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Preliminary Design Study of Wing

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ABSTRACT

The objective of the project was to design the wing section of an aircraft in Catia V5. The wing was designed in catia using various methods, techniques and modules. Wing structure is made of various airfoil shapes such as NACA 4, 5 and 6 series airfoils. In our case, NACA 4 series airfoil was used namely NACA 2412..

Keywords

Wing Section, 3D modeling in Catia V5, spars, stringers, ribs

1. INTRODUCTION

Wing is the most important part of an aircraft, which produces the lift due to the pressure difference generated on the upper and the lower surface. The wing structure has different types of the structural components such as Stringers, Spars, Ribs, Skin, etc. which are necessary for the strength of the wing. The main function of these is to distribute the payload and the forces which act on the aircraft wing including shear forces, tensile forces and direct forces.

1.1 DESIGN AND DETAILS OF MODEL PARTS

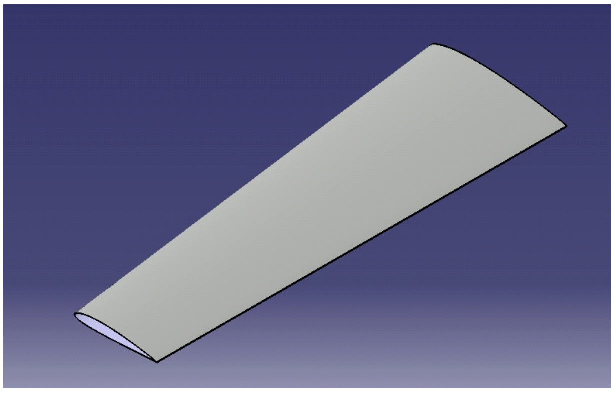
During the designing of the wing we used construction parameters of already designed wing.

1.1.1 Skin

Material: -AL7075 (upper skin) & AL2024 (lower skin)

Construction in catia V5:-

Skin is an essential part of the wing which is used to maintain an aerodynamic shape and is used to transfer different types of loads to the structural members of the wing. Skin is manufactured by the traditional methods of stretch forming for aircrafts. Skin carries the load to be distributed among other wing components from spars and stringers to rib to the main fuselage body.



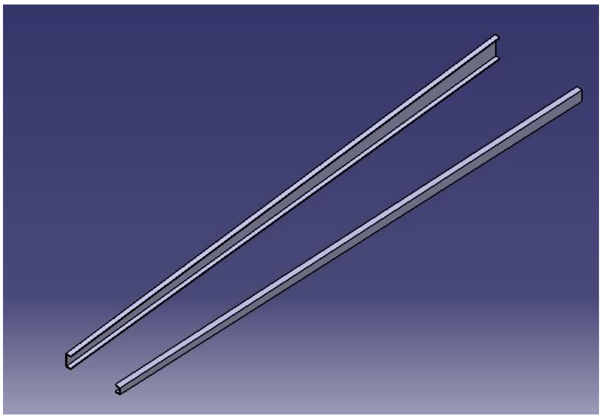
1.1.2 Spar

Material: - AL7075

Construction in catia V5:-

In a fixed-wing aircraft, the spar is often the main structural member of the wing, running span wise at right angles (or thereabouts depending on wing sweep) to the fuselage. The spar carries flight loads and the weight of the wings while on the ground. Other structural and forming members such as ribs may be attached to the spar or spars, with stressed skin construction also sharing the loads where it is used. There may be more than one spar in a wing or none at all. However, where a single spar carries the majority of the forces on it, it is known as the main spar.

Most wing structures have two spars, the front spar and the rear spar. The front spar is found near the leading edge while the rear spar is about two-thirds the distance to the trailing edge. Depending on the design of the flight loads, some of the all-metal wings have as many as five spars. In addition to the main spars, there is a short structural member which is called an aileron spar.

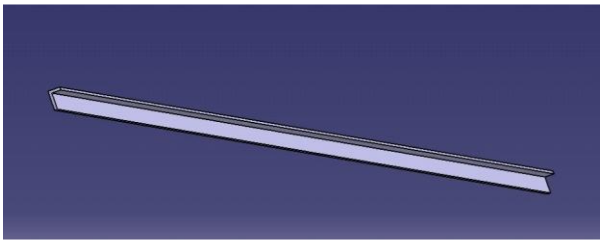


1.1.3 Stringers

Material: - AL7075

Construction in catia V5:-

In aircraft construction, stringer or stiffener is a thin strip of material to which the skin of the aircraft is fastened. In the fuselage, stringers are attached to formers (also called frames) and run in the longitudinal direction of the wing. They are primarily responsible for transferring the aerodynamic loads acting on the skin onto the frames and formers. In the wings or horizontal stabilizer, longerons run span wise and attach between the ribs. The primary function here also is to transfer the bending loads acting on the wings onto the ribs and spar.



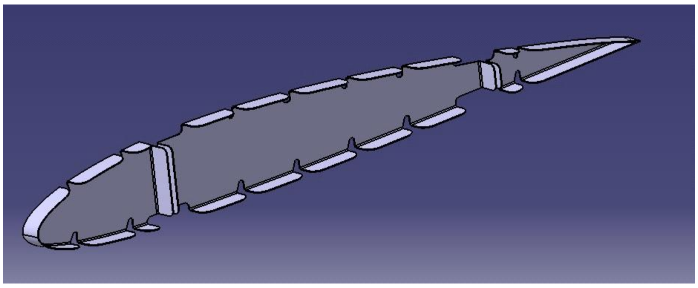
1.1.4 Ribs

Material :- AL7075

Construction in catia V5 :-

Ribs are the structural crosspieces that combine with spars and stringers to make up the framework of the wing. They usually extend from the wing leading edge to the rear spar or to the trailing edge of the wing. The ribs give the wing its cambered shape and transmit the load from the skin and stringers to the spars. Similar ribs are also used in ailerons, elevators, rudders, and stabilizers.

Wing ribs are usually manufactured from either wood or metal. Aircraft with wood wing spars may have wood or metal ribs while most aircraft with metal spars have metal ribs. Wood ribs are usually manufactured from spruce. The three most common types of wooden ribs are the plywood web, the lightened plywood web, and the truss types. Of these three, the truss type is the most efficient because it is strong and lightweight, but it is also the most complex to construct.

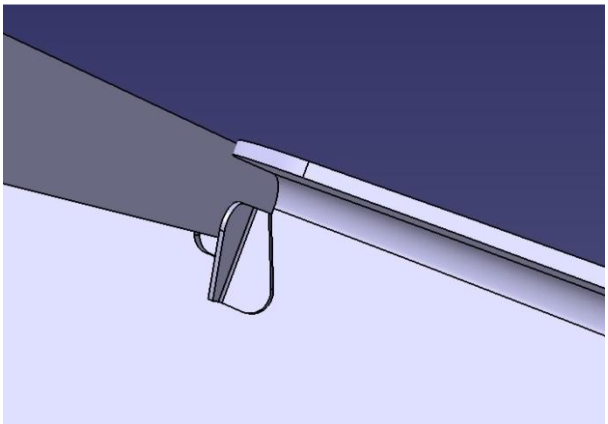


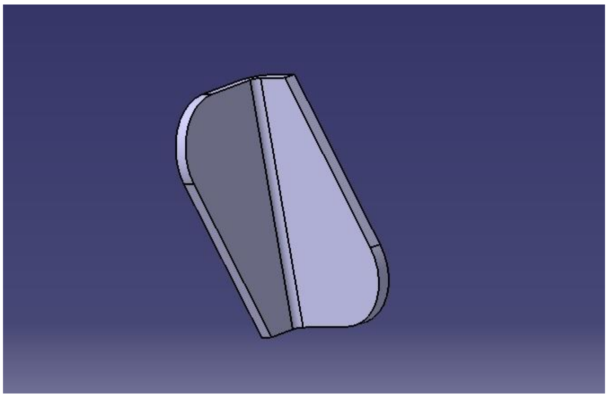
1.1.5 Shear Clip

Material: - AL7075

Construction in catia V5:-

Shear clips are the shear stress bearing components of a primary wing structure. It passes loads from the Skin to the ribs via stringers so that the loads are transferred uniformly.





2. DIFFERENT TYPES OF LOAD ON WING

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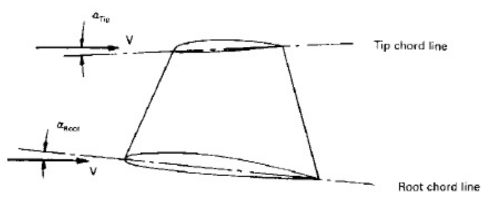
2.1 Wing Design Loads

Design wing loads consist of the shears, bending moments, and torsions which result from air pressures and inertia loadings. Flight loads are those experienced when maneuvering to the limits of the V-n diagram or those caused by gusts. Other flight conditions are those associated with control surface deflections.

In addition, wing design loads must be determined for the landing and taxi conditions.

2.2 Air load Span wise Distribution

Clean configuration: The air loading on a wing consists of two parts, additional loading and basic loading. The additional air loading is caused by angle of attack. On normal aspect ratio wings (>3) this lift and its distribution varies directly with angle of attack. The basic loading is that distribution of air load on the wing when the total lift is zero. This type of loading is caused by wing twist. The distribution is usually carried to the airplane centre line. The fuselage is assumed to carry the same amount of lift that would be on the blanketed wing area. The concept of basic lift distribution is illustrated by figure below which is an end view of the wing with the tip section twisted down relative to the root (washout).



The root section is producing positive lift and the tip section is producing negative lift.

2.3 Fuselage, Nacelle and Wing Stores Effect on Wing Loads

Effects of these items are not readily determined as quantitative values. Stores located near the wing tip or large protuberances on the fuselage, such as radomes, have the greatest effect on wing loads. Both tend to move the center of pressure outboard. The tip tank will effectively increase the aspect ratio. The radome will interfere with the lift near the fuselage causing the airplane to fly at a higher angle of attack and result in higher loads on the outboard sections of the wing.

2.4 Dynamic Gust Loads

The advent of high speed, structurally efficient, flexible airplanes has made necessary the determination of the dynamic response of these airplanes to atmospheric turbulence. Early techniques for evaluating the dynamic effects of turbulence involved representing the gust as a discrete phenomenon and calculating the time response of the airplane to this discrete function.

2.5 Landing and Taxi Landing

Wing loads are of importance because of the down loads experienced and because of the large concentrated loads applied to the wing if the gear is located on the wing. Taxiing must he accomplished at maximum take-off weights when the load in the wing is a maximum and wing stores are most likely to be installed. Rough runways will cause fairly large load factors on the airplane (in the vicinity of 1.7 to 2.0). Because of the flexibility of the wing, a whipping of the wing will occur and a considerable magnification of this load factor will he experienced at the wing tip. This magnification is a function of the wing weight and stiffness.

2.6 Wing Control Surfaces

For airplanes equipped with wing flaps, slats, ailerons, spoilers, dive brakes or other high-lift devices, additional flight loading conditions must be investigated for these control surfaces extended. These conditions are usually not critical for wing bending stresses, since the specified load factors are not large, but may be critical for wing torsion, shear in the rear spar, or down tail loads, since the negative pitching moments may be quite high. The aft portion of the wing, which forms the flap supporting structure, will be critical for the condition with flaps extended

2.7 Wing Weight Distribution

To determine design loadings the weight of the wing must be taken into account. The weight distribution consists of (I) basic wing structure and (2) power plants and landing gear, if mounted on the wing, and removable stores such as fuel, tip tanks, etc.

Since in flight conditions the weight is a relieving load, considerable attention is given to the placement of fuel tanks and the sequence of using fuel.

3. JOINING PROCESS

3.1 Rivets

One of the earliest developed joining methods for metals, riveting, involves a malleable rivet being placed through pre-drilled holes in the mating parts while the end of the rivet is upset to prevent its removal. The most common rivets are of the form shown below, having either a round or countersunk head. The upsetting process is completed using a dolly that is shaped similarly to the head to produce the same appearance on both sides of the project. In the blacksmith workshop, rivets were often finished flat to the surface by firstly countersinking the holes and then burned over and flattened with a ball-peen hammer.

Typical small solid rivets for light fabrication.

On a larger construction scale, rivets could be quite large, as with the rivets on the Sydney Harbor Bridge (the largest rivets used here were 35 mm diameter). These round-head rivets were inserted through pre-drilled holes and headed in the same way as described above, except that to improve malleability, the rivets needed to be hot. To accomplish this heating furnace was located near where the rivets were being fitted; the rivet was removed from the furnace with tongs, inserted in the hole, and headed in as short a time as possible using pneumatic riveters.
Nowadays a range of riveting operations are possible with the development of Tin man's rivets for use with sheet metal Bifurcated rivets used to join leather to leather or leather to metal, as well as Pop rivets which are inserted and closed from the one side and used mainly with thin metal sections.

3.2 Spot welding

A spot welding machine holds two pieces of thin metal together with a strong force while an electric current is applied through the clamping arms. The electrical resistance at the junction causes the electrical current to heat the local spot. The combination of heat and pressure produces a fusion weld. This process is common in joining car body panels, with the small round spots clearly visible at the edges of a panel.

A spot welding unit with sheet metal in place

4. ACKNOWLEDGMENTS
Our thanks to the Project guide Mr. Sandeep Sharma who has contributed towards development of the template.

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