DESIGN AND CALCULATION OF AN AIRPLANE WING WITH TAKE-OFF WEIGHT TO 2000kg

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The task of this work was to design an aircraft wing for a maximum takeof weight of 2000kg. Basic characteristcs were chose according to the konwledge gained in this issue. The basic formula has been calculated baseload wing. In the design of the elementary program was used to Enginieer. Where were analyzed voltage. Under stress, the proposed design modifcations carried out.

Wing, profile, leading edge, trailing edge .

1 INTRODUCTION

Wing aircraft have evolved considerably. The first attempts to use shapes and sactions, like the wing of birds. Development occurred before and during World War I, when the recruits began to use a rectangular ground plan shapes of wings. The wings, however, a great thickness of the profile. Significantly in this time pushed biplanes and multiplane. Structurally wings are built with non-supporting coating. The wars are beginning to enforce the new constructional material of the development of new more powerful engines, wouldrevolutionize the construction of wings. Beginning emerge as the first wing designed semi-monocoque beam. This period is also known geodetic wing construction is mainly used for British Vickers Wellington aircraft. At the forefront wing shape. As a construction material is wood replace metal materials. These changes allowed the aircraft to increase preformance. The practice became trapezoidal shape of wings and discover the first known elliptical wings on aircraft Spitfire. After the end of Word war II with the development of new types of engines are starting to benefit from new froms of wings as the swept wing and delta wing. The wings allow the achievement of supersonic speed. Delta wing has found application in civil transport. It was used on Concorde and Tu 144. Today has been experimentally tested different wing shapes what is seen in the X series aircraft of NASA. Is developing newstronger and lighter construction and materials used. At the forefront are getting layered materials particularly composites. Along the deeopment of these materials to develop a new type of structure called shells. Modern trends demonstrate that the use of these materials is crucial for the future. Their use in construction is growing.

2 RANGE OF MOTION

2.1 Position the wings to the fuselage

It is the most practical terms. There are three possible locations:

- Highwing
- middlewings
- low-wing

The design concept is best suited hornoplošínka. This location is particularly suitable for transportaircraft. For a relatively small trunk floor location iseasier to load and unload cargo. Location landing gear is more complicated. If the vehicle ispositioned on the wing requires large and heavychassis. If the hull, so we have to achieve sufficient stability for windage movement in the country. The wing can be used which facilitates its solid construction and installation of the fuselage. From the aerodynamic point of view, this construction-page good stability. Which means that the angle of the arrow is small and issometimes necessary to use negative angle of swept wing. Another advantage is the higher buoyancy and low interference resistance. The disadvantagelies in the higher increase in resistance, depending on the Mach number.

Figure 1 Highwing

2.2 Ground shape wings

Shape of wings is one of the most important characteristic. Currently. Using different shapes of wings, for subsonic aircraft, the most used shapes rectangular, trapezoidal, elliptical.

The proposal will seek to achieve a wing that would lift distribution for the same range. This model was first approaching an elliptical wing. For my design I use a combination of rectangular and trapezoidal wings. For the middle part of the wing will use a rectangular shape on the wing and use a trapezoidal shape. This choice of shape because I used to like to achieve the greatest form of an elliptical wing which should lead to a better distribution of buoyancy and reduced resistance wing.

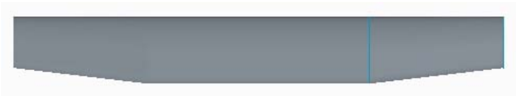

Figure 2 Shape of the wings

2.3 Airfoil

Airfoil are most affecting tha basic aerodynamic characteristics of wings and thus the entire aircraft. The choice we can choose the council has tried profiles. When choosing a profile, the following requirements:

- maximize the lift coefficient c_{lmax} including flap setting,
- the lowest drag coefficient c_d in the range coefficient of lift, the most frequently used mode of flight,
- coefficient c_m torque at zero lift is to be minimized,
- the aerodynamic finese surface $K=c_l/c_d$ should be the greatest,
- ratio c_{lmax}/c_{dmin} should be greatest,
- M_{KR} critical Mach number as mucha s possible
- The relative thickness of the profile should combine the following requirement:
  - appropriate aerodynamic properties,
  - positive constraint, the largest interior space in the wing.

2.4 Basic geometric parameters

We use to describe the wings::

- **l – wing span**
- **b_s – Depth at the center wing**
- **b_k – Depth of wings at the end**
- **S – Wing area**
- **λ – Thinness of the wings**
- **η – Narrowing the wings**
- **φ - Twist wing**
- **ψ – Camber wing**
- **χ – The angle of the arrow wing**

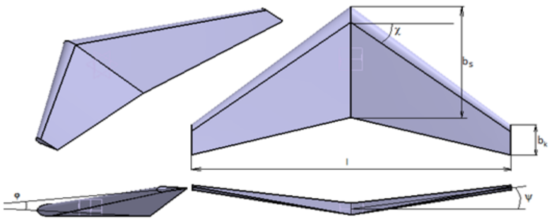

Figure 3 characteristics of the wing

In designing these parameters, we assumethe basic formulas and analyzes the current situation. The analysis is transferred by comparing the aircraft. Compared to the aircraft engine aircraft with a flight speed of 400 km/h and a maximum take off weight of about 2000kg.

3 LOAD OF WINGS

The loads on the wing can be divided into two major types, such as weight and aerodynamic load. All of these loads can be divided into six components of the sliding and axial forces and bending and twisting moments. The load will only count for half of the wing, since we assume that the load is symmetrical in both half of the wing. Base load, we can determine that:

$$Y = n.G.f \qquad (3)$$

Where: n – times the maximum intended load or under the flight envelope with a standard,
G – aircraft weight,
f – safety factor.

3.1 Load the wing aerodynamic forces

To select the basic building blocks of wing, it is necessary to know the effects of buoyant forces on the wing. This effect can be decomposed:

The effect of aerodynamic forces between the wing: This section is necessary to count the local coefficient of lift. We can count on a variety of methods. The method we use Schrenkers formula:

$$C_{y(z)} = \left[\frac{1}{2} + \frac{2.S}{\pi.b_{(z)}.l}.\sqrt{1-\varsigma^2}\right].C_{yst} \quad (4)$$

Where : $C_{y(z)}$ – local coefficient of lift,
C_{yst} – mean lift coefficient,
$\varsigma = {}^{z}\!/\!\frac{l}{2}$ - relative distance from the center wing.

The course load of aerodynamic forces to determinate the range of wing:

$$q_{(z)} = \frac{Y}{2}.\left[\frac{b_{(z)}}{S} + \frac{4}{\pi.l}.\sqrt{1-\left(\frac{2.z}{l}\right)^2}\right]$$

The effect of aerodynamic forces on the depth profile: To facilitate the calculation of subsonic aircraft with a small maximum angle of attack, we canposition the realm of aerodynamic forces to determine the depth profile of the 25% depth of wing leading edge.

3.2 Wing loading of mass forces

Gravitational wing loading forces: In the calculation use the formula:

$$q_{kr(z)} = \frac{n.G_{kr}.f}{S}.b_{(z)}$$

Where: G_{kr} – estimated weight of wing, which i identified as 20% of the gravity of the aircraft.

The course load each mid-range wing is shown in the following graph.

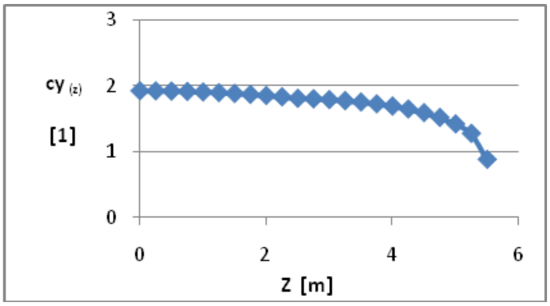

Figure 4 During local lift coefficient of the wing margin

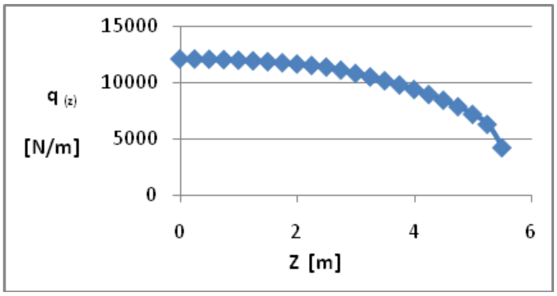

Figure 5 The course load range of the wing

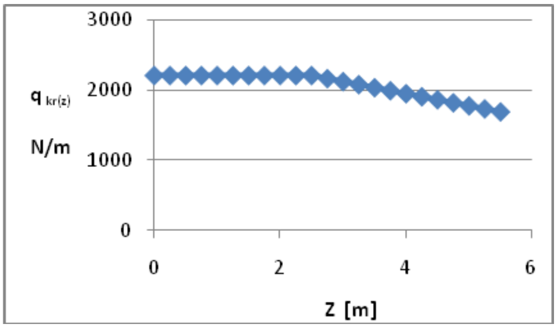

Figure 6 The load on wing of the Gravitational range of forces

3.2 The total load of wing

Shifting power: Calculated as the sum of aerodynamic and gravity loads. Shifting power will be calculated according to:

$$T_{(z)} = \int_0^z \left(q_{(z)} - q_{kr(z)}\right)dz - \sum n.G_i$$

Where: G_i – load the assembly as the motor. The load on the assembly are outboard engine version devices.

The bending moment: shall be determined from the relation:

$$M_O = \int_0^Z T_{(z)}\, dz$$

Twist moment: determines the axis of elasticity. The calculation will use the formula:

$$M_k = \int_0^z \left[q_{(z)} \cdot (x_{eo} - x_p) + q_{kr(z)}(x_{kr} - x_{eo})\right] b.\, dz - \sum$$

Where: x_{eo} – distance from axis of elasticity leading edge,

x_p – distance of the center of aerodynamic loads on the leading edge,

x_{kr} – gravitation distance of the center of force from the leading edge,

x_{Gi} – distance of the center gravitation forces the engine to the leading edge

x_{eo} is determined with respect to design wing for my case will lie at point b 45% from the leading edge. The center of aerodynamic forces in the realm of 25% even in the gravitation forces is 30% b. Center of gravity engine from x_{GI} is leading edge..

The calculations show the following graphs:

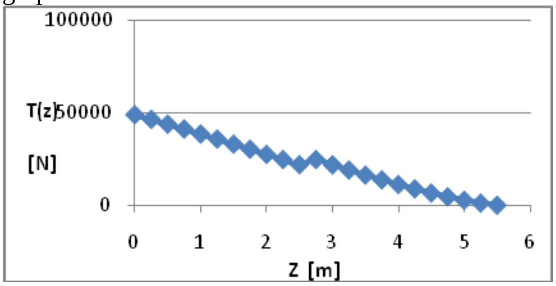

Figure 7 The course of the operation of power range of the wing

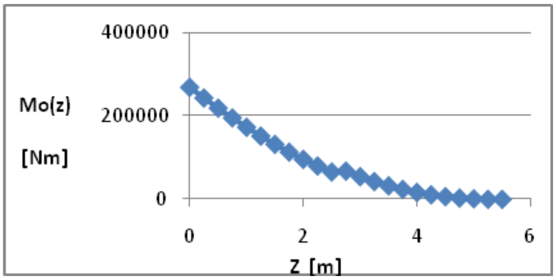

Figure 8 The course of the bending load on range of wing

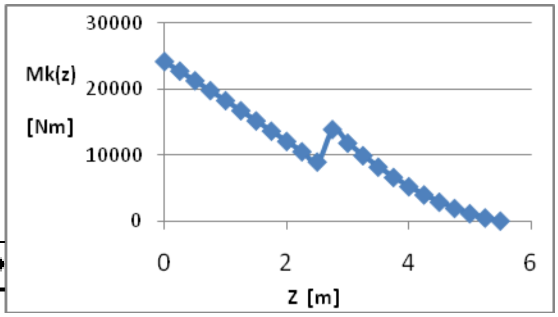

Figure 9 Running torque range f the wing

4 THE DESIGN OF THE WINGS

The design I came from a single Spar. The final design consists of two beams. The first beam is placed at 25% depth profile and the second at 66% depth profile. On the leading edge, I placed the sole bars, which are used for its reinforcement.

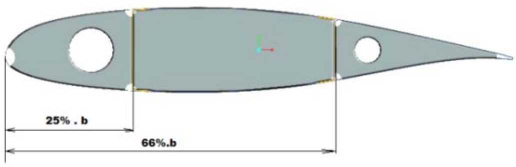

Figure 10 Location beams

The wing fuel tanks are located between beams and between the first and fifth rib mid-range. Fuel tank capacity is 200l. to place additional fuel cold be used in areas of trapezoidal wing.

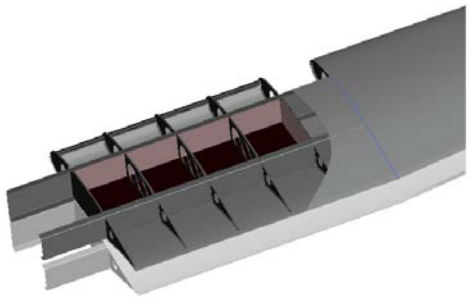

Figure 11 Location of fuel tanks

The wing has 16 ribs on mid-range. They are spaced abut every 400mm. Reinforced ribs are located in the mounting wings, fuel tanks and engine mounting location.

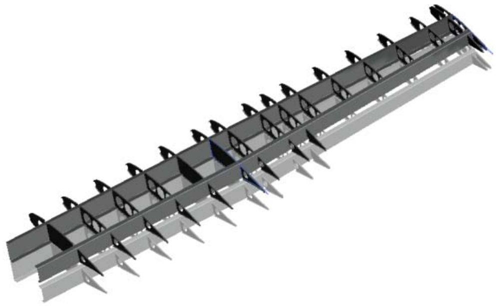

Figure 12 Distribution of ribs

The structural design is working with the ProEnginieer. In this program I've created asimplified model wing design. The model I have detailed calculations, which led me to modify the proposed design.

Figure 13 is an example of how it was loaded mid-range wing. The design of the wings are marked with different colors. The wing was loaded course forces T (z) Constrain is in the middle of wing.

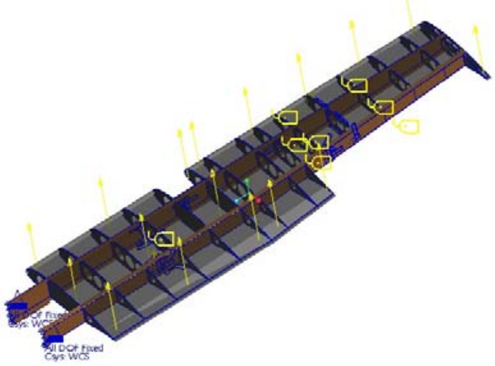

Figure 13 Wing loading

To simplify the calculation, the model calculated by midsurfaces, as shown in figure 14.

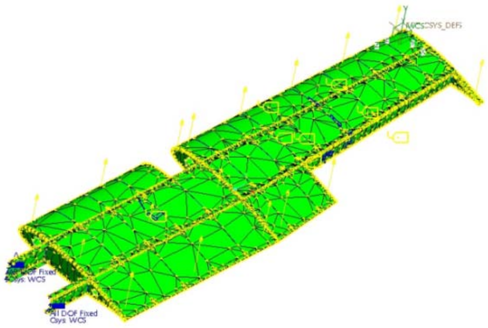

Figure 14 Midsurfaces computational model

Analysis results are shown in figure 15. The analysis shows the greatest stress, which occursat 399 MPa. This voltage is not greater than the strength of the material which the alloy is 450 MPa.

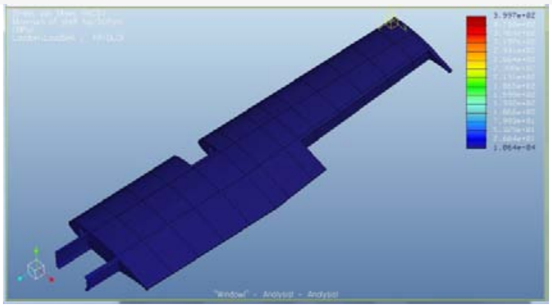

Figure 15 analysis results

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