the bend program. This is achieved through closed feedback between the carriage and the head bend. For example, if the machine makes a bend, the rear end of the tube should move forward at a given distance, given the bend radius. The machine measures this difference and applies it to the bend compensation values for the distance between the bends. Counter and work reports. The counter provides the operator with a method of accurately determining the desired and produced required number of parts. This can eliminate the incorrect calculation of the production run. Work reports can display and print daily tact times and count a series of production launches. Reports measure the actual time of cycling, the number of parts produced and the time during which the machine is in automatic operation. They provide the evaluation or industrial engineering departments with specific data on cycling. They can also be used to justify automatic system loading based on actual manual loading and unloading times during a production run. PURCHASING CONSIDERATIONS There are intangible factors that are separated from the immediate physical properties of the machine They are 217 233 Pipeline Processes: Comprehensive Leadership should be conducted in high regard, but should not dictate the selection process Possibly). Delivery is always a problem. Bender manufacturers often stock up on more popular models of machines. If the machine is ordered in a warehouse, it can usually be delivered anywhere in the United States within one or two weeks. Ordering a specific machine at the plant can take four to six months. The characteristics of the manufacturer characteristics of the bender-machine company is considered to be important. The manufacturer of the Benders tube should have a good reputation and be solvent. The best way to learn about the manufacturer is to talk to people. A potential buyer needs to figure out who is using the machine manufacturer and see what kind of business they ising people in the pipe-making business should be called. A small study before committing significant capital expenditures can prevent a disaster. Location Choice Machine based on where it made discounts the whole selection process. Capital equipment should stand on its merits. Personal preferences should be rejected in favor of doing what is right for the company. Protectionism does not reflect American competitiveness abroad and is inconsistent with capitalist ideals. Conversely, it is wrong to buy based on the idea that, because it is from a given place, it should be the best. The equipment supplier organization has a significant impact on the overall success of the project before and after the purchase. Service calls of technicians cost $per hour, plus costs. The availability and qualification of service personnel directly affect 218 234 The rationale and choice of equipment for the cost of calling the service. Recording the ability to modify electrically programmable programmable memory-only (E-PROM) programs and provide RS232 or other interface methods may indicate the competence of the service organization. This may not be necessary for the buyer now, but future changes, maintenance, expansion and automation bender requires this experience. If possible, it may be appropriate to visit the manufacturer's service facilities to determine the extent of spare parts stock and the quality of service technicians. BIBLIOGRAPHY Miller, Gregory G Reason Pipe Bender Shopping. Dearborn, MI: Society of Manufacturing Engineers who justify, choose and implement pipe-bending techniques. Dearborn, MI: Society of Manufacturing Engineers. Stange, Ronald R Major tube bending the manual. Dearborn, MI: Society of Manufacturing Engineers. 219 235 236 Tube End Formation 5 Tube End Formation METHODS AND DESIGNS Pipe end forms are essential for many tube applications. They are used to create some type of connection with other media (tube, hose or block). In most cases, they can be formed by any style of the tube, although there are some discussed further in this chapter. The formation of a cold end is a process that has been around for many years, but many changes change were made by the automotive industry. Finding cleaner, lighter and better ways to move fluids through systems found in the car fuels research for stronger end forms. Tolerance has been tightened to minimize the possibility of leaks. The elimination of the rations has also spurred some of the best projects. All this history and innovation positions the shape of the end of the tube as an essential part of the fluid processing systems found in many products. There are five main forms that can be applied to the end of the tube: reduction, extension, flash, ball, and impact (thickening). Cuts and extensions are simple if both are not made on the same end of the tube. Consistent cuts and extensions can create many problems. Burning allows you to use the end view in many new applications. Beading has advanced significantly and allows engineers to keep the best tolerances and produce the best compounds. These apps are discussed in detail throughout this chapter. 221 237 Tube-forming Processes: Comprehensive TUBE REDUCTION Guide Depending on the product being formed, ram formation is one of the most commonly used methods of reducing the tube. This method holds the tube motionless and forces you to reduce the impact above the end to reduce the diameter of a particular section. The 5-1 figure illustrates the shock of completing the cut. For some applications, the pilot can be added to create a reverse extrusion that will control the internal diameter. The main impact on the reduction (see figure 5-1) consists of four sections of passage for the tube. The tube is part of the so-called tube-sized section, which is no more than the outer diameter of the starting tube. Capturing this section helps maintain the tube and minimizes the backup or bulge of the material. Then the tube is in the transition section, which begins to reduce the tube to the desired measurement. The tube is then moved to an area of size that controls the outer diameter of the end of the tube. The final punch area provides relief for the tube and the usually oversized inch (0.13 mm). This area minimizes friction on the pipe as the impact passes through the cycle. It also helps prevent springback on the end of the tube. Springback gives a flared look to the end of the tube. The thickness of the wall, the strength of the column and the composition of the material play an important role in the degree of reduction. All these drawings are 5-1. Jaws and reduced impact. 222,238 Tube End Formation above the elements, the average reduction for each operation is 2 times the thickness of the wall. Each type of metal reacts differently. The general rule for total carbon and stainless steel is the softer material (annealed), the better the tube reacts to a cut kick or die. The tube can be reduced to 20% in diameter. Conversely, the more complicated the more likely that the tube under the decline emphasizes as he tries to try retreat from initiating force. Copper and aluminum tubular materials tend to react in reverse order. The strength of the column is smaller in the softer material, and the tube tends to go away and start from the force. Reducing the thickness of the wall by 2 times can exceed the possibility of a softer material, and the degree of reduction should be reduced. When cuts are much higher than 2 times the thickness of the wall is required, then a few cuts are needed. Reducing the tube by more than 20% can cause the tube to plunge into the transition zone. Instrumentation of wear and tear are important factors to consider when reducing, because the internal force in the kick takes the greatest punishment, and that, in turn, can change the size of the outer diameter. When the size of the end of the tube has been changed, the wall will thicken and the length of the tube will increase. The following equation can be used for practical but not precise value for growth in length: D L'D, where: d d l (5-1) L - tube length, B. (mm) D - external tube diameter, b. (mm) d - internal diameter tube, B. (mm) D 1 - outer diameter section reduction or expansion, b. (mm) The purpose of the completed tube dictates whether the outer or internal diameter is relevant. Some aluminium tubes allow you to control both the external and internal diameter. In most common applications, the outer diameter is usually a controlled party. The size of forming a punch in the right dimension and forcing it over the tube end can reach control. Admissions range from 223,239 pipe-forming processes: A comprehensive guide based on the use of the finished product and tubular material. Most often tubes the size of a V. (0.13 mm) more. In general, when creating a contraction, the inner mundrel is not needed. A material that has low strength may need mandrel if the tube has a tendency to collapse in the transitional impact section. When a part requires control of the internal diameter, it is likely that the outer diameter has control or tolerance placed on it. The next operation involves a blow with the size of a mandrel for the inner diameter. This kick looks like all other blows except the fluke flow will only be for relief. This requires that the stack-UPS is properly tooled and minimizes the transition. Although problems are created, most configurations can be formed. In the figures 5-2 and 5-3 the tube is carried, which controls the outer diameter during the reduction of the tube. The internal pilot will pass through the tube while the impact is being retracted. Diameter and the size of the outer diameter of Figure 5-2. 5-2. extrusion (position to jaw). 224 240 Tube End Formation Figure 5-3. Reverse extrusion (jaw entry position). Tools must line up and perform the size at the same time to ensure unified consistency throughout the reduction. The premature-size effect can be an intolerant end form. The transition section is the key to the quality of the end forms and the longevity of the life of the tool. The angle during the transition should give the best results. More than 30 angles can cause tube wrinkles, or if the strength of the tension is low, the tube can bulge and push back into the face of the jaw. Following this corner is a radius that mixes the tube with an area of size. The radius should be approximately 0.25 inches (6.4 mm) long. This radius will help reduce friction and prolong the wear of the punch. When a steeper angle is required than 30, the percentage reduction should be lower due to the higher compression load forced onto the tube. Where the angle of the cone is smaller than recommended, the percentage reduction is less due to the friction build-up from the larger impact surface exposed by the tube. For these reasons, the 30-one angle of the cone supports the least friction-compatible pressure. Reducing the area is a key factor in the success of the reduction. The correct lubricant and pressure valve to drop into the punch also provide proper formation. 225 241 Tube Formation Processes: Comprehensive Guide to TUBE EXPANSION Expansion, of course, the opposite of reduction. Unfortunately, there are a few variables in the tube that make the previous statement not so easy, at least in any situation. Several situations may require fewer or more bumps. The first element to consider is the method by which the tube end is formed. There are three common methods. Method A uses a ram machine. This method uses the same methods and is usually the same machine as the abbreviation. Differences are first seen in the formation of the punch and the clamp of the jaws shown in the 5-4 pattern. The enlargement punch resembles the inner diameter of the tube. There's a 5-4 pattern. Expanding punch, tube and jaws (expanding jaws). 226 242 Tube End Forming may be some difference, depending on the degree of cone angle present during the transition period. The impact can also be an insert attached to the end of the tool stack. This is to ensure that the extra travel time required to strike is necessary; Speed up the transition time tooling, and minimize the cycle time and tool cost. The ram or axis of the traverse forces the tool into the tube, creating an extension. If the inner diameter of the tube is crucial, the end can be formed inside the jaw. When the outer diameter should be controlled, it is best to form an extension with a jaw cavity The purpose of containing expansion is to minimize or or arches that can be created in most aluminum, carbon and stainless steel. Bypassing the impact into the tube creates a great load on the outer walls, and they tend to bow outwardly. The clamp-jaw cavity squeezes the material back into the punch. The angle of the transition also plays a key role. No more than 15 corners of the transition period are difficult to reach. The radius at the beginning and end of the transition helps speed up the process of making a hit, and prolong the wear period by extending the expanding impact. The sharper the angle, the greater the tube trend to try to continue flowing towards the corner. All the same factors that apply to reduction are applicable in this form: the thickness of the wall, the strength of the column, and the composition of the material. Expanding more than 135% tube diameter can thin the wall and possibly crack the material. A second or third impact of expansion should be added to the operation when the extension gets closer to 135%. When other extension tools are added to the operation, the degree of formation should be evenly distributed between the impacts. If two strikes are used, the first strike should expand 50% of the desired size, and the second blow should expand the remaining 50%. The tool's lifespan is extended and better extensions should be made. The same restrictions on the strength of the tube column used in the reduction also apply to expansion. A tube with low column strength folds up when the strength of the ram exceeds the strength of the tube wall. The actual strength of the column changes along with the tubular material and can affect tolerances. Tube with tolerances for 227,243 pipe-forming processes: Comprehensive guide inside and outside diameters is difficult to hold if the thickness of the wall is uniform. Copper tubes have the most difficulty holding both tolerances. Traditionally, the thickness of copper pipe walls can vary ±0.01 inches (±0.3 mm), while the industry standard for other pipes is ±0.003 inches (±0.08 mm). As with most types of end forms using the ram forming method, lubricant is very important. It is recommended to draw a combination of good lubrication and high strength of the film. There is not a single oil that fits all situations. Different metals require different formulas. The operator must contact the lubricant supplier to get an accurate formula for the forming requirements. The power of the punch/tool is also very important. Heat kick treatment helps to increase hardness and prolong the duration of wear. In some cases, a thermal diffusion process is necessary when dealing with high wear strokes or abrasive tubes. This process should be taken into account at the end of the formation of most steel pipes. The volume of the ends that need to be formed and the type of final form should also be factored into the decision. Two other methods of expansion formation, B and C, are radial-force rolling and radial-axial force Accordingly. B is effective when you need to achieve a relatively sharp transitional shoulder. The clamp jaws work the same way they did in previous examples. After the jaws clamp the tube, the mandrel extension enters the tube and then compresses the tube against the cavity in the jaw clamp. Most or all of the tube's ovality can be removed and close tolerance can be carried on the outer diameter of the extended section. This method is especially suitable for roll-sized pipe ends. Radial-force rental minimizes the effect of variations in the thickness of walls. The welding flash on the welded steel pipe can be reduced due to the compacting effect of the expansion of the mundrel. Extending length can be a problem if it is more than 2 inches (50.8 mm). The material tends to deviate and the tapered extended section usually results. Figure 5-5 shows the C extension method, which can smooth out the section as it expands. This form end method can be used to penetrate further into the tube than the radial extension method since interaction with the length of the tube can be limited to a relatively short distance. The deviation of the expanding mundrell within the limits of Mundrel fatigue does not have the same detrimental effect on the maintenance of the size faced by 228 244 Tube End Forming Figure 5-5. Expanding the tube with axial and radial forces. The method of B. Tube lubricant is not essential for methods B and C due to the rolling action of the mundrel. When the diameter increase is severe, cladding and a small chamfering operation are recommended. This prevents fractures from beginning at roughness points at the end of the tube. The length of the tube is reduced by all three methods, because the transverse area in the extended section is larger than the transverse area of the tube, and the length is collected to make a difference. The 5-1 equation can also be used to get an approximate length of reserves needed to obtain the desired extension length. Compensation can be resolved in the transition zone from the tube to the extended section. Cross area at 229,245 Tube Formation Processes: Comprehensive point guidance halfway through the transition can be used for practical purposes. It is not uncommon to experience an unequal length reduction about the circumference of the tube. The larger the expansion, the more pronounced this characteristic is. This result is more pronounced on a welded steel pipe than on seamless pipes. TUBE FLARING Single FlareRing is defined as extending or opening the outside end of the tube. In this process, the same three methods of extension formation are used, because in fact there is an extension. Method A, illustrated in figure 5-6, uses the process of formation of a ram. The same ram-forming machine used to reduce and expand can also Burning. This end-forming style is the most versatile all-purpose has a faster cycle time than other methods. These benefits are also transferred to a machine that is cheaper to operate. The clamping of the jaws is the same except the burning occurs in the flash cavity cut to the jaw. The impact resembles an expanding impact only with the entry and transition area. In most cases, this kick is an impact that fits into the impact holder or tool holder. This reduces the cost of the toolkit and facilitates the transition of the toolkit. A punch or tool passes the nose hitting the tube, which helps the center of the tube. The transition area extends the tube to the jaw cavity, creating a flash. Most single outbreaks are made in a single operation. Method C (Figure 5-7) is a compromise between methods A and B, as radial and lash forces are each smaller than those required by methods A and B. Methods B and C are the intended flash site through a mobile impact action or instrument without the use of a higher formation pressure. Shorter clamp blocks can be used by C than A method required. Method C works best on larger-diameter pipes with a thicker wall. Method B, shown in figure 5-8, uses radial forces for formation, which requires more bias to form a single flash than method C. This requirement limits the use of method B in size 230 246 Tube End Formation Figure 5-6. Flash blow with tube and jaws, pipes with a diameter above 0.75 inches (19.1 mm). The tubes should be loaded over the mandrel/tool and against the shoulder on the mandrel/tool for correct positioning. The B clamp pressure method, sufficient just to compensate for radial pressure formation, allows for shorter clamp blocks than methods A or C. This function is desirable when the clamp area is very minimal and when a serious increase in the diameter of the flash is required. Rolling allows you to gradually form around the circumference of the tube. The thickness of the metal in the flash cones from the thickness of the tube wall to the minimum wall at the outer diameter of the flash. The inner diameter of the flash is always larger than the outer corner. This thinning is less pronounced with rolling techniques than with straight line or ram forming method. Incorrect tuning of rolling tools without adequate pressure and control of passage can over-bomb the metal seat. 231 247 Tube Formation Processes: Comprehensive Guide Figure 5-7. Rolling flash with a 1ed and radial force. Flare Double flashes are found in applications that connect one tube to another, thereby minimizing the leakage path. For example, a laminated tube or welding tube provides a stronger base of connection for tubular assemblies. Two methods of producing a double flash internal double flash and external double flash. Inside the Double Flare The first method, inside a double flash, is the most common double flash. It's This. Two flash kick operations, but requires only one 232 248 Tube End Formation Figure 5-8. Rolling flash with radial force. set of jaw clamp eliminating the need for a transition tool. Figure 5-9 shows the first operation, which is a single tube flash and produces disorders for the next operation. The second incineration strike puts the tube back on itself and closes the ball. Coin pressure is desirable to provide a satisfactory place. There is little or no thinning of the metal wall as the precipitation process places the metal predominantly under compression stresses. The end of the tube becomes a flash seat with a double circle. (The presence of a circular ring in the seat is sometimes misinterpreted as the beginning of a fracture.) The width of the flash site is limited to the size of the diameter of the ballroom. Attempts to exceed this limit can lead to the collapse of the metal formed in the double ball at the first operation. Welded carbon tubes have the potential to break along the welding seam. With this approach, you need to use a higher grade of steel. 233 249 Tube Formation Processes: Comprehensive Guide Figure 5-9. Double flash (first and second surgery). Outside of Double Flare, the B method shown in Figure 5-10 is commonly referred to as the external double flash. The first operation lays the metal outside the tube in place, curling the blow curls of the tube and turning it around back into the jaw face, creating a ball at the end of the tube. The second operation requires changing the clamp of the jaws to those that have a burning cavity in the front. The second blow of the operation then close the ball, creating a double wall. Little or no thinning walls are experienced. Coin pressure is again desirable to ensure seat quality, and analysis of curling operations shows limitations in the size range and width of the seat. The external radius of curling should be 2 to 2-1/3 times the thickness of the tube wall. The increased diameter of the end of the cork places the metal under stress, which is limited by wiring (percentage lengthening) of the metal. Strike Action sets friction from behind the surface of the 234 250 Tube End Formation Figure Method B to produce a double flash. 235 251 Tube Formation Processes: Comprehensive Guidance Works. Excessive friction when the tube's surface comes into contact with the impact can cause stress that exceeds the strength of the column of the unsupported part of the tube. As a result, the tube buckles or collapses before impact. This friction, when carried out within reasonable limits, creates compressed tensions to balance stress. Thus, little has changed in the thickness of the wall. SINGLE-LAP FLANGE Single-atein flank is used in several applications, including locking nuts and connecting to a mold or metal plate. Two methods are usually used to form the same flank. The first method (figure 5-11) uses the formation of a ram to influence the tube. The jaw clamp ensure the tube is in place, the nose of the first impact enters the tube, and the conical transient area directs the material to erupt. The jaws remain closed, and the second blow goes forward and moves the end of the tube back against the jaws chasing the surface. The advanced position of burning the punch should be controlled to avoid excessive pressure, to build up in the radius between the flash and the tube. Failure to limit forward traverse-burning kick can lead to unnecessarily thinning of metal and test failure. Only the percentage lengthening (extension) of the metal limits the height of the flank. For example, if the physical properties of the metal indicate an elongation of 30% to 2 inches (50.8 mm), the diameter of the flank may be about 30% larger than the diameter of the tube. For a standard welded steel tube, the diameter of the flank should be limited to a 25% increase for good results. Under certain circumstances, a single-can-see operation can be performed with a single blow. The first combustion operation can be eliminated if the flank height is low in proportion to the diameter of the tube, and the outer radius of the transition between the outside of the tube and the back of the flank is equal to or exceeds the thickness of the wall. The second method of forming one flank rolls the end with radial pressure force. Figure 5-12 demonstrates the process. This rolling method is only suitable for swinging pipes above an inch (19.1 mm) diameter. The method allows for formulations of relatively high flanks in a single operation. Spiral serrations at 236 252 Tube End Formation Figure Method A for one circle flanging tube ends (direct line of motion). outside the flank seat is caused by the formation of a radius of transition between the horizontal and vertical work surfaces of the flank mandrel. The larger the transition radius, the less pronounced is the appearance of serration. As in the first method, the percentage of material lengthening limits the height of the flank. 237 253 Tube-forming processes: Comprehensive method of A-list guide B for one circle flanging tube ends (rolling with radial force). In both methods, if the desired flank is relatively high, consider cladding and chamfering operations before flanging. The quality checks before and after the formation must be performed, because any rough edges or dents present on the pipe can be the starting point of fractures as the metal thins during formation. DOUBLE-LAP FLANGE Double flank is a closed ball, transferred to the end of the tube, providing a double thickness of metal in the flank seat. When the diameter of the flank does not exceed 125% of the diameter of the tube, the method of formation of the ram can be used in one operation. When the diameter of the flank exceeds 125% of the diameter of the tube, the large open ball at the end of the tube should be rolled up force on the first operation and then closed the ram formation in the second operation. 238 254 Tube End Formation Tube BEADING Tube Beading has probably seen the most growth and progress among many different end forms. Internal roll formation methods have good tolerances, but are usually slower. Ram formation has developed and become a faster solution, with most beading applications in the automotive field using this method. When high production volumes are mandatory, the short cycle time yields good results. Method A uses axing pressure and provides a wide range of beading possibilities. The machine and jaw clamp are the same style as used in previously discussed endoformation techniques. In most cases, clamping jaws have serrations cut into the jaw cavity. The serations, which range from an inch (mm), are perpendicular to the pressure of the aus, which prevents the tube from sliding back into the jaw. Serrations should be a part of each jaw where the pressure is applied (see figure 5-13). Figure Jaws serration pattern. 239,255 Pipe-forming Processes: Comprehensive Guide Simple Ball with a height% of tube diameter can be formed in a single hit application. The thickness of the wall should remain the same, giving the ball a thickness twice the thickness of the wall. When forming very large beads over 200%, it is best to end up with some pipes and then cut them through the middle and measure the thickness of the wall. The ball can form either in the jaws of the clamp, or in the shape of the impact. Both applications are quite equal in function and quality, but if there is a difficulty, the formation of the ball in the cavity of the jaw clamp gives a better chance of recovery of the operation. For example, if there is too much exposure outside the jaw material, excess material fills the jaw bead cavity and flows out of the jaws. When the jaws open, the tube can usually be removed. When a tube ball is formed inside the punch, the excess material first fills the punch cavity and then flows out. In some situations, when the punch returns home, the end of the tube is separated from the clamped tube and sticks to the punches. This end of the form is extremely difficult to remove from the impact. The formation of the ball in the jaw clamp is the method most recommended by toolbox providers. A completed product usually dictates the method by which the o-ball is captured. Ram formations can also be used to form a ball larger than 140% of the diameter of the tube. This end shape uses clip jaws to hold the tube, which is extended to desired ball heights by using an extension punch. There may be some minor walls thinning that depends on the amount of expansion. Once the extension is complete, another impact passes and reduces the tube to the pilot's diameter. The third blow moves forward forms a ball. It is best to form a ball in a kick with this scenario because it avoids making the jaw clamp jump on on Blow. The three-stroke end-forming machine also eliminates costly tool transitions because the tool owner indexes each tool into a position of formation. Several beads can be formed using extension and reduction techniques. Some double or hose ball/foot beads end shapes can be completed in one stroke with a single stroke with sliding jaws. Sliding jaws consist of two sections. The first one holds the phone in place. The front section also clamps on the tube, but moves backwards and an inner ball appears as soon as the kick hits the front of the jaw. The punch forms the front ball as soon as the rear ball is formed. 240 256 Tube End Formation of the distance between the two beads is the determining factor of how effective this method is. The composition of the material and the thickness of the wall determines whether the sliding jaw process can be used or whether the secondary attachment of the jaw would be better. The diameter control of the ball is affected by many different variables. The material flow should always be evaluated because it varies depending on the tube material. Controlling the flow with the pilots in the impact significantly improves the sequence. The thickness of the wall is also difficult to control. Soft copper, for example, makes the diameters of the ball vary. Outside the jaw the material directly affects the height of the ball. Capturing the ball in the jaw or in the impact can control the height of the ball. Adjusting the tube stop in the right position captures this material. All of the above elements, as well as the machine, which has good repetitiveness, helps to ensure a successful process of beads. TUBE GROOVING There are two main grout operations. The roll groove exerts radial pressure on the tube with single or several rollers to force the material in the desired diameter. The incision groove again uses radial pressure with one or more incisors to remove the material and avoid the inner ball. This book discusses the use of multiple videos and incisors in comparison with single rollers and incisors. Restrictions on material flow and control are also considered. Roll grooving uses radial force on a stationary tube. Setting voltage compression in metal minimizes the thinning of walls. Compressed voltages counteract the intense loads caused by drawing metal over relatively sharp radii. The pressure clamping technique is similar to the methods of formation of a ram. The clamp jaws need serrations to hold the tube and prevent any movement. Again, serrations should be ground about an inch (mm) deep and run longitudinally with the tube. The tube receives energy from the force initiated from its end and tries to move in the same direction. The force of the clamp should be proportional to the number of tools used to form the groove and depth or cutting. Actual rolling can be done with one or more rollers. One roller method needs minimal clamp pressure because the roll involved on 241 257 Tube Formation Formation A comprehensive guide tube is very small. However, this method requires more radial force. One roller requires a mandrel that rotates with a roller to ensure the uniformity of the wall and help in carrying tube sizes. A multi-roller system has some advantages. The radial force may be smaller due to several commitments on the tube. Three rolling tools allow you to better control the tube, produce a better part and hold tighter tolerances. The tube positioning stop is located on the mundrel to ensure the correct position of the ball (figure 5-14). Mundrell is stationary, acts as a support for rollers, and provides a proper diameter of the tube end. The material tries to fold at the end of the tube because the strength of the tube is weak at this point. The speed of rollers, which varies depending on the thickness of the wall and the composition of the tube, can increase the pressure. The time of the machine cycle varies from tubular material to rolling operation; operation with multiple rollers is faster than operation one. Systems with three rollers have more tools on the tube at the same time than two-lime systems, and are recommended for working with close tolerance. The material will usually flow from the point of contact, and back to the clamp of the jaw. Thinning walls is minimal, but can occur on both groove radii. The depth and sharpness of the groove are directly related to the amount of thinning. Drawing a grooving tube (radial force rendered by several rollers). 242 258 Tube End Formation shallow groove with small angles can not thin. The groove depth of 20% of the diameter of the tube can cause some thinning and need surgery to thicken the walls (another ram-shaped operation) before the groove is cut. Multiple grooves present other problems because many deep grooves create too much contact with the surface and can twist or tear off the end of the tube. Cut grooving actually removes the material from the tube end, and there are limited circumstances where it can be used. This operation is best performed on 0-test aluminum. Tolerances and groove depth are factors to consider when evaluating a cutting operation. The end of the tube must first go through the wallthickening procedure. This consists of using a ram-forming machine to impact the end of the tube, which causes the material to flow back from the impact. When exposed, aluminum tends to thicken; Steel tries harder to maintain its column strength and push through the jaws. The punch controls the outer diameter of the tube and causes thickening to occur in the outer diameter. The inner diameter of the mandrel supports the inner wall to keep the tube from crushing on itself. Once the operation is complete, the tube can be transferred to the winding machine. In most cases, One groove can be shortened for surgery because the end of the tube cannot maintain much contact with the surface. Too much and the end of the tube turns or tears out of the tube. Tube. The cut groove can be held in tight tolerance and radii. The top four tubes in 5-15 cut grooves with sharp radii. The bottom three tubes rolled the groove. These tubes show a more gradual narrowing at the bottom of the groove. TUBE ATTACHMENTS Brazing was the main method of adding attachment to the tube. In recent years, the trend has shifted to the end of the formation to block the attachment in place, eliminating many costly ration operations. However, depending on the application, some attachments may need rations to provide a non-leak surface. First of all, it depends on the material flowing through the tubular assembly. One of the most common operations, used mainly in automotive air conditioning systems, is the locking of an aluminum-connective unit on an aluminum tube (Figure 5-15b). 243 259 Pipe-forming Processes: Comprehensive Guide Pattern (a) Cut grooves with sharp radii and b) roll grooves into aluminum tube ends. (Courtesy of Manchester Instrument and Die) A direct line or ram formation is used in making these finite forms and fixing blocks. The first punch reduces the tube to an amount that depends on the outer diameter of the tube and the diameter of the attachment hole. Usually the tube shrinks enough to move the block on it. If the tube eventually gets to cut the groove, then the impact can be performed with the same cut kick. Next hit: 1. raises the attachment during the first operation; 2. rotates the attachment into place; 3. Crosses forward to attach the block, and at the same time, extends the tube to block the block on the pipe. The third impact reduces the size of the pilot's tube and leaves a transitional area for the fourth impact to form a protective ball. Over 244 260 Tube End Pressure Formation is necessary because the tube affects several times and the greater clamp force pushes it a bit out of the round. The last two operations depend on the application of the tube assembly. Another common attachment is the ferrul, which is used when the tube is attached to the hose to complete the assembly. The surface of the ferrula, which comes into contact with the tube, is very narrow and requires a double ball lock. The ball is formed with the first punch and tube the size of the inner diameter of the hole of the ferrul. This punch also leaves some transient material that is used for the second stroke. Usually this type of tube/hose assembly requires a rolled or prickly groove at the end to disrupt any leakage pathways. The next operation requires the transfer of the tube to the grout operation. The tube is clamped and the grout tools perform the operation. The tube can be placed in the frame of the end of the former. Once the tube is clamped, the punch lifts the ferrul and pushes it onto the tube. At the same time, the punch captures material and creates inner beads, which which ferrul in position. Some pipe-forming machines are built with a frame-end-forming system and several roll-grout systems that allow the pipe to remain clamped while the end formation and grout head slide into position. This process ensures better repetitive machine and process. Once the ferry is secured, the tube is ready for the next operation, which consists of loading the hose into the ferr and pressing the two together. SWAGING Rotary Swagers Rotary is a mechanical forging process used to reduce the diameter of symmetrically transverse rods or pipes to a circular section of a predetermined diameter. The process is performed by a pair of fluted, hardened and hardened steel dies that quickly reciprocate in a spindle slot while spinning around work. As shown in Figure 5-16, dies move outwards by centrifugal force and are driven inside by the action of radial hammers (called defenders), which strike on hardened steel rolls. Number of strokes delivered to work in minute 245,261 tube-forming processes: Comprehensive Guide Figure Principle rotary swaging.

varies from 1000 to 5000, depending on the size of the swager. The material flows in all directions in quantities depending on the conditions surrounding the metal swaged. Another action that takes place at the same time is the slow rotation of work. Visually it is a steady movement; in fact, the movement is intermittent at intervals blurred so close together that they cannot be detected by vision or feeling. Dies periodically compress the work and rotate around it. During the compression period, the clutch of the piece dies and make it rotate at about the speed of the spindle. At the end of the impact, the release dies and the work continues to rotate at a slower pace due to inertia. This sequence is repeated at very fast intervals, giving the impression that the work rotates constantly. Because of the rotating action, frictional resistance must be put in place to prevent the operation from spinning at spindle speed. Otherwise, all actions to die or swaging will occur in one place at work, produce excessive ovality or flash, and force it to stick in dies. Manual tools are best prepared for friction control of rotation, although mechanical means are sometimes used. The stationary Spindle Swagers Of the Swager Stationary Spindle Movement are based on the reciprocal action of rotary swagers, the only difference being that the spindle does not rotate. Instead, the head rotates 246,262 Tube End Formation about the spindle and produces the same reciprocal action as the rotary swager (see Figure 5-17). The mechanics of this action do not rotate the work, and while the forging action is still present, almost any form can be produced, reduced or modified to different form. Figure stationary spindle swager. Die-closing swagers die closing swagers essentially just like conventional rotary swagers, having conventional rollers, roll racks, inside rings, spindle, shell, etc. adjustments for death opening and hitting are the same as for rotary swagers. The main difference between the two types is the addition of a wedge-operating mechanism with the cone back dying (see figure 5-18). Two wedges are mounted opposite each other at the end of a wedge-shaped rod that moves back and forth. This action allows you to put the work in the machine in a given position. The deaths that revolve around work are moved radially using the same radial and response to reduce work. The maximum cut per pass in this type of swager is 25% of the original diameter. 247 263 Pipe-forming processes: Comprehensive principle of the manual figure on closing endangered piles. Materials Since swaging is a process of plastic deformation, materials selected for swaging are usually the same as those selected for bending, drawing, or similar deformation processes. Solidity, strenuous strength, and percentage reduction in the area usually assess swag ability. The latter is the best indicator. The capacity of low-carbon steels is excellent, with a possible reduction of 60 70%. As the alloy and carbon content increases, the maximum reductions that can be obtained, respectively, decrease. Some fusion elements, such as Mn, Pb, Si, Ni, P and S, have a more negative effect on their ability to self-contain than others, while Mn and Pb are particularly harmful. 248 264 Tube End Manganese Formation, because it increases strength and hardness, causes a noticeable decrease in duct water, while the lead content causes cleavage and collapses when contractions are significantly less than would be expected. Other alloy elements that reduce the material's inherent air ductivity, such as chromium and tungsten, significantly reduce the ability to do so. Materials high in non-metallic inclusion are undesirable due to the non-uniformity of the microstructure. Table 5-1 is a guide to the maximum reductions that can be obtained by cold whistling of various metals. Two or more passages for the harvest are necessary if the production of a certain part requires a reduction, more than indicated in the table 5-1. Between passages, stress relief surgery in the subcritical range of 1100 1250 F (C) for steel approximately restores the original air duction without altering the microstructure, allowing further reduction. Other materials may need to be re-doused. Materials that have poor ducting at room temperature can be sagging at high temperatures. Seamless It is generally a better swaging material than a welded tube, and is available in heavier wall thickness in proportion to its diameter than a welded tube. However, the hole in the seamless seamless Can be irregular and out of center from the outer diameter, and the thickness of the wall can be irregular as well. When buying seamless tubes, any two of the three dimensions can be specified, depending on the requirements of the part. Welding tubes usually have a single thickness of the wall and a good concentricity of the internal diameter to the outer diameter. It is available in thinner thicknesses of walls than seamless tubes. However, welded tubes outside of diameter tolerances are often not as good as seamless. Welding tubes don't take as much cold work as seamless. Swaging is likely to produce curvature, since the weld does not flow as fast as the base metal. The welded tube must be physically carried on the central feed line to produce a straight piece. Solid or defective welds are broken down when sagging. Cuts in the pipes cause the tube wall to thicken in reverse to the diameter of the seams. The diameter at the end of the swaged tube is usually slightly bell to about 3/8 inches (9.5 mm) from the end. The mandrel is used to hold a hole in diameter in a swaged tube, either mounted inside the machine or held in a hand or fixture. 249 265 Tube Formation Processes: Comprehensive Guide Table 5-1. Maximum reduction can be obtained by cold rotary swaging % Reduction of metal in the area of plain carbon steel (low Mn, spheroidized, annealed) Up to AISI AISI 1020 to AISI A ISI 1050 to AISI 1060 Low-alloy steel (spheroidized annealed) 0.20% C % C % C 20 high-speed steel tools (spherized, spherical, annealed) Stainless steel series (annexed) stainless steel series (annexed) low-carbon 40 high-carbon 10 aluminum alloys Titan (clean) 50 Tantalum (clean) 90 Colombium (clean) 90 zirconium (clean) Nickel 30 Reniy 10 Uranus 30 Copper 80 Copper Alloy Colomb-25% zirconium Inconel X 60 Kromarc 50 Hipernik 80 Kovar 80 Vicalloy 50 Hipernom 80 T 266 Tube End Formation For a thinner wall, than usually the results of normal contraction, the tube should be swaged over the hardened mandrake. The wall can be reduced to 40% of its thickness, but no less than an inch (0.64 mm) because the mundrell will either sink or break. To create a contour inside the tube, the path is first charred in the opposite direction, and then the section is swaged down flush with an external diameter. This moves the extra stock into the tube hole, producing the internal shape to the desired size. Where the cuts are heavy and there is a substantial thickening of the wall, sometimes it is necessary to trim the ends of the swaged sections by handling because the end will be rough due to the compression action of the piles. The best corners of the swaging hand cone are 8 and under, although angles of up to 15 can be swaged by hand, depending on the wall and material, with a proportional increase in pressure and lower feed speed. In addition to this angle, either manual mechanical feed or hydraulic feed is required. Light Light Can be done in one pass before a 30-enabled angle. Larger cuts can take two or more swaging passes. Corners over 30 can often be done in multiple passes, although the trend for stock to pick up in dies is due to heat and pressure. This is especially true for aluminum pipes with a low-like 20-enabled angle. Swaging long cones on the tube includes such variables as material, outer diameter, wall thickness, and total length, since these elements determine the size of the machine, die design, and the type of feeding attachment needed. Almost any reasonable length of the cone can be swaged at any length of the tube having a diameter within the power machine. Long cones usually require more than one operation. The practical size and shape of Swaging has been successfully used to reduce the 14th (35.6-cm) diameter of the pipes and the 4-c (101.6 mm) diameter of the hard rods. Maximum diameters that can be swaged are regulated by the capabilities of the swaging equipment and the physical characteristics of the material. The general rule governing the practical ranges of swaging is: 251,267 Pipe-forming processes: Comprehensive manual of the outer diameter of the tube should not exceed 35 times its wall thickness if the mandrel is used, in which case the tube should be treated as a hard rod. In practice, it is possible to reduce the higher ratios of tubular external diameter and wall thickness, but this requires a lower production rate and a material of a certain quality. The simplest configurations are abbreviations from one diameter to a smaller diameter. However, the number of configurations that can be obtained by swaging has virtually no limit. Determining the reduction of area when pilling reduces the transverse area of the hard rod, the result is commonly referred to as a reduction in the area calculated by: R A - A1 D or 1.00 D, where: R A - decrease in the area, % A 2 - swaged area, in. (mm) A 1 - original area, v. 2 (mm 2) D 2 - swaged diameter, B. (mm) D 1 - initial diameter, B. (mm) (5-2) When the tube is swaged by a swaged diameter, the elongation of the piece is only a minor consideration, which is about 10% of the swaged length in the average cuts. This figure increases with a large reduction. As the tube approaches solid, more material flows end-wise until the average tube is solid at 65 75% of its original region. Overall, the final swaged transverse area is 80 90% of the original, depending on how nearly solid the tube becomes. Thus, the percentage reduction for pipes is given in terms of reducing diameter rather than reducing the area, but for pipes, the equation becomes: D R D and D1 (5-3) 252 268 Tube End Formation, where: R D and wall reduction, % D 2 - swaged diameter, B. (mm) and original diameter, B. (mm) can be successfully executed where the swaged walls are no less than an inch (0.64 mm) and where no more than 10 times the Wall walls is under contraction at one time. In this case, the following equation is used: T R W t (5-4) 1, where: R w - wall reduction, % T 2 - wall thickness after swaging, in. (mm) - the thickness of the wall before whistling, V. (mm) T 1 Determining the thickness of the wall Reducing the diameter of the pipes tends to increase the thickness of the wall in reverse proportion to the number of reductions; The larger the reduction, the larger the resulting thickness of the wall. The actual thickness depends on the physical properties of the material, surface conditions, the proportions of the original tube, the angle of the cone and the configurations of the groove. In general, the more ducted material, the more the wall will thicken. The thickness of the wall can be calculated within 6 10% or the equation is 5-5 or 5-6, depending on the degree of desired accuracy. Equation 5-5, the method of proportion of diameter, gives a higher proportion of accuracy than the method of the area (Equation 5-6). D F W and W D (5-5) 1 where: F W and final wall thickness after swaging, v. (mm) W - original wall thickness, B. (mm) D - original external diameter, v. (mm) d 1 - swaged outer diameter, v. (mm) 253 269 Tube processes: Comprehensive guide F W , where: 2 - outer diameter tube area after swaged, b. 2 (mm 2) 1 - Tube diameter area inside , v. 2 (mm 2) However, 1 is unknown and must be first calculated: where: (5-6) 1 2 (A 2 A 1 0.9) (5-7) 2 - the area of the outer diameter tube before swaging, v. 2 (mm 2) Area 1 - tube area inside diameter before whistling, v. 2 (mm 2) 0.9 - approximate material loss at whistling, v. 2 (mm 2) Radial swaging is a formative operation in which the material is compressed, which results in a stream of perpendicular force. A segmented machine for an endangered machine uses two or more dies to form a part. Radial swaging can be used for many applications. Some of the most common are: the reduction of the central or final part of the tube; Combining two sections of the tube together With a knife pipe; Forming a circular tube into a square; The press part inside or outside the tube; and pressing the hose to the tube with the ferul. Two main categories of cars are available. Closed machines (see figure 5-19) require that the part be loaded into the machine by linear motion (straight to and from). These machines generate more power, but are limited in the type of parts that can be processed. The open-throated machines (see figure 5-20) divided the segments to die, allowing the parts to be loaded into the car from the side. These machines are commonly used to connect curved pipes to hoses. They are also easily automated by walking a beam of translations. 254 270 Tube End Formation Drawing closed throat radial swager. (Courtesy Finn-Power USA) The most modern radial-forming machines have complete control over the course of the toolkit. This means accurately measure and produce some very close tolerances. The ability to control the course where these machines reach their cycle time. By limiting the running of a machine opening to where just enough space to feed the tube into the machine, some very fast cycle times can be obtained. The downside of radial whistling is the cosmetic look of the finished part. This type of machine uses all its labor at the same time. It presses the entire work area at the same time with the same force. As segmented deaths merge, some displaced material flows between tool segments. The procedure triggers instruments or flashes of marks around the surface of the tube. For some applications, this is not acceptable. Using a toolkit that has 255,271 pipe-forming processes: A Comprehensive Guide to Drawing An Open Throat Radial swager. (Courtesy Finn-Power USA) A the same applications, it is possible to the desired measurement can minimize the flash of signs. The second deficit of the radial machine is the amount of reduction they can make. Because the labor is used immediately, there is less control over the flow of material flow. The general rule is that a base of 10% reduction can be achieved. Slip-installation of the tube in itself is another guiding principle. BIBLIOGRAPHY Comparison Study of various stationary and autonomous pipe cutting techniques by Metro International, a journal for metal pipes and pipes produced and recycled, November/December. Forum Place, Hatfield, Hertfordshire, England: Mackbooks Publishing Co. Coldforming Techniques for The Pipe and Pipe Industry Pipe International, a magazine for metal pipes and pipes produced by 256,272 Tube End Formation and Processing, Dec. Forum Place, Hatfield, Hertfordshire, England: Mackbooks Publishing Co. Donaldson, Cyril, LeCain, George H. and Gould, V. C Tool Design, 3 rd Edition. New York: McGraw Hill. Johnson, Jeff. 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The most well-known method of branching is affordable tee fitting, which has been used in residential and commercial construction for more than a century. This requires the least planning, but the cost of the cost can be the most expensive. There are many lower-margin alternatives used for industrial use, some of which provide the industry by welding or shaping the process. The choice of tee connection is based on many factors. The choice of a commercial tee connection depends on whether the user is able to perform various alternative connections. The commercial availability of fittings affects the chosen method, but Tee-connected systems offer significant savings if a number of tee connections are required. COMMERCIALLY AVAILABLE TEE CONNECTIONS Tee fittings are available in the tube and tube for most materials that are covered according to ANSI B16.9 (for butt welding fittings) and ANSI B16.5 (for lap welded compounds) standards. Figure 6-1 illustrates a typical setup. Most production facilities have welding and manufactured equipment in the house and can produce pipe coils or tube fabrication for tee fittings. When the pipe was based on the use of relatively 259,275 pipe-forming processes: Comprehensive Guide Figure 6-1. Typical tee fitting. Cheap, graphics-40, carbon-steel pipe for most system requirements, tee installation was the most practical branching method used. With the advent of higher labor costs, and the desire for a longer life system, the trend is to switch to more exotic materials (mostly stainless steel). Tee fittings in materials other than carbon steel are expensive and often their availability for accelerated projects is not good. One consideration is that the standard fitting tee has three welds, while the other processes have two or even one. Additional tee joints installing increase tube cutting and welding costs, as well as the potential for quality failure. Fittings are available in three classification sizes, depending on where the fitting will be used: 1. plumbing, 2. air conditioning and cooling, and 3. process pipelines or general purpose applications. The most widely used fittings are copper, used for drinking water, fire sprinkler and/or heating systems. These fittings are the size of a nominal dimension in which the outer diameter is 1/8 inch (3.175 mm) larger than the nominal fitting size. Standard fittings are available in four thick walls: DWV, M, L and K, which results in a diameter inside that varies 260,276 pipe branching methods with a thick wall. The size range is available from nominal (3/8-inch 9.53 mm) to 12-inch (30.48 cm) (12-1/8-in. Pipes are available for most metals (copper, CuNi, stainless and carbon steel, titanium, etc.), in which the outer diameter is the same as the diameter of the designation, internal diameter depending on the thickness of the wall. Metric and English tubes are available up to cm (20-in) and 12-in) (30.48 cm) of external diameter, respectively. Installations for use in pipe installations in different thickness of the wall (so-called graphs from graphs 5-160, and XX strong). In each case, up to 14 inches (35.56 cm), the outer diameter is larger than the nominal size of the pipe by 1 3/4 inches (cm), increasing as the diameter of the wall decreases. At 14 inches (35.56 cm) and above, the outer diameter is the same as the nominal size. Contact ANSI B36.10 for graphs of the thickness of carbon steel, and ANSI B36.19 and ASTM Specification 409 for corrosion-resistant materials. Fittings are available in both lap and docking configurations, and welding requirements are covered by various standards issued by the American Welding Society (AWS), the American Society for Testing and Materials (ASTM) and the American Society of Mechanical Engineers (ASME). Saddle adapters/weld-o-allows an alternative to the standard tee setup, saddle adapters/weld-allows attached to a pipe or pipe over the pre-hole. The procedure produces a tee configuration, allowing the branches of the tube or pipe to be attached. In the tubing, the component has the shape of a saddle, corresponding to the diameter of the main tube to which it must be attached. This shape is usually put on the end of the mating tube using a ram-end forming machine. The attachment is usually done through a brazing saddle over the hole so as not to prevent the flow (see figure 6-2). On the pipe, the fitting is called a welded o-let (see figure 6-3), which is welded to the main pipe above the precut hole. This fitting is available for most applications and is available for attaching pipe branches through a welded or threaded connection. This type 261 277 Pipe-forming processes: Comprehensive Guide Figure 6-2. A typical saddle adapter. The connections must meet the same standards for construction and welding as the tee fitting. It is commercially available for use mainly on steel pipes. Figure 6-3. Typical welded-o-let. 262,278 Pipe Branch Methods FABRICATED TEE CONNECTIONS nozzle welded nozzle compound (Figure 6-4) is the most commonly used branching method for carbon-steel pipe. It is also used on some stainless steel applications. A round pilot hole is made, and then a branch tube (with a contour end to drain the diameter of the pipe outside) is welded over the opening. It is commonly used for low pressure applications of up to 150 psi (1 MP), and often requires code to be amplified around the pilot hole for material loss, leading to calculated permitted pressure to be less pressure than the system. Figure 6-4. A typical welding nozzle. While welding nozzle is a relatively inexpensive method of getting a pipe connection, it requires the ability to contour (fish mouth) tube branches and weld a contour pipe. Welding is not easily automated. In softer, more colored used in automotive or air-conditioned applications, this process is even more basic. The hole is drilled into the main main and a tube branch is inserted into the hole (figure 6-5). The ration material is then built around the compound, welding the two pipes together. 263,279 Tube Formation Processes: Comprehensive Guide Figure 6-5. A typical hole drill. The extruded outlet outlet extruded socket represents the 1700th tee connection, which provides the flow characteristics of the manufactured tee fittings. The socket is formed from the main tube by cutting the pilot hole and then forming the material around that hole into the joint. Figure 6-6 illustrates the connection of the lap type in which the internal diameter is formed to take a branch tube, which is then brazed (welded) as a meeting of AWS standards. This type of compound is mainly used for small diameter pipes used in automotive and air conditioning and refrigeration equipment. It is made by drilling (stamping) the round hole and then pulling the ball through the hole or using a spin-forming process to produce an outlet (collar). Figure spin 6-6. Communication with the knees. 264 280 Pipe branching methods drawing 6-7. A typical spin-shape formation process. formation is preferable to quantity production because the process lends itself to varying degrees of automation. Figure 6-7 illustrates the typical process of spin-shape formation. A similar process is used for butt welded compounds, starting with the pilot's elliptical hole, to provide more material in the stirrup area and then using the same ball or spin-forming process. Once the socket is formed, it is trimmed to ensure the butt is a compound ready to weld (see figure 6-8). The extruded outlet has been in use for almost a century. Recent machine development and code testing continue to make this method of savings acceptable to engineers by designing systems. The process complies with ANSI, ASTM, AWS and other code standards. 265 281 Pipe Formation Processes: Comprehensive Guide Figure 6-8. Butt communications. BIBLIOGRAPHY Holyoak, William H Extrusion process reduces costs for pipelines. Heating/Pipeline/Air Conditioning, October a. Small diameter pipes branch. Pipe and Pipe Manufacturing, March, Tom B. Pipes and Pipe Manufacturing Alternatives to Welding. Tube Technologies, November/December Flanking and Branching Pipe. Manufacturer, Aug. Johnson, Warwick Production quality pipe and pipe branches and fittings on extrusion. Manufacturer, Dec. 266,282 Brazing and joining 7 Brazing and joining this chapter determines the basic steps in product development and ration process, leading to achievable, repeated high quality rations. HOT PROCESS CONTROL Although many people do not agree that rations is a science repeated quality braze If each of the variables affecting the process can be reduced or controlled. Many believe that rations are an artistic adventure or black magic. This is because, from their personal experience, the positive results were usually not by applying scientific principles. More than likely, the reason for the lack of success in obtaining high quality rations is that all variable controls cannot be properly defined. Uncontrolled variables remain the root of the problem. Adjusting the process to improve quality, without one addressing the root cause of the problems, usually complicates the solution. For the first time, the cornerstone for high bandwidth lies in the ability to control variables during rations. When controlling the main variables, the process window is more forgiving, and minor changes have less impact on the end result. Everyone, from control to brazer, can experiment to improve quality when variables affecting braze quality are not properly resolved; this can add unnecessary steps. Every change or additional step can create new and unknown variables. Over time, these unnecessary steps can even be recorded in the job specification. Once this moment has passed, it becomes difficult to 267,283 pipe-forming processes: A comprehensive guide to eliminate the specifications because they have been adopted as needed. Getting high quality requires a thorough analysis of production processes, starting with a product or co-design. Every step in the production process from start to finish must be carefully analyzed. You have to think of the production process as a recipe. Any omissions or compromises can change the ultimate goal of getting the highest quality at the lowest cost. Additional processing and scrap metal costs should be identified. In addition to the cost of material, labor and overhead in the production of parts for the first time, the possibility of costs should be added when recycling rejected parts. The time and cost spent on detection and processing operations could be better used to create new products. Many times this goes unnoticed until more equipment and labor is required to achieve production goals. Management may not include all processing costs, tabulating only those costs that have been determined after the official testing procedure. In many cases, however, significant repair costs are accumulating before the formal table is drawn up. For example, a bra of the hand can touch the part because it looks like a casting. Or the machine operator can load the suspicious part into the brazing fixture for a second trip around the ration machine, just to make sure the piece is undergoing a quality test. Thus, if all the variables that affect the quality of the braze are controlled, then repeated high-quality results can be obtained. However, it may not be economically feasible to achieve perfection. By reason, it may be justified to take a low level of recycling and scrap because the cost of zero rejects can be too expensive. Potential liability, if recycling is delivered to customers, must be determined before Some variables have a greater impact on quality than others. The information in this chapter focuses on the basics of rations and identifies the main known variables of the process that have historically proven to be effective. Practical, realistic methods and solutions known for quality improvement are discussed. While many of these points will enhance the results of hand brazing, the quality of results can be easier and more reliable achieved through automation. 268 284 Brazing and joining BASIC JOINING TECHNIQUES There are many different options for joining metal including welding, braze welding, ration, ration, bonding, riveting and bolting. Each option offers benefits and limitations that need to be considered for use in specific applications. Welding welding is a process that creates metallurgical bonds between the base metals that join. The size and configuration of components and joints are the determining factors when considering the use of rations or welding for the application. Typically, large, massive or thick components may be the best choice for welding. Porosity in the joint interface can occur, especially at the junction of the beginning and end of welding. Complex configurations can be difficult to track during welding, making the process slow and expensive to automate. When welded, heating the base metals to melt the temperature drains the components together. The grain structure migrates between the components at the point of welding. In braze welding, metal filler is fed into a collaborative interface. The alloy of filler melts above 840 F (449 C) or at or below the melting point of the base metal. Streams can be used to protect and assist in wetting base metal surfaces. Heat is applied to the joint area using different environments that include plasma, electronic beam, tungsten and submerged arc, resistance, laser, etc. due to the high temperatures generated in welding, distortion or deformation of base metals connected is common. Residual voltages around the welding area are also likely. There is a high potential for leaks through a collaborative interface. The decision to weld should also take into account the costs incurred to remove the sludge residues after welding. Brazing Brazing creates a metallurgical joint. Many different facilities are available to give heat to a collaborative area including torch, induction, infrared, and furnace. In brazing, base metals are not 269,285 pipe-forming processes: Comprehensive lead melt during the process. A filler alloy is always needed and it flows at a temperature below the melt temperature of the base metals. Streams can protect and assist in wetting base metal surfaces. Filler alloys containing phosphorus can be used on copper and brass, eliminating in the stream. Phosphorus prepares the base metal for wetting the alloy filler. Bake rations of some metals in a vacuum or oxygen reduction reduction may be an alternative to using the flow. Heat induced in any metal can lead to distortions that can be minimized through product design and ration process. Typically, rations allow you to maintain access to a close assembly. Different metals, or those that exhibit different masses or changes in thickness, can also be brazed. Brazing usually produces a more attractive joint than can be produced by welding. One of the most important advantages of rations is that the process is automated. Soldering Soldering produces only a mechanically kabed joint and is therefore selected primarily for applications requiring sealing rather than strength. The alloy of filler flows below 840 F (449 C). Streams raise surface oxides in faying compound surfaces and assist in wetting base metal surfaces. Heat is usually induced into the joint by a torch, iron solder, oven or ultrasound. Since most solder filler alloys flow in the F (C) range, there is a slight distortion of base metals. DESIGNING FOR AUTOMATION Pitfalls leading to the crash below is a list of many conditions that lead to high recycling and recycling of scrap in mass production. The components of the part are made to incomplete dimensional tolerances. This condition is currently the main cause of recycling and scrap. Inconsistency in dimension causes many interconnected problems. The braze toolkit is designed to provide 270,286 brazing and attach thermal factors that occur during the heating and cooling phase of the braze operation. However, the toolkit cannot be flexible to ensure changes in the external dimension of the part components. Dimensional variations in the joint interface change the thermal profile required during the ration process and can affect the strength of the joints. The joint structures do not meet the generally accepted specifications for rations. Compounds that are too loose or too tight can limit the flow of alloy filler or reduce the optimal strength of the joint. Burrs or extrusions with torn edges can also reduce the flow of the alloy filler; they are commonly referred to as capillary dams. The unclean components of the part are brazed. Many think that the flow is a general purpose cleaner or a skim agent is applied to the joint area before rations. However, the main functions of the flow are to slow the oxidation from forming during the heating process and promote the wetting of the alloy filler. Pollution left in faying the surfaces of the joint after rations is one of the main reasons contributing to the joints that leak. If a thorough post-cleaning operation is omitted, these failures can occur after the parts are sent out of production. Failures can also After the contamination that has filled the void leachs when parts are exposed to heat or chemicals in the final application of the product. Several joints are in close proximity to each other. Induced in a particular joint can affect the amount of heat that needs to be caused to other joints if they are located in close proximity. This complicates the heat scheme, thereby reducing the process window. Several joints are in different planes from each other. It is always best to orient the compound to be brazed to allow gravity to pull the alloy filler into the joint interface. Compromise reduces the process window and increases the risk of recycling. Post-braze dimensional tolerances are unrealistic. Hidden voltages in a given metal can relax and new ones can be created when the metal is heated to the temperature of the rations. The pressure can be so intense during rations that this phenomenon may be impossible to control, even with the help of a locking device. When the brazed assembly is released 271,287 pipe-forming processes: A comprehensive guide from clamps, the connected components may occur elsewhere depending on the stress caused by the heat generated during the ration process. For this reason, it is recommended that the pipes be formed after the rations, if the configuration of the tube should be maintained. The parts contain pre-assembled, easily damaged components in close proximity to the joints that will be brazed. Components made from easily damaged materials including plastic, rubber, seals, springs, O-rings, painted, and coated surfaces placed in heat-affected joint areas are being brazed to increase the complexity of ration surgery. Complex ration operations usually increase the risk of alteration. Parts or components are massive in size. Large or massive components increase the time it takes to heat them to the temperature of the filler alloy flow. As the flow of the filler alloy increases or the heating time increases, the risk of failure may also increase. The flow is usually active to a certain temperature and for a certain period of time. Once either limit is reached, the flow becomes inactive or the oxides quickly form, which prevents the fuze of the alloy filler. Some components are thin and tend to be deformed or distorted as they heat up. Trying to contain the stresses created by heating by clamping is usually ineffective. It's hard to beat the laws of physics. Parts require a perfect cosmetic appearance. There are many new methods to improve the appearance, but it is still difficult to create a part that is comparable to the part that would be after cleaning using chemical processes. FUNDAMENTALS BRASING Collaborative Designs Figure 7-1 illustrates several collaborative designs. Brazing is used to form the butt, knees, butt knees, scarf, and saddle joints. The butt butt joint is formed from two metallic either flat or tubular, connected at the ends. Force Butt Joint 272 288 Brazing and Joining Figure 7-1. Types of stewed joints. depends on the area of communication or interface and determined by a thinner component. This type of collaborative design can be difficult to automate if component alignment is important. Lap Lap joints are formed when the mating components are blocked. They are used in both flat and tubular applications. Provisions should be provided for measures to control the depth of the joints when assembling parts in order to reduce the complexity of the braze toolkit and the risk of alteration. This can be achieved in different ways. One approach is to reduce the diameter and depth of the tube insertion, which is inserted into another component. Other end-to-end operations, such as beading or saddles, can determine the depth of the insertion. 273 289 Pipe-forming Processes: Comprehensive Guide Tot nodt Lap A butt lap joint similar to the miter joint used in wood cabinetry and offers a solution for self-fixing. The surface of the faying is enlarged because the filler alloy flows through the length and through the width at the base of the joint. To limit the flow of the alloy filler through the entire joint interface, the diameter at the end of the tube is sometimes reduced to interference or push fit. If the stream is used in the braze process, the knurled design can reduce the flow of capture, a common cause of possible brazed joint degradation. Scarf To create a scarf joint, the ends of a flat or tubular component are cut into offsets to increase the faying surface. This type of collaborative design can be difficult to automate due to difficulties in positioning or feeding the alloy filler into the joint. The saddle of the saddle joint is used to attach the end of one tube to the side of the other. The end of one tube has the shape of the contour of the second tube. The cutouts added to the design help in self-fixing and reduce the complexity of the braze toolkit. Since stress can be formed at the end of the tube where the enlargement occurs, strength tests must be performed if any stress or vibration is applied to the joint after the rations. Design tolerances Are Recommended Joint Spaces commonly spec for joint rupture when rationing steel, copper and brass ranges from an inch (mm) to a radius, and an inch (mm) through diameter at braze temperature (see Figure 7-2). The recommended tolerance to the joint rupture for aluminum rations are in. (mm) in radius, and B. (mm) in diameter. Smaller gaps create capillary dams and can prevent the filler alloy from joining the faying surface of 274,290 Brazing and joining the figure 7-2. Recommended gaps in the joints. Joint. Alloy filler may not overcome large gaps and alloy diffusion may not occur. Alloy diffusion fusion diffusion phenomenon occurs after the alloy filler flows throughout the joint interface (see figure 7-3). While keeping the temperature even For a moment after the alloy flows, the molecules of base metals and alloy filler are mixed mixed form a new alloy. This new alloy has different metallurgical characteristics than base metals or alloy braze fed into the joint. The new alloy is stronger and more interrupted at a higher temperature than the original alloy filler. Under the enlargement, the initial joint boundaries disappear or disappear. The structure of the joint appears to be a mixture on each side of the former joint and has a different, but uniform, grain structure. As a rule, if the joint gap exceeds the recommended tolerances, alloy diffusion does not occur and the expected strength of the joint may not materialize (see figure 7-4). The strength of the brazed joint begins to increase when the joint rupture, while brazing 275,291 pipe-forming processes: Comprehensive Guide Figure 7-3. Alloy diffusion. temperature, reaches about an inch (0.03 mm). The compound reaches maximum strength when the gap reaches about an inch (0.08 mm). Joint strength decreases as the gap widens around 0.10 mm (0.10 mm) and drops sharply as the gap widens further. Typically, the tube inserted into the fitting will be self-centered in the joint if the components can move into a brazing fixture. However, for a variety of reasons, this phenomenon may not occur. For example, the recommended joint permissions required to apply may be too strict to obtain through processing. Processing tolerances can lead to excessively tight or free fitups for rations. The expansion factor between the two different metals can also lead to excessively tight or free fit. There are solutions to assist in providing recommended tolerances in the joint at braze temperature. Crimping, swaging, expanding, and betting operations can solve this problem. Another solution is to add knurles, or vertical perpendicular indentations, in three or more places around the tube so that the alloy flows down and through the joint interface. 276,292 Brasing and joining Figure 7-4. Diffusion without alloy. The recommended depth of the joint depth connection is another important specification. Typically, the rule is used three times to determine the maximum strength of the joints in relation to the optimal depth of insertion. The rule states that the depth of the joint must be three times the thickness of the thinnest of 277,293 pipe-forming processes: A comprehensive component of the guide being brazed. Some recommended joint depths range from three to six times the thickness of the thinnest component. However, increasing depth can cause voids in the interface. Strength tests must be applied to this joint design before deciding on the final specification. The finished size of the heat voltages exerted on individual components during the ration can affect the size of the finished assembly. Each tolerance should be carefully reviewed in terms of its ability to be achieved. The harder it gets quality standard, the higher the risk of recycling. A number of issues should be addressed to facilitate the development of rigid dimensional specifications, including: is the application clearance specification commensurate with the application? And if the specification isn't absolutely necessary in the application, why increase the risk of failure? When possible, tubes should be formed after rations, especially if the finished sizes are a critical specification. This option makes it easier to design tools, processes, and equipment. It can also reduce the cost of automated ration equipment. The engineer should focus on designing the braze toolkit, predicting the projected growth of each metal component during the heating process. Readers can refer to the expansion chart factor available in the reference sources in the bibliography of this chapter. The design of the toolkit can stimulate expansion in specific areas that are easier to control. Heat considerations This will certainly be uncomplicated if the finished sizes on the assembly after rations can be guaranteed to meet those specified on the assembly print simply following the recommended joint tolerances. However, other factors may also influence the predicted result. For example, thermal extension and compression of 278,294 Brazing and Joining should be taken into account when determining clearance tolerances, rebar design and total dimension of the part. Each metal expands or grows to a certain length when heated to a certain temperature. This is called the metallic expansion factor (see figure 7-5). It is easier to predict the amount of expansion that will occur during heating when two components of the same metal are extinguished. Parts consisting of different metals will complicate the formula for predicting expansion. The extension for each metal is different. Additionally, braze tooling, usually manufactured by stainless steel, can expand at a yet different rate. The pace of expansion is one of the reasons why rations fixtures are so difficult to design and one of the root causes for recycling and scrap. If the locations on the toolkit don't allow each component to be expanded accurately, the finished sizes may distort and fail to match the assembly print tolerance. In addition, the weakest component, both the assembly and the tool itself, can deform or distort due to the high voltages created in figure 7-5. Expansion rate for different materials. 279,295 Tube Formation Processes: Comprehensive Leadership Expansion. For the same reason, it may not be good to have braze components on both ends of the long tube at the same time. As the tube heats up, it expands. If components or fittings are collected at each end of the tube, the extension forces the joint to position in the outer direction From a friend. Even if the toolkit is built to accommodate projected expansion, expansion, other reasons for failure. If the tool has multiple components with different masses and expansion rates, it is difficult to predict a combined overall expansion of the entire build. The expansion increases the difficulty of predicting joint gaps between mating components at brazing temperature. The two opposing fittings located at the end of the tube are usually difficult to braze because at least one of the fittings moves outwards as both components heat up. It is difficult to focus the torch pattern on the moving component when brazing on an automatic machine. The placement and shape of the filler alloy are considerations when positioning the components of the brazing part in an inverted or vertical orientation. In addition, it can be difficult to apply a certain and repetitive amount of heat to each joint that can move during the heating process. Even if the deviations are small, they can be the direct cause of a certain level of rework. The complexity of the process increases as the number of joints that will be brazed at the same time increases, especially if the components are made up of different metals, masses and shapes. Predicting the expansion of each component becomes difficult, if not impossible. These conditions also make it even more difficult to identify joint ruptures. The design of the ration fixture becomes a nightmare. Designing brazing tools to prevent the movement of each component is a mistake and can contribute to distortion in the brazed assembly and instrument. The brazing device cannot serve dual functions: that of locking component parts during brazing and as a check device for the completed part. Brazing filler alloy forms are available in various forms of rod, wire, preform, ring, stripes and paste. Each form offers benefits and limits- 280 296 Brazing and joining tions. The build design is brazed, production volumes, and whether the assembly is manual or automatically brazed to determine the type of alloy to use for a particular application. Typically, the more value-added operations are required in the production of each alloy form, the higher the cost of filling the filler for each joint. Rod Rod is one of the most popular and affordable forms of alloy filler. It is widely available in alloys based on silver, copper, copper/phosphorus, bronze and aluminum. The genus is usually used in handmade applications on manufacturing plants and commercial applications such as heating, ventilation and air conditioning (HVAC) equipment in the area. The quality of the braze achieved and the efficient use of the filler alloy heavily depends on the skill of the hand brazer. Wire wire is a popular form and is usually available in all filler alloys for hand rations. It is formed in the and braze rings. Wire, the level of wounds on the drums, is used on automatic wire feed systems in automatic ration rations With the exception of the rod, the wire is usually the least expensive filler alloy option, but it offers the same limitations as the hand rod brazing. Braze wire is automatically fed to the upper joint when the temperature of the joint is heated to the temperature of the filly alloy flow. For the re-quality of the results, the joint break should be consistently treated with recommended gap tolerances for rations. This option requires careful control of the heat, time and amount of filler alloy fed into the joint or filler alloy can accumulate at the base and outside the joint. Ring Ring alloy shape is chosen when it is important to control the amount of alloy filler used in a given joint. The amount of alloy filler needed to fill this compound can be determined by 281,297 pipe formation processes: A Comprehensive Guide that calculates the number of gaps in the joint interface. Braze rings control the amount of filler alloy fed into a given joint, facilitating the hand brazer need to make a decision as to how much filler alloy to feed into a given joint. Too much or too little alloy in the joint can lead to quality problems. As a result, the rings provide both cost savings and co-improvement of quality. There are three options for placing a braze ring outside the joint, at the base of the joint and inside the joint. Placing the ring in the machine ring groove located within the joint interface can offer the best quality results. Placing the ring between the components at the back of the joint requires that the tube be forced into place after the ring melts. Aside from the problems discussed previously, the complexity and cost of rationing the device increases when braze rings are used. Gravitational force is applied to the bottom of the braze ring when it is outside the joint. The ring softens when heated. This condition, along with the weight of the ring and gravity, tend to cause the lower half of the ring to fall away from the joint, leaving only about half the amount of alloy filler remaining to fill the joint interface. The rings are ideal for both manual and automatic stewing apps. The key to success depends on the recurrence of the size of the joint being brazed. Except where the ring can be automatically placed on assembly, additional labor costs for manual ring placement must be considered. The additional labor costs to assemble the braze ring into parts, however, can be comparable to the reduction in costs incurred in reducing the use of alloy filler. The Preform Category preforms consist of all shapes except the braz ring, and includes washers, bullets, and custom wire shapes. Washing It is usually stamped from sheet material and can be round, square or irregular in shape. Bullets are usually cut from the length of a wire or rod. Custom wire forms form to match the irregular shape of the joints. As with braze rings, these shapes are good for both manual and automatic rations. 282,298 Brazing and Joining Strip Sheet material is cut into strips and drums to make this form of alloy filler. The striped form is used mainly in automation applications; For example, brazing carbide teeth onto saw blades, where the filler alloy is automatically cut and sandwiched between two flat components. The band can also be shortened in a certain length for use in applications such as rations of electrical contacts or carbide tools. Alloy filler paste is a mixture of powdered alloy filler, braze flow, and binder system that provides shelf life for the product and keeps the mixture in suspension until it is distributed. Most rations and rations of alloys are available in the form of pasta. The main advantage of choosing a paste is the convenience of automatically distributing both the alloy and the flow to the given joint, which will be brazed. Pastas are commonly used on torch and induction machines, furnaces and furnaces. The best results can usually be obtained if a tank exists on top of the tube to accommodate the paste. The reservoir contains a deposit of paste as it heats up and holds it close to the joint until the capillary attraction pulls the molten alloy into the faying surfaces of the joint. Without this tank, the risk is increased for the paste deposit to flow down the tube side or drop off the part. Placing the Brazing alloy as a whole, it is best to target the joint being brazed in order for the filling alloy to flow down and into the joint. This allows both capillary attraction and gravity to trigger the flow of the alloy. Sometimes there are conditions that require a compromise with this recommendation, such as multiple joints in close proximity to each other, such as three tubes brazed into an assembly block. Compromise, however, may increase the risk that it will not be able to get high quality first pass bandwidth. When considering each segment of the process, the question to ask is whether a specific approach will produce 283,299 Pipe-forming processes: Comprehensive guide acceptable results all the time? not only, will this approach work? The base joint Many recommend placing the alloy filler at the base of the joint because it is easy to see the filler alloy as it flows at the top of the joint. There are several reasons why this approach may not always produce an acceptable quality of brazed joints. As the braze ring melts, the space he was formerly occupied displaced by a tube that rested on top of it. Reducing the strength on the tube can cause the filler alloy to be twisted out of the joint interface. Gravity Down. By applying the filler alloy to the base of the joint, it may be more likely to flow down the inner fitting surfaces or block being brazed to the tube. This will allow in leaving capillary attraction as the only force pulling the alloy filler up and through the faying surfaces of the joint. It is generally best to load the assembly components into a ration device, not depending on the individual components moving in the finished measuring position during the ration. For example, sometimes the tube cannot fall all the distance to sit at the bottom of the joint. As a result, the finished build sizes of the brazed may not match the size required by the assembly seal. The sides of the vertical alloy filler on the sides of the vertical joint may be required when a horizontally oriented tube is inserted towards the fitting (see figure 7-6). Without exception, this approach depends only on capillary attraction to accelerate the alloy filler throughout the joint interface. Each of the following options should be carefully considered before choosing the one that can offer the highest quality first bandwidth. The lower side of The Joint Is Almost Without Exception, applying an alloy filler at the bottom of the joint is not a good option for getting high for the first time through-284 300 Brazing and joining Figure 7-6. The placement of the alloy. Put quality. This option defies gravity, because successful penetration throughout the entire joint interface depends only on capillary attraction. In this orientation, gravitational force disrupts the flow of the filler up and into the joint. Sandwich braze ring between the base of the fitting and the top of the tube may have been affected by the problems discussed previously. Gravity, however, increases the risk of molten rings flowing down both outside and inside the diameter of the tube being brazed. Metallurgy alloy filler Most metal fillers used for rations consist of a combination of two or more metals that are fused into specific filler alloys involving demanding metallurgical characteristics developed for 285,301 pipe-forming processes: a comprehensive guide to individual application types. The American Welding Society (AWS) classifies specific metal fillers according to recipe ingredients, flow temperature, and other characteristics. While there are many specific categories of filler alloys, those commonly used in most industrial applications include silver, copper-phosphorus, bronze, copper and aluminum. Before discussing the specific specifications of the filler alloy, the following definitions of common technical and metallurgical terms should be understood: a filler alloy contains two or more ingredients. The solid temperature determines the point at which the ingredient with a low temperature reaches the melt or flow temperature. The temperature of the liquid is the lowest temperature when all the ingredients are in the alloy filler melt flow temperature. Eutectic filler alloys have the same temperature of solid and liquid flow. Because of Characteristic of these filler alloys, they can be considered for ration joints exhibiting long, narrow gaps. Filler alloys exhibiting the wide temperature discrepancy between solidus and liquid temperatures can be chosen to braze the joints possessing wide, long gaps. A liquefied, metallurgical condition occurs when a prolonged heat time causes one or more alloy filler ingredients to come out of the mixture, leaving behind a new alloy with a higher liquid temperature than the original alloy filler. Metal filler with wide melting ranges offer a greater risk for slyation when heated too slowly. However, this condition may occur for all filler alloys exposed to extended thermal cycles. Typically, the operator recognizes this condition when he or she sees the porous surface of the skull on the remaining alloy deposit. The solution is to bring the basic metal components being brazed to flow temperatures in a shorter time. Embrable phosphorus is the formation of fragile, intermetallic phosphate compounds that occurs when phosphorus is used for braze ferrous or nickel base alloys, causing the brazed joint to become brittle. This condition can occur shortly after 286,302 brazing and joining rations and can be accelerated if the joint is exposed to heat or vibration stresses. Families Following sections identify family filler alloys are widely available and their brazing applications. Silver bearing alloys. Silver alloys are used to attach most non-ferrous and non-ferrous metals, with the exception of aluminum and magnesium. Most alloys included in this classification include silver, copper, zinc, nickel, tin and magnesium in different quantities, depending on the formula. All alloys of silver fillers are classified as BAg alloys, as stated in AWS. Cadmium is added to silver-bearing filler alloys primarily to lower the temperature of their flow, thus making them easier to braze. Although these alloys are still available, with the advent of new environmental laws protecting the workplace, many users have replaced them with alloys that have similar characteristics to rations and contain a small amount of tin. Silver alloys are often selected because they are easy to work with, flow at low melting temperatures, produce good cosmetic joints, are actively moist on most metals, and are economical to use. Fillers in this group suitable for rations are steel, copper alloys, precious metals, stainless steel, nickel, tungsten carbide, copper and nickel alloys. Silver alloys are selected by temperature and strength characteristics, color and compatibility with specific base metals. Nickel in the alloy to help in wetting tungsten carbide and stainless steel rations because it reduces susceptibility to interfacial corrosion. Copper-phosphorus alloys. Copper-phosphorous alloys are used to join copper and brass. These filler alloys should not be used for rations of any ferrosal or nickel base metal due to the possible formation of fragile joints after rations (phosphorus anesthesia). AWS classifies filler alloys in this group as BCuP alloys. These materials usually contain silver in the range of 0 15% and phosphorus ranging from%, with the balance of copper. 287 303 Pipe-forming Processes: The Comprehensive Phosphorus Guide in this alloy lifts oxides from the surfaces of base metals and prepares faying surfaces to wet alloy rations. Typically, the flow is not required for copper rations, but is used in brass rations. Applications for copper rations include the use of nitrogen to clean internal surfaces from the air and the use of gas flow to reduce external surface oxides. The level of phosphorus activity is high, but short-lived. Therefore, a short heat cycle is recommended to insure phosphorus active at a time when the alloy filler is ready to flow into the joint interface. For this reason, massive pieces made of copper may require the use of a stream to braze. Copper-phosphorus alloys in this classification containing 0% silver are the most economical to use and are known for their fast and extensive flow. Because of these flow attributes, the fitup needs to be narrow and the heat needs to be carefully controlled to get good fillet characteristics. Filler alloys containing 15% silver and 5% phosphorus have excellent fillet properties and are recommended whenever joint gaps or temperature control rations are not ideal. Other filler alloys in this classification have adjusted the content of silver, phosphorus and copper, which changes the flow characteristics and fillets for specific applications. Nickel-based alloys. Nickel-based alloys are used for applications requiring high-flight maintenance ranging from 1000 to 2000 F (538 1093 C). They provide good corrosion resistance and maintain mechanical properties at low levels (up to 450 F and 268 C) and high temperatures. Nickel fillers are usually sluggish in a liquid state, a characteristic that needs to be considered in a collaborative design. All nickel-based alloys can be used in atmospheric furnaces; Some of the alloys of the lower flow temperature can be tossed by the torch using the stream. Bronze alloys. Cheap bronze alloy fillers that are copper and zinc-based can contain small amounts of tin to make them lighter than braze by increasing their flowability. AWS classifies these alloys as RBCu'n. They are used for rations of steel, stainless steel, tungsten carbide, copper and nickel-based alloys. They flow in the mid-1,600 F (871 C) range and have high strength and fillet characteristics. These alloys are available in the rod, ring, preform, and paste shapes. High boron temperatures - 288,304 brazing and joining acid streams were to stay active at the high flow temperatures required for this filler alloy. Because of their low cost and excellent fillet characteristics, these alloys are widely used in the automotive, medical and furniture industries. Copper alloys. Copper filler alloys classified by AWS as BCu contain 99.9% copper and flow with approximately 1,981 F (1,083 C), depending on traces of metals included in the alloy. Since the flow temperature of these alloys exceeds the active level of any ration flow, the extinguishing requires a hydrogen atmosphere or vacuum furnaces. Different types of furnaces will be discussed later, but they all reduce oxides by catalytic action of the hydrogen atmosphere furnace or by extinguishing them in an oxygen-free vacuum. Copper alloys are mainly used to extinguish carbon and alloy steel, stainless steel, nickel and copper nickel. Since the alloy of filler is high-flowing at flow temperature, interference fits of the joints are recommended. If the fit-up is free fitting, sometimes iron or nickel sawdust is added to the copper paste to enhance the properties of the fillet. Aluminum alloys. AWS identifies two aluminum filler alloys for aluminium rations. However, the Al-718 is the most popular to use in the entire industry. It consists of 88% aluminum and 12% silicon; its solid temperature is 1070 F (577 C) and the liquid temperature is 1080 F (582 C). Al-718 is widely available in all forms: wire, rod, preform and paste. It is used for rations 3003, 6061 and 6063 aluminum main metals. Al-719 can offer favorable advantages because the average temperature difference between the melt temperature of the widely used metals of the aluminum base and the flow temperature of AL-718 can be as little as 25 F (4 C). The recipe for this filler alloy contains 76% aluminum, 10% silicon, 10% zinc and 4% copper. The temperature is 960 F (516 C) and the liquid temperature is 1040 F (560 C). Unfortunately, due to the small demand for the An-719, today it is only available in the form of pasta. Manufacturers who use aluminium in the production of their products are constantly studying new and exotic aluminum alloys to make basic components. Some are looking for lighter pipe formation processes 289 305: A Comprehensive Guide to Aluminum Alloys for the Machine; other users are interested in the heat-learning characteristics of various aluminum alloys. While there may be very good reasons to use these new aluminum metals in production, some cannot be successfully brazed until new filler alloys and streams are developed. FLUXES As metals heat up, oxides are formed on surfaces exposed to heat. The only purpose of the thread is to raise that are formed on the faying surfaces of base metals connected as they heat up to prepare the surface for the alloy filler. This process is commonly referred to as called wetting the surface. The parts components must be thoroughly cleaned before rationing to remove grease, oil and other dirt to get optimal strength and maximum penetration of the alloy filler into the joint interface. Brazing flow can dissolve pollution, but residues of pollution, along with residues of flow, can remain in the faying surfaces of the joint after rations. The connection of base metals does not occur in the space occupied by interface pollution. Once the ration is cleaned, the contamination can be removed leaving empty voids. If these voids extend from the top to the bottom of the joint interface, a leakage path can form. If the void is internal to the joint, fusion diffusion may not occur. As a result, these areas of the joint are not strong; In some applications, the joint may fail due to stress. Fluxes are made from a variety of ingredients tailored to reduce the oxidation of specific metals as they heat up. Typically, an active flow lifestyle depends on temperature and time. As the stream heats up outside the recommended temperature range, or outside the active life of any of its ingredients, it becomes inactive and unable to continue to protect the metal surfaces during ration surgery. Specific ingredients included in different types of flow are selected based on the fact that the base metals are overextended, the temperature of the filler alloy flow and the estimated amount of time it takes to complete the ration. The 290,306 Brazing and Joining Formulas used in the production of streams are usually property. However, most commercially available streams include ingredients from the following list: Used in high-temperature flow, borotas fuse at 1400 F (760 C). and stay effective above that temperature. They have a good oxide-dissolving action but viscous and require mixing with other materials to increase the flow. Boron powder improves fluxing action at high-vex ranges to protect fireproof materials and oxides of chromium, nickel and cobalt. Fluoborates reduce the high temperature oxides of the flow compound. Fluorides reduce the high temperature oxides of chromium and aluminum and improve the flow of borats. Chlorides work in the temperature range lower than fluorides, and depress the melting point of fluoride. Boric acid facilitates the removal of glass residues of flow after rations. Lithium salts dissolve aluminum oxides in aluminum streams at ration temperature. Alkalia, or potassium hydroxide and sodium hydroxide, increase the useful flow temperature. They dissolve and become liquid, absorbing moisture from the air. They have a short shelf life. Wetting agents to facilitate the flow of the flow before brazing. Water is present in connection with the ingredients of the flow or in the additions to the thread for consistency. Fluxes forms are made in the form of paste, powder, suspension, liquid or or Pasta is the most common form and is now available in a creamy form for convenience. Typically, specific streams are available for rations of aluminum, aluminium-bronze, silver, magnesium, as well as for high-temperature applications. Dosed versions are becoming popular because of the benefits they offer in managing the process. 291 307 Tube-forming Processes: Comprehensive Guide to Dispensers flows distributed streams are applied using a manual or automatic gun applicator. The benefits of dosed streams include health and safety factors because brazer is less likely to come into contact with the flow, and environmental considerations because less is washed down the drain after rations. As the recurring deposit is distributed to each joint, it becomes easier to predict the annual usage requirements. However, the most important advantage of the dosable flow is its ability to improve and control the ration process by distributing repetitive flow deposits in successive locations at each joint. This is important because the amount of flow applied to this joint increases the total mass in the joint area, which must be heated to brazing temperature. Inconsistent flow deposits change the amount of heat (BTUs) that must be caused to the joint area to increase its temperature to the point of the filler alloy flow. Flux also has a reflective characteristic that changes the rate of heat absorption, reflecting heat from the joint being brazed. The consistent placement of the deposit flow allows a consistent heat directed in the joint area being brazed. Controlling the total mass of all ingredients in the heat zone improves the quality of rations. Other characteristics including homogeneity gap around each joint being brazed, thermal output, and time should be consistent to get high results for first time bandwidth in automatic brazing applications. The generic fluxes White Stream is the most common and is used for low temperature rations of most metals, except aluminum, magnesium and titanium, which are brazed with silver-based filler alloys. This type of flow is usually active to about 1600 F (871 C). The flow becomes transparent before the temperature of the ration, making it easy to see the flow of the alloy filler. It is easy to wash off after rations. Boron and other ingredients are added to white streams to increase their active range to about 1,800 F (982 C) for massive components that require long-term heating, or high-dark-th coincided- 292,308 Brazing and Joining perature alloy filler. This type of flow works well when used at lower app temperatures, and is recommended for stainless steel, carbide or rations long-term heating. These threads are commonly referred to as black streams. Aluminum streams Are usually two popular streams available for rations of aluminum. They're Them as corrosive or non-corrosion-based activity residues after ration. Sodium chlorides and fluoride are used for corrosive flows; non-corrosion flows are formulated using potassium chloride and fluoride. The main advantage of corrosive aluminum streams is that they are active over a long temperature range, thus providing the oxide-free surfaces needed for proper fuze of the filler alloy. The process window is usually more forgiving because the flow is active for a longer period of time than is typical of non-corrosion threads. Assuming that all other variables that normally affect the quality of braze are controlled, it may be easier to get high results for first time bandwidth when using corrosive streams. Parts brazed with corrosive streams appear clean and shiny after cleaning in 20% solution of nitric acid and water with at least two freshwater rinses. The main reason for choosing a non-corrosion flow is that after rations are not required after ration. However, you should consider a number of other characteristics related to the use of this product before deciding on the type of thread to be used for a particular application. While the activity level of non-corrosive streams is very active at low temperatures, the actual life expectancy is relatively short. As a result, the process window is reduced because the link surface faying must achieve a brazing temperature while the stream is still active. The narrow window is caused by a short active flow time, which increases the difficulty of synchronizing the ration cycle time. As a result, it may be more difficult to reach high first-time bandwidth levels, which can usually be achieved by using corrosive aluminum streams. During the ration, free flowing, the non-corrosive stream dissolves in the surfaces of aluminum base metal. The flow extends to 293,309 pipe-forming processes: A comprehensive guide across the entire outer and inner surface in the thermal area around the joint, leaving behind a rough, abrasive, white surface. This cosmetic condition may be undesirable for some types of applications. Duration and unsightly appearance are the two main reasons why many decide to use corrosive streams and invest in after cleaning the processes needed to remove the residues of corrosive flow. OXIDE REMOVAL SYSTEMS In addition to using braze flux to reduce surface oxides during non-oven operations, steam or gas currents can be used to reduce external oxides, and inert gases to reduce oxides from the inner surfaces of the part. Gas gas is usually formulated from a mixture of boron and acetone. Sometimes it is called the flow of steam. Typically, fuel gas is prescribed through a liquid mixture placed in a closed tank system (see figure 7-7). As the mixture and fuel gas come out of the torch, acetone acetone spreading the national mixture over visible and invisible parts of the flame. Flames are usually clearly defined, changes in green color and becomes thick in appearance as normally invisible parts of the flame absorb the boron mixture. Boron, as it comes into contact with moisture in the air, turns into boric acid, a widely used ingredient in the production of rations. Boric acid, completely distributed throughout the flame, establishes a protective barrier enveloping the thermal surfaces of the part. Boric acid in this application is non-corrosive and does not require post-cleaning. The safety barrier is the main function of the gas flow. No post-cleaning is required when it is used for rations of copper or brass as long as the filler alloy containing phosphorus is used and no braze flow is applied to the joint. The stream only protects the external surfaces it comes into contact with during heating. Since the flow of gas is usually unable to reach deep into the faying surfaces of the joint, it may not be able to protect these surfaces, allowing oxides to form during the heating process. Gas Flow 294 310 Brazing and Joining Figure 7-7. Gas flow system. should not be replaced by rations as a way of eliminating after cleaning after rations. Nitrogen cleansing While many companies use nitrogen, most inert gases can also be used to displace the space occupied by atmospheric air on the inside of the assembly. Cleaning the inside with nitrogen reduces the likelihood of oxidation on heated internal surfaces during rations. Inert gases are slowed down by the formation of oxides, but they do not remove those that have formed. Thus, the flow should be used, except when copper-phosphorus alloys are used in rations of copper metals. PRECLEANING PARTS Unfortunately, pre-cleaning parts is one of the steps that is either completely altered or completely eliminated due to its cost and environmental problems, which it sometimes creates. Flux has not developed 295 311 pipe-forming processes: A comprehensive guide to pre-clean parts components. The decision to remove the pre-cleaning operation can lead to poor ration quality and increase the cost and scope of the operation after cleaning. Any oil and pollution left in the heat-affected area is likely to be carbonated and become very difficult and costly to remove. Pre-cleaning processes range from wiping the components of the part with a cloth to partially immersing them in low-fat liquids. The problem with wiping is that oils and other contaminants cannot be completely removed. Residual contaminants remain in pores located on metal surfaces. In addition, pollution from one placed on subsequent parts rubbed with the same fabric. Dive the tube into the skimming liquid oil leaves on the upper surfaces. Capillary attraction draws oil down and into While heated. In addition, skimming is generally unable to remove other types of pollution, such as dirt and heavy oxidation. Explosion of beads is an acceptable method for removing pollution; however, the media should not contain silicon. Brasic streams are not able to penetrate and dissolve silicon, which is extremely difficult to remove from the pores of base metals. Its presence prevents the fusion of filler. HEATING Heat source selected for a specific application should ensure uniform heating within the joint area of the part that is brazed. Capillary attraction does not occur if the base metals are not heated to the temperature of the filler alloy flow. However, if the heat is directed at the filling alloy, it can melt into the faying surfaces of the joint. This condition is commonly referred to as cold alloy flow. However, optimal strength is not achieved and the phenomenon of alloy diffusion does not occur. This condition is one of the main reasons for the recycling and scrap in the manual ration process, because the hand brazer has difficulty producing a repetitive and uniform thermal pattern. The trend is to devote a process to each application on the machine to get repetitive. Whether the induction or torching process is used as soon as a single thermal pattern is determined, it can be difficult to recreate it during the transition process. However, sup- 296 312 Brazing and Joining pliers of both of these types of equipment are developing methods to eliminate the transition. The purpose of the heating process is to increase the temperature of all parts components evenly. Massive components require more heat. Thin, light parts require less heat. The efficiency of the heating process is determined by how well the heat system chosen for a particular application works. The Gas Systems Gas System provides a simple and inexpensive location of torches in specific models to evenly cause heat in all assembly components, especially in applications that use multiple thermal stations on the machine (see figure 7-8). Gas systems direct heat to specific assembly components, while limiting heat induced to others. This is important in rations, which include components from different base metals and masses. Gas heating systems are also automated because of the ease of designing a thermal pattern. Systems are available that offer a digital transition to ration different components on a single machine. Gas systems have some limitations that can make other heating methods a better alternative. Since large heavy parts require more heat (BTUs) than smaller ones, it may take too long to heat the joint area before the flow temperature of the filler alloy. When (a) (b) (c) Figure 7-8. System Heating. 297 313 Pipe formation Comprehensive guidance of this condition exists, a high risk for the elimination of alloy filler also exists. The longer the time it takes to increase joint temperature, the greater the potential for conducting heat away from the joint and in delicate areas at the assembly. This can be especially important if sensitive materials including rubber, springs, diaphragms and painted surfaces are located next to the joint being brazed. In addition, the finished size of the assemblies with the formed tubes near the joint can be distorted due to the heat, easing the stresses created during the formation. Induction systems Induction system provides an effective method of inducing heat to a certain area of the part (see figure 7-9). Localized heating is a major advantage of the induction system as it reduces the time it takes to heat the joints to brazing temperatures. This is especially important when putting out heavy massive parts. Carrying out heat away from the joint is limited. Because the induction figure is 7-9. Induction heating system. 298 298 tube forming processes a comprehensive guide pdf