Gear pump torque curve

Courtesy Bailey Intl. LLC; www.baileyhydraulics.comElectrical motors can generate a multi-time output torque corresponding to their operating torque. This gives them an advantage over gasoline and diesel engines for driving a pump in a hydraulic unit. Understanding the power and torque of different Prime Movers helps you design powerful and efficient HPUs. 1. If a gasoline engine (shown here) or diesel engine is the main drive when driving a hydraulic unit, the size calculations differ from those when using an electric motor. This ™ because electric motors develop a very high start-up torque, while gas and diesel engines develop approximately the same torque in the entire speed range. (Image courtesy of York Portable Machine) When specifying components for a hydraulic unit, the main drive is dimensioned based on torque, speed and power requirements of the hydraulic pump. This is quite easy for electric motors because they usually have a starting torque that far exceeds the running moment. However, designers often specify engines that are larger than necessary. This leads to energy wastage, as the motor operates with less than maximum efficiency. Diesel and gasoline engines are another matter. They have a much flatter torque speed curve, so they deliver about the same torque at high speed as at low speed. This means that an internal combustion engine (Fig. 1) can develop a high enough torque to power a charged pump, but not enough to accelerate it to operating speed. Therefore, if all other factors are the same, an aggregate that requires an electric motor with a certain rated power usually requires a gasoline or diesel engine with a power more than twice that of the electric motor. The cost of operating an electric motor over the entire life of the electric motor is many times the cost of the motor itself. Therefore, the correct size adjustment of the motor for a hydraulic unit can save a considerable amount of money over the life of the machine. When system pressure and flow are constant, the motor size simply includes the standard equation: $hp = (Q \times P) / (1714 \times EM)$, where PS PS psis PS, Q is flow in gpm, P is pressure in psi, andEM is the mechanical efficiency of the pump. However, if the application requires different pressures during different parts of the operating cycle, you can often calculate root-mean-square (RMS) (PS) and select a smaller, lower-cost engine. In addition to the calculation of the rms-PS, the maximum torque must also be determined at the highest operating pressure of the pump. the two calculations are quite simple. 2. Shown is the multi-pressure pressure cycle for a 6 gpm gear pump with calculated PS values. For example, Fig. 2 is an application that uses a 6 gpm transmission pump at 3,450 rpm to drive a cylinder connection that works for 85 seconds. Works. System requires 3,000 psi for the first 10 sec. 2,200 psi for the next 30 sec., 1,500 psi for the next 10 sec. and 2,400 psi for the next 10 sec. The pump then goes 20 seconds to 500 psi, followed by 15 seconds with the motor switched off. It is tempting to use the standard formula, plug the high-pressure segment of the cycle and then calculate: HP = (6 × 3,000)/(1,714 × 0.9) = 11.7 hp for 10 sec. To ensure this performance, some designers would choose a 10 hp engine; others would be ultra-conservative and would use a 15 hp engine; and a few could take a chance with 71.5 hp. These engines in open-to-trip-proof C-Face models with feet would carry a relative price of about 570, 800, and 400 Us dollars, so there could be savings of between 170 and 400 US dollars per unit if you opt for the 71.2 hp engine – if it does the job. To determine this, first calculate the PS for each pressure segment of the cycle: hp1 = (6 × 2,200)/(1,714 × 0.9) = 8.5 hp for 30 sec.hp2 = (6 × 1.20 0) 500)/(1,714 × 0.9) = 5.8 hp for 10 sec.hp3 = (6 × 500)/ (1,714 × 0.9) = 1.9 hp for 30 sec. The RMS PS are calculated by square the square root of the sum of these PS values, multiplied by the time interval at these PS and divided by the sum of the times plus the term (toff ÷ F): where hprms is root-middle square horse, t the time interval in seconds and F is a constant: 3 for open, drip-proof motors; 2 for completely closed, fan-cooled motors. Replacing the sample values in the nested equation and solving shows that hprms = 7.2. Thus, a 71 hp engine can be used from the point of view of the psyth alone. However, the second point, the maximum torque, has yet to be verified before a final decision is made. The maximum torque required to drive this particular pump is found at the highest pressure because the output current of the gear pump is constant. Use this equation: T = D × P/(12 × 6.28 × EM), where T is torque in ft-lb, andD is displacement in in.3 For this example D = (6 × 231)/(3.450) = 0.402 in. 3 Then, T = (0.402 × 3,000)/(12 × 6.28 × 0.9) = 17.8 ft-lb. Since electric motors produce 1.5 ft-lb/HP at 3,450 rpm, the 17.8-foot Lb torque requires 11.9 hp (17.8 ÷ 1.5) at 3,000 psi. This is close enough for the sample application. (At other standard engine speeds, 1,725 Rpm generates 3 ft-lb per horsepower; 1,150 rpm, 4.5 ft-lb per horsepower; and 850 rpm, 6 ft-lb per horsepower.) Now the second criteria can be compared with what the proposed engine can deliver in torque. How is the winding torque of the 71.2 hp engine chosen? Since the torque is at least as high as the engine from 0 to 3,450 rpm above 11.9 ft-lb with an acceptable safety margin. Note that a low-voltage motor generates only 81% of the rated traction torque; in other words, (208 ÷ 230)2 = 0.81. 0.81. The power curves of the engine manufacturers will have several available 71 hp models with a higher tensile torque. Each of these engines could be a good choice for this application. Both engine criteria have now been reviewed. The RMS-PS are equal to or smaller than the PS of the rated motor. The pulling torque of the engine is greater than the maximum required. Gas and diesel engine power The right dimensioning of an electric motor for a hydraulic unit is a simple process. And if load pressure and flow remain relatively constant, determining the power requirement is relatively simple by using the known equation: hp = (q × p) / (1,714 × EM), where q flow, gpm (and the volume tefficient of the pump is taken into account), the system pressure at full load, psi andEM is the mechanical efficiency of the pump. Suppose an application requires a flow rate of 13.7 gpm at a maximum pressure of 2,000 psi and with a pump efficiency of 0.80. From the above equation: PS = (13.7 × 2,000) / (1,714 × 0.80) = 20 hp. It may seem that a gas or diesel engine would have the same power as an electric motor as the main drive. However, the general rule of thumb is to indicate an internal combustion engine with a rated power of 21.2 times the equivalent of an electric motor (Fig. 2). This is mainly due to the fact that internal combustion engines have different torque-speed relationships than electric motors. Examining the different torque properties will provide an understanding of making a decision based on sound considerations rather than relying on a rule of thumb. Pump Torque Requirements Power is, of course, the combination of torque and speed. The torque requirement of a pump is the main factor determining whether an engine or motor is suitable for use. The speed is less critical because when a pump runs slowly, it still pumps liquid. However, if the main mover does not develop enough torque to power the pump, the pump does not generate output current. To determine the torque required by a hydraulic pump, use the following equation: T = (p × D)/(6.28 × 12 × EM), where T torque, lb-ft and D is displacement, in.3/revolution. The pump shift is provided in the manufacturer's literature. When using the above equations, at a displacement of 1.75 In.3/Rev., the required torque is calculated as follows: T = (2,000 × 1.75)/(75.36 × 0.80)T = 58 lb-ft torque can also be calculated with the known PS equation: HP = (T × n)/5.250 where n is wave speed. Replacing values from the example: 20 = (T × 1,800)/5250T = 58 lb-ft. Electric Motor Torque Signature To reduce the differences in performance characteristics between an electric motor and To understand the properties of a standard 3-phase electric motor. Figure 3 shows the torque speed torque speed 20 hp engine, 1,800 rpm, NEMA Design B-motor. When the power is absorbed, the motor develops a first, locked rotor moment, and the rotor rotates. When the rotor accelerates, the torque drops slightly and then begins to rise when the rotor accelerates over about 400 revolutions from 3 p.m. This slump in the torque curve is generally referred to as the elevator moment. The torque finally reaches a maximum value of about 1,500 rpm, i.e. the engine's moment of failure. If the rotor speed rises beyond this point, the torque applied to the rotor drops sharply. This is called a running moment, which becomes a full-load moment when the engine is running at its rated full load speed– usually 1,725 or 1,750 revolutions for the watch. 3. The torque speed curve of an Ac electric motor shows that a much higher torque can be generated at low speed than is required to drive a hydraulic pump at full load speed. The torque-speed curve for a 3,600-rpm engine would look almost identical to that of the 1,800-ummin engine. The difference is that the speed values would be doubled and the torque values would be halved. It is customary to ensure that the torque required by the engine is always smaller than the moment of failure. By applying a torque that corresponds to the failure moment or is greater, the engine's speed drops suddenly and sharply, causing the engine to stall and most likely burn it out. If the engine is already running, it is possible to charge an engine for a short time near its failure moment. But for reasons of discussion, assume the electric motor is selected on the basis of full load torque. Note that Fig. 3 shows a temporary large torque surplus that can provide additional power to drive the hydraulic pump through instantaneous load increases. These types of electric motors can also be operated indefinitely with their rated HORSEpower plus an additional percentage based on their service factor – usually 1.15 to 1.25 (at heights up to 3,300 ft.). Catalogue ratings for electric motors list their usable performance at a rated speed. When the load increases, the engine speed decreases and the torque rises to a value higher than the full load torque (but less than the failure moment). Therefore, if the pump is operated at 1,800 rpm, the electric motor has more than enough torque in reserve to power the pump. Torque behaviour of motors A gasoline engine has a significantly different torque-speed curve (Fig. 4) than an electric motor. This means that a gasoline engine in the entire speed range has a significantly less variable has. Depending on the design, diesel engines with the same ratings at lower speeds can produce slightly higher or lower torque than gasoline engines, but diesels have a similar torque curve in their overall speed range. 4. The torque-speed curve for an internal combustion engine is much more linear than that of an electric motor. This shows that the torque to connect a hydraulic pump at low low Gas and diesel engines must have a higher power than an electric motor to power the same pump. Calculations above showed that 58 lb-ft of torque is required to drive the pump at any speed. Referring to Fig. 4, the 20 hp gasoline engine develops a maximum torque of only 31 lb-ft – obviously not enough to power the pump. This is because its 20 hp performance is based on the power at 3,600 rpm. The maximum torque occurs at speeds close to 3,000 rpm, but is still well below the 58 lb-ft required by the pump. Even if the engine produced enough torque at this speed, the power would still be insufficient due to the lower speed. This is where the 21/2 size rule comes from. An HPU that requires a 20 hp electric motor to power the pump at 1,800 rpm would require a gas or diesel engine with an output of about 50 hp. In addition, these values are based on an engine that operates with its maximum torque and rated power. However, manufacturers recommend that petrol and diesel engines operate continuously at only about 85% of their maximum values in order to prevent a serious shortening of their service life. Referring to Fig. 4, a 20 hp gasoline engine would thus develop slightly more than 26 lb-ft maximum torque and only 24 lb-ft at 3,600 rpm. It is also interesting to compare this performance with fuel consumption. The consumption table (Fig. 5) shows that a 20 hp gasoline engine achieves the highest fuel efficiency with around 2,400 revolutions per minute, consuming just over 8.2 lb/h (0.41 lb/hp × 20 hp). At 3,600 rpm, the engine would be significantly fuel-saving. 5. Depending on the design, an internal combustion engine is ™ optimum fuel consumption often occurs at a different speed than when it generates maximum torque. It should now be clear that specifying a petrol or diesel engine to drive a hydraulic unit follows a different procedure than the indication of an electric motor. If you are accustomed to specifying electric motors for hydraulic power units, you may be tempted to equip a pump at 1,800 revolutions per minute, and then specify an oversized motor that can develop enough torque to power the pump at that speed. This technique produces a reliable aggregate, but it is relatively heavy, bulky, inefficient and noisy. Instead of following this procedure, one of the different options should be considered. One would be to drive the pump at a speed of more than 1,800 rprouts. Pump literature for mobile devices should list reviews with a variety of speeds. this is not the name already the trap, contact the pump manufacturer. Driving the pump at a higher speed reduces the required displacement and thus reduces the need for size, weight and torque. The operation of the higher speed unit thus adapts the engine power more closely to the application by increasing the torque generated by the engine and reducing the torque required by the pump. More specifically, the operation of the pump pump Our example at 2,800 rpm would increase the engine torque to more than 30 ft-lb and reduce the torque required by the pump to perhaps 38 ft-lb. Although the engine torque still lags behind demand, it obviously comes much closer to the appropriate pump torque than at 1,800 rpm at 1,800 rpm. Designers may be tempted to operate a gas or diesel engine at or near the speed at which it has optimum fuel efficiency. However, an operating speed at which the engine generates maximum torque usually takes precedence. If the engine does not generate enough torque at its optimum fuel efficiency speed, a larger engine would be required. But a larger engine consumes more fuel, which would nullify the purpose of saving fuel by a certain operation at a certain speed. In addition, pumps usually have a speed range where they are most efficient. So even if an engine operates a few hundred revolutions per minute above or below its optimum fuel efficiency speed, the torque generated and the pump dynamics usually have a greater impact on the overall efficiency of the unit. Therefore, the speed at which the gas or diesel engine operates should take all these considerations into account. In pump performance, many designs have higher mechanical and volumetric efficiency when operated at speeds of more than 1,800 revolutions per minute. On the other hand, operating a pump at a speed higher than what it was designed for would reduce its service life. Therefore, it is important to choose a pump speed that offers the best combination of pump and motor performance. Perhaps an even better alternative would be to provide a gearbox or some other type of speed reducer between engine and pump. Although this would add components to the unit, it would increase torque and reduce the speed, while both the engine and the pump can operate at their optimal speeds. The additional cost of the speed reducer can be compensated by the lower cost of a smaller, lighter and cheaper engine. Other considerations Since gas and diesel engines do not have the torque reserve of electric motors – especially when accelerating from the rest period – it is particularly important that the pump is discharged every time the HPU is put into operation. This can be done hydraulically or mechanically via a centrifugal coupling or another drive element. Finally, as with HPUs, those used by electric motors can pump size – and thus the size of the main mover – are often reduced by integrating accumulators into the hydraulic system. When the hydraulic system operates in cycles where full flow is only needed for short periods of time, an accumulator can store hydraulic power in times of low flow demand and release that energy when full flow is needed. This information is taken from the Fluid Power Handbook & Directory. Subscribe to hydraulics & Pneumatics eNewsletters The hydraulic radial piston motor is a Component used to power and power a wide range of mobile machines. It operates as a direct drive and operates as a low-speed, high-torque hydraulic motor that is directly coupled to the axle it moves, so there is no need to add a gearbox in between. Since they can deliver high power densities in a very compact housing, radial piston motors are well suited for wheel, chain and chain motors. They are also robust, with a minimum number of moving parts that do not require routine maintenance. These engines are designed to operate environments in mines, construction sites, forestry and agriculture that require high performance and the ability to move large machinery and loads in rough terrain. These basic features —power density, compact size, robust design and high performance—have made the radial piston engine a reliable mobile machine drive for decades. And while these engine types are considered sophisticated technology, innovative new features and drive concepts seem to meet the new requirements and requirements of OEMs of mobile machines and end users in various industries. Since they can deliver high power densities in a very compact housing, radial piston motor systems are well suited for wheel, chain and chain machines. Bosch Rexroth advantages of low-speed, high-torque Direct DrivesRadial piston motors often drive machine functions that require considerable force to move heavy loads, such as the chain drives for screws and conveyor belts in asphalt laying plants. They also provide fine positioning control more precisely than solutions that include high-speed motors and transmissions. For example, using a radial piston motor to control the Slew drive, which rotates the torso of an excavator 360 degrees celsius, makes it easier for the machine operator to control the stop point and position the shovel to work. In several industry segments, mobile machine end users value drive systems that offer optimal fuel efficiency, high power density, maximum productivity, and reliability. These performance requirements are matched by systems with compact floor plans, so that they fit into narrow mobile machine frame rooms. To meet the industry's requirements for radial piston equipment, Bosch Rexroth has developed a wide range of versatile, modular engine designs with functions for specific application requirements. As a result, this hydraulic motor technology offers mobile machine OEMs and end users several advantages: high volumetric and mechanical efficiency. In order to achieve maximum fuel consumption, all radial piston motors have optimized sealing and low-friction properties in flow passages and rotating elements. Increased launch efficiency and smooth rotation. Precise control, even at shaft speeds of up to 0.5 routs, is achieved by a rotation group construction for high-temperature applications and maximum efficiency without compromising durability. High temperature range capability. Tribological developments in rotary group design have improved durability and resistance to high temperatures, helping to reduce the overall cooling requirements of the system. Low operating sound level. Low-speed, high-torque direct drives have very smooth interacting mechanical parts. This results in a lower operating noise level compared to other technologies such as gearboxes. Combined with the improvements in hydraulic flow optimization, radial piston motors are a valuable way for mobile machine manufacturers to meet the increasing customer demands for lower noise emissions from hydraulic components. In addition, the modular design offers integrated drive solutions for a wide range of customer applications. An example is the use of a radial piston semi-motor in combination with a drive axle. The versatility of this design also allows you to connect a second shaft for two-axle drive (four-wheel drive). The direct drive properties of the low-torque, high-torque radial piston engine eliminate the requirements for a drop box. This significantly improves the ground clearance of the vehicle and reduces the overall machine costs. The HTA system uses radial piston motors, hydraulic axial piston pumps, a control block and sensors, and an electronic hydraulic control system with user interface in each side of the front axle. Bosch RexrothAdvances for evolving industry needsDespite its long service, new concepts of radial piston engine technology and design advances are constantly emerging to meet current OEM and end-user requirements. Reliability and maximum machine uptime are important industry drivers. There is also a growing movement to apply IoT technology so that OEMs and end users can monitor and capture a wider range of real-time operating data on the performance of the radial piston engine. End users are always anxious to prevent unplanned downtime, which can be very expensive, as most machines with radial piston motors are expensive to operate in high-quality applications. A wider range of sensors are introduced to provide real-time data that machine operators can use to plan or intervene in predictive maintenance programs to prevent major equipment failures. These include pressure sensors, temperature sensors and vibration sensors. These sensor arrays are connected via mobile device controllers and new edge computing devices, with cloud connectivity now integrated into many portfolios for mobile electronics in construction and introduced. In addition, this data may also be relevant to operators to improve the way they use and manage devices on-site. This includes new business models in which equipment is rented out to construction companies or other operators. Be. Cost parameters based on operating time obligations. With real-time radial piston engine data, it can help ensure that the equipment is properly serviced. In addition, oeMs for mobile machines are increasingly looking for more real-time sensor and operational data to support research and development efforts in the development of the next generation of products. The compact drive solution MCR-T radial piston motor for rail and wheel applications offers a 10% improvement in start-up efficiency compared to conventional versions. Bosch RexrothNew designs improve efficiency & performanceThere are also ongoing efforts to improve energy efficiency and reduce emissions in mobile machinery by improving radial piston engine designs. By continuously increasing engine efficiency, it is possible to reduce the fuel consumption and diesel emissions of the mobile machine without compromising the ability to work a full day. This includes the effort to reduce the overall size of radial piston motors without sacrificing power, depending on the application, so that they can fit into tighter machine shells. For example, Bosch Rexroth presented its compact DRIVE solution MCR-T for rail and wheel applications. The design offers a 10% improvement in start-up efficiency compared to conventional designs and has an optimized shaft position that can accommodate higher radial loads due to better load distribution. For chain drives, a parking brake on the drive motor is required. To save space, the parking brake was moved inside the engine instead of being outwards, reducing the overall length of the engine by 20%. By reducing size, it can be integrated into a larger number of mobile machines with track drives, while also saving component weight, which can help with fuel efficiency or equipment performance. There are ways to integrate this space-saving design into other radial piston motors, such as .B used in skid loader drives. Radial piston engine designers also improve opportunities to provide higher speed for wheel drives, allowing mobile machines to move faster from one workstation to another. This uses a reduced displacement mode that reduces the number of active pistons, transmits hydraulic power to torque, and thus increases the speed. Operators can choose which displacement mode to use, depending on the performance requirements. This makes it possible to increase the speed of the radial piston motor without having to install a larger displacement hydraulic pump. A further significant development in the application Radial piston motor technology is the Hydraulic Traction Assistant (HTA) platform. This system is designed to give additional traction to the steering axle for heavy 18-wheel trucks, such as loads under difficult ground conditions where traction is traction-related. Give. The system combines two radial piston motors integrated into each side of the front axle as well as hydraulic axial piston pumps, a control block and sensors, and an electronic hydraulic control system with user interface. In neutral mode, which is used when no additional traction is required, the radial piston engine is inactive, reducing resistance losses to a minimum and improving fuel efficiency compared to a mechanical all-wheel drive system. If the operator has a full load and requires traction to get out of the pit, the system is turned on automatically or manually. This transmits power and torque from the diesel engine of the truck via the closed hydraulic pumps to the radial piston motors and thus ensures the driving force of the steering axle. Once the vehicle reaches a sufficient speed – about 18 mph – the system automatically returns to neutral mode unless the operator decides to keep it on. Bosch RexrothIncreasing the value of radial piston motorsThe increase in vehicle traction is just one example of how the compact dimensions and power density of radial piston motors can provide a powerful way to apply the technology in a new and effective way. Mobile machine builders work with key radial piston engines and system vendors to apply this technology, taking advantage of new developments to improve the versatility and performance of their device delivery drivers. Understanding the evolving needs of mobile machine end-users is also critical to maintaining innovation in radial piston engine technology. Major system and component suppliers with extensive experience in hydraulic technology, together with a long history of developing and developing radial piston engine products and systems for specific machine requirements, are helping to further improve radial piston engine technology to keep pace with today's development of mobile machine requirements. Steve Zelich is Product Manager – Radial Piston Engines at Bosch Rexroth Corp. Corp.