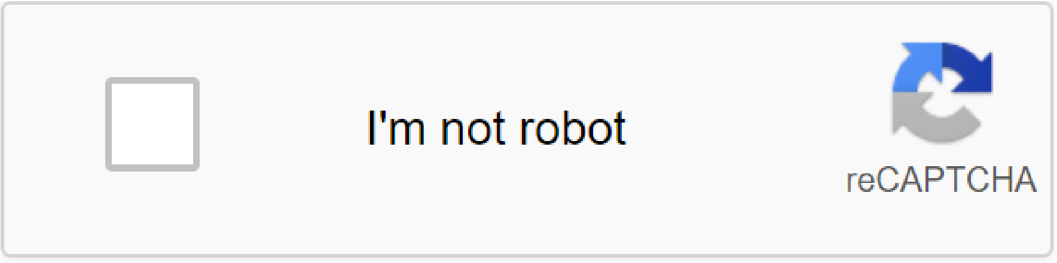
Ornithopter design calculation pdf



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Content: Image cover guide There is no general method of calculating flapping wings. Each source of information describes different methods. All orni calculation tools below are based on the calculation method listed in the Ornithopters guide. In particular, the power and twisting of the wing in stationary flight situations can determine it. In addition, the calculation method allows at least an approximate estimate of the dynamics and aerodynamics of profiled flapping wings. First of all, a numerical comparison of various factors influencing the flapping wings. It is assumed that profiled flapping wings and quasi-stationary flow conditions. Thus, calculations only lead to useful results for a quick flight forward with a relatively low flapping frequency (e.g. large birds; please see the description of the flight with the elevator). Mathematical models are only performed with relevant software applications. The calculation scheme for creating your own calculation program can be found in the Handbook in annex D., in particular to describe the wing twisting equation directory used in a small calculation tool MS-EXCEL: Download Orni 1 version 5.0 (xlsx, with short instruction, 0.1MB) This tool primarily allows the calculation of wing twisting when data is a wing. Force promotion in principle The Force Calculation Scheme for flapping wings Additional calculation of the data of the flying model is greatly simplified. Detailed calculation of the progression of force during the stroke cycle has been replaced by sinusoidal force progression. Thus the fine connection of stroke and twisting movement remains unconsidered. Only the reference line (e.g. in gliding flight) and the amplitude of the sinus half-wave in the middle of each wing impact are defined. At the same time, the area under the progression of the curve or the size of the force is roughly calculating. The basic method of calculating the Ornithopters Fly guide is reconstructed step by step. Many of the detailed equations are generated with accompanying text, diagrams, and pictures. The calculation tool automatically guarantees the number of operational range of the lift factor used by the air thme. In addition, the balance of power during the flight takes place in a simple way. Thus, of course, it is possible to achieve flight data of the selected configuration of the model. For the design of the flapping wing model the calculation method describes the different development of strength and moment on the wing. In addition, the required power and, above all, the twisting of the wing along the span is calculated. The calculation tool was written (in German) with Mathcad software. Because of the amount of data and pages, this requires little familiarness. This tool is based on Orni 2. Here you can analyze the gliding and power flights of the model of flapping wings in real and in the series. To calculate the ornithopter model, the various input parameters are first specified. One is defined as a variable area. In the selected data area, one then receives flight and drive data, while automatically retaining the gunpowder data and the balance of power. Since there are only a few specifications included, the Orni 2 calculation tool should be known in advance. The calculation tool was written with Mathcad software (in German). The web page for finding a table for Mathcad-user here listed calculation tools are too understood as open source software. Thus, everyone has the opportunity to look at the understanding of the method of calculation. Everyone has permission to rebroadcast, vary and in particular fix and improve this source code. The performance of a silent swan flight is compared to the performances of a propeller and a flapping wing model. Download Comparison (xlsx, 28KB) a mute swan needs the most energy. In particular, this is due to the small efficiency of his muscles, but not his way of flying. Instead, the swan has the advantage that its fat provides a relatively high energy storage density. Using the tools used, the flapping wing model is slightly more efficient than the model propeller. Also the flapping handbook wing model is compared with according to the propeller model. To references and other literature 1. The introduction of the Design and Design Tasks of flapping aircraft has attracted the attention of scientists and engineers. Anyone can see birds with their own eyes, using this principle of flight, can, on the one hand, fly and fly in difficult terrain, and on the other hand, they can perform long passages, in the end, the flight of the bird is almost inaudible. Thus, humanity has long dreamed of flying like birds, but a scientific and practical approach to solving this problem was found only recently. Leonardo da Vinci, in his works, was perhaps the first to present a description of some man-by-have-flapping device that could probably get out of the ground with this power. By now, 300 years later, humanity has received quite advanced industries, i.e. aviation. Using propeller force or jet explosion, planes fly quite successfully within a wide range of speeds. However, the advancement in ornithopters design is very modest. Currently, there are only two ornithopters that have flown manned more or less successfully. The first flight using an additional engine was performed in 2009 by the group Institute of Aerospace Research at the University of Toronto. The second attempt of human-powered flight was made in University group above. Despite this, a lot of work has been done lately were published, which are dedicated to the study of the flapping wing, and no more manned ornithopters were built. According to the authors, this is due to the fact that duplication of natural structures in ornitopters is quite a challenge, both in terms of the development of the theoretical model, and in the construction of a real engineering structure. Therefore, this work proposes, on the one hand, to use a simple kinematic model of ornitopter, and on the other hand, to identify a correlation between the general kinematic and physical parameters of ornitopter and the engine that the design can provide. This will allow engineers, without conducting expensive aviation and labor-intensive full-scale and numerical experiments, to determine the basic parameters of the future manned ornitopter, controlled by human power. 2. The simple Ornithopter In Figure 1 model, a model of a simple ornitopter and the forces influencing it, is presented. Let the basic axis system be oriented as follows. Y-axis versus gravitational direction, X-axis is located along the direction of horizontal flight of ornitopter. Let's introduce some simplifications that will reveal the basic interaction between ornitopter and the environment. 1) Let the weight of the ornitopter be in the center of gravity and position steadily relative to the hull, regardless of the position of the wing. Fg force is directed straight down. This is equivalent to acknowledging the assumption that the wing is weightless. 2) The lifting of the wing by definition is perpendicular to the trajectory of the wing, which deviates under the γ during flapping motion. 3) The aerodynamic drag force of the ornithopter Fx is applied at the center of gravity and does not depend on the position and cost of lifting the wing. Figure 1. A simple ornichtopter. 4) The angle of the wing trajectory to the horizontal is γ < 20 max. (1) (2) 5) The ornitopter wing is always pre-streamlined. Strouhal Number St. taken amplitude swing (3), where: F-flapping frequency. 3. The formula for the simple movement of the Ornithopter now, let's turn to the bidimensional performance of the simple ornithopter traffic. In order to meet the conditions of direct and equal flight, it is necessary that the lifting of the wing on the vertical axis was equal to the gravity affecting the ornitopter. However, analysis of bird surveys or video recording shows that the body of a bird or ornitopter has periodic acceleration in both vertical and horizontal planes. Thus, we will consider the flight of a simple ornitopter as a straight one, if at the same time the flapping cycle, the ornitopter is at the same altitude and is moving at the same speed. We accept when the wing is at the top of the dead point, like the initial height (Figure 2). Figure 2. A diagram of the forces that affect the ornitopter during the cycle. Let's establish a harmonic law of wing oscillations in the vertical plane. (4) Then the vertical speed of wing w can be expressed as follows: (5) And accordingly the angle of the wing's trajectory to horizontal: (6) Let's leave other assumptions as in page 2. As is well known from the training materials, in the area of wing frequency, where there is no separation of the boundary layer, the dependence of the wing lift on the angle of attack is linear and can be expressed by the formula (7), where: Fa0 is the lifting of the wing at an angle corresponding to the level of flight at an average speed of U∞. The increments of the wing lift γ is the angle of deviation from the horizontal trajectory of the wing. Given that in horizontal flight (8) We can record (9) As a result of interaction with the environment, the center of gravity of the ornitopter will be shifted under force. (10) Connecting the law γ changes in harmonic fluctuations in formula 6 to formula 10 we get the value of the center of gravitational acceleration, as follows: (11), where: M e ornithopter takeoff weight. Add initial conditions: Y0 and 0; UyT/4 No. 0 After integrating the equation and calculating the constants based on baseline conditions, we conclude on the equations of the vertical velocity of the ornitopter center of gravity (Formula 12) and the movement of the ornitopter gravity center (13). (12) (13) Y minimum will be received on T/4, and a maximum of 3T/4. Consequently, the peak-peak amplitude of the center of gravitational motion (h) can be calculated: (14) Now let's establish a holistic equation to preserve the linear pulse on the axis of X. (15) The left part of the equation (15) is the engine of the ornitopter. After integrating the expression we get (16) After a certain integral picked up on the cycle, we get (17) Can get a correlation between the amplitude of the wing flap and the amplitude of the center of gravitational motion out of the equation (14): (18) Connection (18) in expression for ornithopter movement (17) we finally get: (19) 4. Conclusions As revealed from Formula (19), according to assumptions taken for a simple ornitopter, the P engine depends only on the general kinematic parameters of the movement of the ornitoper. The main parameter is the frequency of clapping, as the engine depends on it cubicly. It is also worth noting that without the center of gravitational movement of the ornitopter, caused by aerodynamic forces, the development of propulsion systems is also impossible. At the end of this study, a fairly simple human algorithm powered by ornithopter construction takes shape. It can be divided conditionally into two stages: in the first stage the parameters of the glider selected, providing a horizontal flight with an energy consumption of 250-300 W. As a result, the following parameters should become known: 1) ornithopter take-off weight M M M 2) Cruise speed U∞ 3) Wing Surface area S 4) Ratio of wing sides No. 5) Options of air wing Cl Cd 6) Fx resistance force at U speed U∞ In the second stage the ratio of SIL is calculated. Then, based on the presence of structural implementation, the following parameters are selected: the frequency of flapping f; amplitude flapping H; h amplitude of the center of gravitational motion. According to Formula (19) the P engine is calculated, which should be no less than the previously calculated resistance force Fx. If this ornithopter center of gravitational movement is desirable to avoid, then the biplane model (figure 3) with wings moving in the opposition phase. Formula (17) can be used to calculate movement. It is necessary to take one wing of the amplitude flapping, as the amplitude of slapping H. In this case it is necessary to remember that in this case it is possible to avoid the translational amplitude, however, the mutual movement of the step will remain. Thus, in order to save the pilot from any fluctuations caused by the movement of wings, it is necessary to fix the cockpit on a horizontal hinge. Therefore, this article does an equation of correlation of ornitopter movement with kinematic parameters of its movement in the environment. The ornitopter design algorithm for human nutrition is proposed. Recommendations are given to reduce the oscillator movement of the pilot or the payload of the ornitopter. The resulting data is applicable in the best possible way, and strouhal number St zlt; 0.1 is calculated by the amplitude of clapping, but can be applied in other cases as an estimate of calculations too. Figure 3. An example of compensation of the center of gravity of the ornitopter. This work was supported by Grant No. 14-08-00369 A of the Russian Foundation for Fundamental Research. Research. ornithopter design calculation pdf