ISSN (O): 2393-8609

International Journal of Aerospace and Mechanical Engineering

Volume 1 – No.1, September 2014

Preliminary Design Approach of the Wing Box

Vikas kumar
Punjab Technical University
Gurukul Vidyapeeth Institute Of Engineering And Technology
Banur
kumar16vikas@gmail.com

Pushpraj
Punjab Technical University
Gurukul Vidyapeeth Institute Of Engineering And Technology
Banur
rajpushpraj171@gmail.com

Harpreet Singh
Punjab Technical University
Gurukul Vidyapeeth Institute Of Engineering And Technology
Banur
terrysarao700@gmail.com

ABSTRACT

For designing of wing box it should be noted that the structure should be strong enough to withstand the load forces and exceptional circumstances in which aircraft has to be operate. Wing is essentially a beam which transmits and gathers all the applied loads to the fuselage. Spar, ribs, stringers and skin are the major essential part of the wing. The primary function of wing is to generate a lift. Wing requires longitudinal member to withstand the bending moments which are greatest during flight and landing of aircrafts. Ribs are structural members which maintain the aerodynamic shape of the wing. In this paper we study a wing box, this wing box is subjected to flight loads. We design a wing box in CATIA V5. Load distribution on wing is also carried out in this paper.

Keywords

Aircraft, wing box, skin, spar, stringer and ribs.

1. INTRODUCTION

A wing is a lifting surface, lift is produced due to pressure difference between lower and upper surface. We study a wing box which is a part of wing of an aircraft. Wing is perpendicular cantilever beam to the horizontal plane of the fuselage. It is attached to the fuselage, at the top, mid fuselage or at the bottom depending on the type of aircraft. Primary function of wing is to generate lift. The design of wing depends on many factors such as size, weight, rate of climb. Wings are of full cantilever design. There are many terms which are significant for a wing design i.e. aerodynamic forces, loads etc. However, wing also produces two effects drag force and nose down pitching moment. A wing with a high aspect ratio will perform well at slow speeds and produce large quantities of lift, but at the expense of manoeuvrability and airspeed. It is a framework made up of skin, spar, stingers and ribs. A small section of wing is wing box. There are several types of wing box structures for high speed airplanes

- Thick box beam structure
- Multi spar box structure
- Delta wing box structure

2. MATERIAL AND SIZING SPECIFICATIONS

The material used in the construction of wing or wing box should have the properties

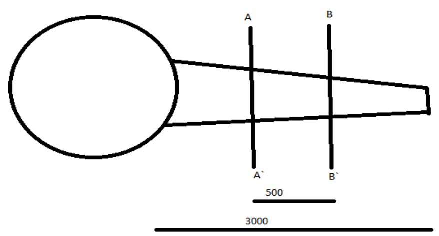
1. high stiffness
2. high strength
3. high toughness
4. low weight

Table 1 Material specification

No.	Part Name	Material	Thickness
1	Upper skin	Al	1.2
2	Spar web	Al	3
3	Spar top flanges	Al	2
4	Spar bottom flanges	Al	2
5	L stringer (horizontal)	Al	3
6	L stringer (vertical)	Al	3
7	Rib top flanges	Al	5
8	Rib bottom flanges	Al	5
9	Rib web	Al	3
10	Lower skin	Al	1.2

3. LOAD CALCULATION

It is generally assumed that the total wing load equals to the total wing aircraft times the limit load factor times the factor of safety.As per preliminary design of wing box to the load calculation as follows:-



Let us consider wing box between AA` and BB`.

Let total wing span =3000mm

Span of wing box section =500mm

Weight of aircraft =5000 k

Factor of safety = 1.5

Design load factor = 3.2

Therefore total design load on aircraft = 24000 kg-f

Lift load on aircraft wing is 80% of total lift load on aircraft

Total load acting on wings = 19200 kg-f

Total load acting on each wing = 9600 kg-f

Resultant load acting at a distance 1300mm from wing root

The resultant load is at a distance of 400mm from the root end (A-A`) of the wing box

Bending moment at the root end (A-A) of the wing box = 3840000kg-mm

Load to be applied at the other end (B-B) of the wing box = 7680kg-f

4. COMPOSITION OF WING BOX

A wing box can be classified into two structure's i.e. internal wing structure consist of spars, stringers and ribs. The external structure consists of skin.

4.1 Wing Skin

It is outer surface of the wing. It is made up of fabric but modern aircraft use aluminium as well as composite material. Due to light weight and corrosion- resistant property of Aluminium it is the most common material for construction a wing. It also transfers the whole stress to the wing ribs.

4.2 Spars

Spar is the main structural member of the wing. They run parallel to the lateral axis of the aircraft, from the fuselage toward the tip of the wing. It is the beam type structure which is designed to carry structural or air loads and transfer them to the fuselage, or body, of the aircraft. It provides strength to the aircraft wing. A thick box consists of two or more spars with high aspect ratio for low altitudes and multiple spars are used, with low aspect ratio for thin box structure for high speed aircraft. It carries shear force and bending loads.

4.3 Stringers

Stringer run span wise from the wing root to the wing tip. It help wing to withstand the tension and compression produced due to bending the fuselage.

4.4 Ribs

Ribs run span wise (leading edge to trailing edge) in the aerofoil wing. It gives the wing aerofoil shape and transmits the air load from the wing cover to the spars. Ribs are designed to carry shear loads it provides shape, strength and rigidity.

5. WING BOX DESIGN

The wing box is designed in CATIA V5 in 2d model. A model has been created in solid geometry. In order to assemble a wing box structure by individual part or section we should keep in our mind that all the dimensions are necessary to generate a model. First of all, to make an upper and lower skin of the wing box. The dimensions are 3000mm*2000mm*2mm.

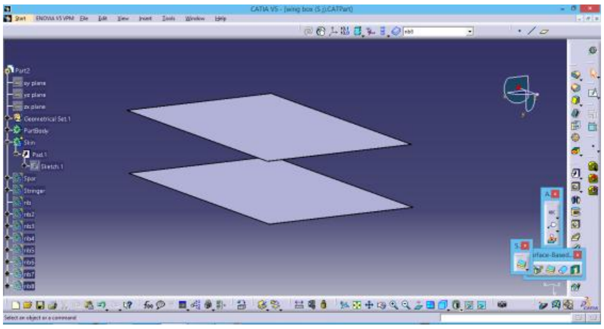


Fig 5.1: Upper and lower skin

Now, we proceed to the spars, which are attached to the skin. The dimensions of top flange and bottom flange are 30mm*5mm.

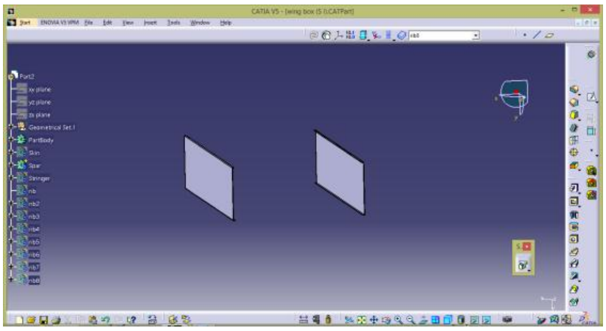


Fig 5.2: Spars

Then, insert a new part i.e. stringer. Being a shape such as L-type, Y-type, J-type, T-type, W-type etc. But at this time, we consider L-type structure and dimensions are 30mm*5mm.

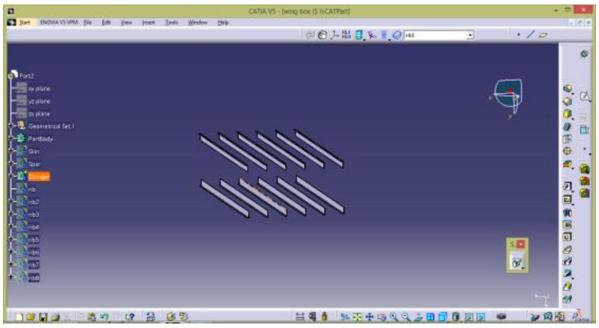


Fig 5.3: Stringers

Now we move to the last part i.e. ribs which are side member along its span wise. Shape like a rectangular block and dimensions are 2000mm*1000mm.

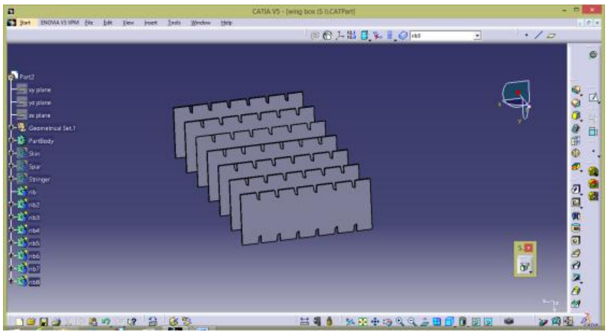


Figure 5.4 Ribs

Finally, we assemble all the components together and form a wing box.

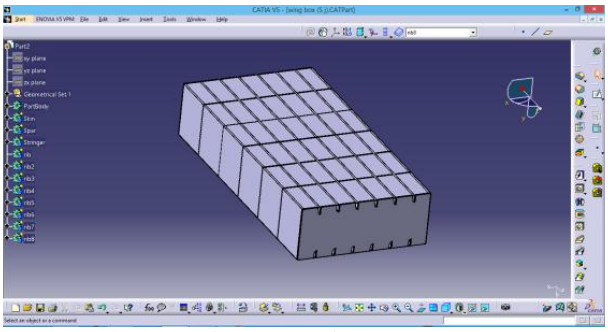


Figure 5.5 Wing Box

6. CONCLUSION

We design a wing box in CATIA V5 and introduce all the components of the wing box in the paper. The wing box we design is a basic structure of wing box that can be drawn with the help of software CATIA V5. We also calculated load on the wing.

7. FUTURE WORK

Wing box skin will be modified to get a proper shape of the wing like an aerofoil. In future we will modify the design of wing box to get a new outcomes which can be seen in future while further study on NACA series. Further modification work on finite element method (FEM) should we done in future.

8. ACKNOWLEDGMENTS

We sincerely thank Mr. Sandeep Sharma, Technical head, AeroSphere for his kind guidance and helping us in pursuing this technical paper.

9. REFERENCES

[1] Bruhn, E. F., “Analysis and design of flight vehicle structures”, Jacobs and Associates Inc., June 1973

[2] Megson, T. H., “Aircraft Structures For Engineering Students”, John Wiley and Sons, Inc., 1999.

[3] John D. Anderson.,” Introduction to flight”.