

Design Consideration and Construction of a Biplane

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Abstract: A biplane is a type of an aircraft where two fixed wings are placed one over another providing lift. In the early aviation era, the first plane to overcome gravity was a biplane. The first prototypes of aircrafts were monoplanes which ceased to provide the required uplift due to technological barriers of the bygone era i.e; weak and underpowered engines coupled with non-refined, weak construction materials and wings. Biplanes, were designed to overcome the shortcomings of monoplanes and generates a 20% more lift than a monoplane. This paper provides the design considerations to build symmetrical wings of a biplane and the fuselage to mount the wing. And then provide mechanical installations to make the biplane airworthy. The design work for the fuselage and the wings are done using catia and the analyses of the same are done using solid works. The material used and the fabrication process is enclosed the article

Keywords: Biplane, Catia & Solid works, Fuselage, Lift, Symmetrical Wings.,

I. INTRODUCTION

1.1 Fuselage

The main body of the aircraft that holds and supports the passengers or the cargo is the fuselage. In the Single Engine Aeroplanes, the fuselage contains the engine. It provides the position control and stabilization surfaces. In respect to the lifting surfaces important for the overall stability and maneuvering abilities.



Fig-1 Biplane

1.2 Wing

A wing can be defined as a fin which provides a surface for flight by generating aerodynamic force through a medium i.e; gas or liquid. The word 'wing' has been derived from an old Norse vængr and is referred to the foremost limb of a bird. But with the advent of technology it has come about to include lift producing airfoils of insects, boomerangs, bats, fishes, and animals which use fins to propel themselves. The expression of aerodynamic quality of a wing is given by its lift to drag ratio.

1.3 Propulsion Systems

'Propulsion' is derived from 2 Latin words: pro meaning before or forwards and pellere meaning to drive. Propulsion is the generating of force directed towards motion. A propulsion system includes some type of motor or muscles which provides a raw mechanical power. This is coupled with devices (propellers, axles, nozzles, etc) which convert the power to generate force.

1.4 Control surfaces

The flight control surfaces provide the pilot the means of maneuvering and controlling the airplane's flight altitude. The flight control devices of the modern era are more or less self-sufficient and capable of handling flight sequences of increasing complexities. The fixed wing aircraft designs were capable of generating lift, sufficient enough to get them off the ground but were harder to maintain control of once airborne. Effective flight control developments in the later stages allowed stable flight sequences.

II. Design Considerations And Fabrication

2.1 Design Aspects:

2.1.1 Wing support:

The wing is affixed on the fuselage with cantilever support. The upper and lower wing are further supported by strut at both ends of the wing. Hence, the wing support is of **cantilevered strut braced type**.

2.1.2 Airfoil:

Airfoil is symmetrical type, i.e. the profile is **symmetrical** below and above the camber line. Camber is usually designed into an aero foil to increase the maximum lift coefficient. This minimizes the stalling speed of aircraft using the aero foil. Aircraft with wings based on cambered aero foils usually have lower stalling speeds than similar aircraft with wings based on symmetric aero foils.

2.1.3 Angle of incidence:

Angle of incidence meaning the angle between the chord of an aero foil and some fixed datum in the aero plane. The angle of incidence in the model used is greater than zero as wing shape is symmetrical.



Figures-2,3,4 Bi plane model

2.2 Fabrication:

Tools used:

- Cutter
- Hammer
- Sand paper
- Glue
- Epoxy
- Iron
- Nails

2.3 Fabrication Technique:

Balsa wood is very soft so most of the parts were handcrafted using cutter. Sand papers were used to smoothen the surface. Glue and epoxy were used to fix the wooden parts with each other. Nails were hammered for fixing the plywood. Iron was used to cure the lotto cot paper over the surface.

2.4 Specifications:

- Wing length: 1390 mm
- Chord length : 255 mm
- Aspect ratio: 5.4
- Fuselage length: 1135 mm

2.5 Material used:

- Balsa Wood(2,4,6,15,12)mm
- Plywood(2 mm)
- Lotto cot paper

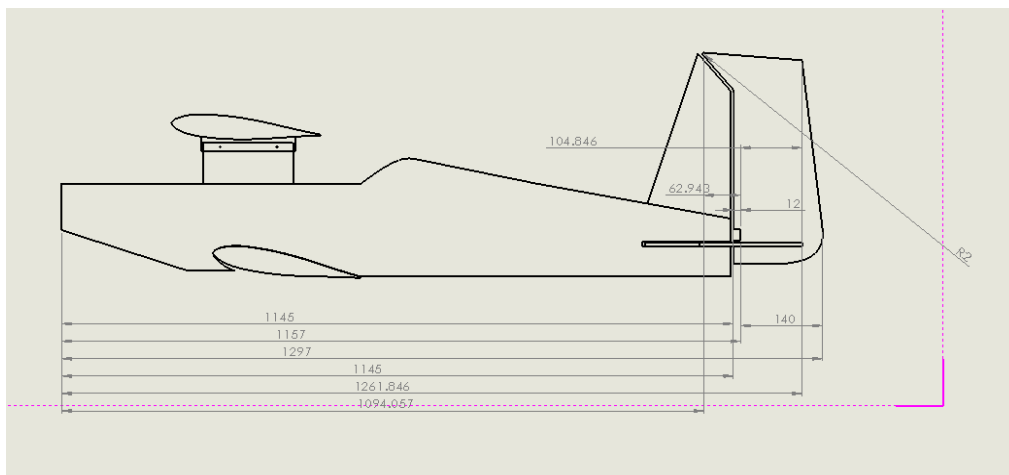


Fig-5 Side view

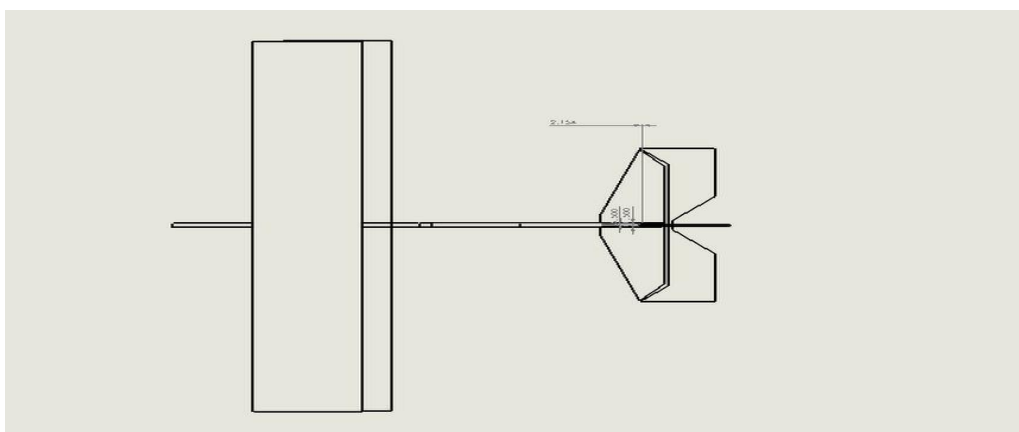


Fig 6 Top view

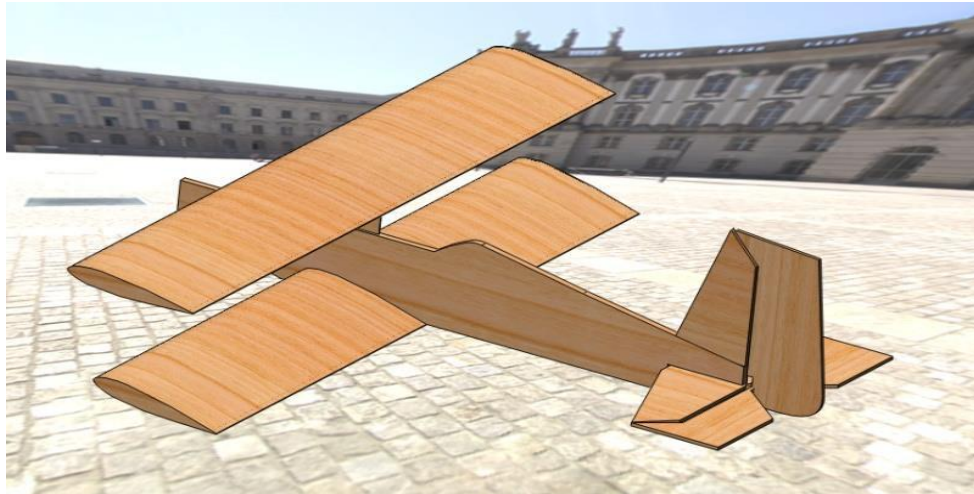


Fig-10 CAD models

IV. Full Report

4.1 System Info

Product	Flow Simulation 2013 SP0.0. Build: 2177
Computer name	REDDY-XPS
User name	SRAVAN SINGIREDDY
Processors	Intel(R) Core(TM) i3-2310M CPU @ 2.10GHz
Memory	3990 MB / 8388607 MB
Operating system	(Build 9200)
CAD version	SolidWorks 2013 SP0.0
CPU speed	2100 MHz

4.2 General Info

Model	R:\Extra feature\Google Drive\Solid works\FUSELAGE\Assem1.SLDASM
Project name	Default
Project path	R:\Extra feature\Google Drive\Solid works\FUSELAGE\1
Units system	SI (m-kg-s)
Analysis type	External (exclude internal spaces)
Exclude cavities without flow conditions	Off
Coordinate system	Global coordinate system
Reference axis	X

4.3 INPUT DATA

4.3.1 Initial Mesh Settings

Automatic initial mesh: On
 Result resolution level: 5
 Advanced narrow channel refinement: Off
 Refinement in solid region: Off

4.4 GEOMETRY RESOLUTION

Evaluation of minimum gap size: Automatic
 Evaluation of minimum wall thickness: Automatic

4.5 LOCAL MESH SETTINGS

Local Initial Mesh 1

Components	Face <3WING2-4@Boss-Extrude1> Face <1WING-3@Boss-Extrude1> Face <4WING2-4@Boss-Extrude1> Face <2WING-3@Boss-Extrude1>
Solid/fluid interface	Small solid features refinement level: 1 Curvature refinement level: 0 Curvature refinement criterion: 0.318 rad Tolerance refinement level: 0 Tolerance refinement criterion: 0.102 m
Refining cells	Refine fluid cells: Off Refine solid cells: Off
	Refine partial cells: Off
Narrow channels	Advanced narrow channel refinement: Off

4.6 COMPUTATIONAL DOMAINS

Size

X min	-0.978 m
X max	1.027 m
Y min	-0.173 m
Y max	0.382 m
Z min	-0.686 m
Z max	0.776 m

4.7 BOUNDARY CONDITIONS

2D plane flow	XY - plane flow
At X min	Default
At X max	Default
At Y min	Default
At Y max	Default
At Z min	Symmetry
At Z max	Symmetry

4.8 PHYSICAL FEATURES

Heat conduction in solids:

Off

Time dependent: Off

Gravitational effects: On

Flow type: Laminar and turbulent

High Mach number flow: Off

Humidity: Off

Default roughness: 0 micrometer

4.9 GRAVITATIONAL SETTINGS

X component	0 m/s ²
Y component	-9.81 m/s ²
Z component	0 m/s ²

Default wall conditions: Adiabatic wall

4.10 AMBIENT CONDITIONS

Thermodynamic parameters	Static Pressure: 101325.00 Pa Temperature: 293.20 K
Velocity parameters	Velocity vector Velocity in X direction: 20.000 m/s Velocity in Y direction: 0 m/s Velocity in Z direction: 0 m/s
Turbulence parameters	Turbulence intensity and length Intensity: 0.10 % Length: 0.004 m

4.11 MATERIAL SETTINGS

4.11.1 Fluids

Air

4.12 Goals

Surface Goals

4.12.1 SG Av Velocity (X) 1

Type	Surface Goal
Goal type	Velocity (X)
Calculate	Average value
Faces	Face<3>@WING2-4 Face<2>@WING2-4
Coordinate system	Global coordinate system
Use in convergence	On

4.12.2 SG Av Velocity (Y) 1

Type	Surface Goal
Goal type	Velocity (Y)
Calculate	Average value
Faces	Face<3>@WING2-4 Face<2>@WING2-4 Face<1>@WING-3 Face<4>@WING-3
Coordinate system	Global coordinate system
Use in convergence	On

4.12.3 SG Force (X) 1

Type	Surface Goal
Goal type	Force (X)
Faces	Face<3>@WING2-4 Face<2>@WING2-4 Face<1>@WING-3 Face<4>@WING-3
Coordinate system	Global coordinate system
Use in convergence	On

4.12.4 SG Force (Y) 1

Type	Surface Goal
Goal type	Force (Y)
Faces	Face<3>@WING2-4 Face<2>@WING2-4 Face<1>@WING-3 Face<4>@WING-3
Coordinate system	Global coordinate system
Use in convergence	On

4.13 Calculation Control Options

Finish Conditions

Finish conditions	If one is satisfied
Maximum calculation time	360 s
Maximum travels	2
Goals convergence	Analysis interval: 5e-001

Solver Refinement

Refinement: Disabled

4.14 Results Saving

Save before refinement	On
Periodic saving	Units: Iterations Period: 10

4.15 Advanced Control Options

Flow Freezing

Flow freezing strategy	Disable
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V. Problems And Proposed Solutions

5.1 PROBLEMS

We lacked the expertise of simulating the forces that the wing would encounter in flight. Besides, the attempt to analyze the prepared model in Solid Works resulted no concrete findings as the software generated millions meshing points. As a result the memory in the system could not process such large number of meshing points.

There was lack of wind tunnel of required size. So the real time data of the forces experienced by wing was therefore unavailable. Servo mechanism to link the control surfaces basically ailerons of both the upper and lower wings was difficult.

5.2 PROPOSED SOLUTIONS

- The model could be further reduced in scale to eliminate the meshing problem in the existing software and system.
- Also high power computing could be done to process the data in the existing scale.
- Wind tunnel testing of the wing and other structures for real time forces

VI. CONCLUSION

Symmetrical wing for a bi plane was constructed using balsa wood. The support structure for the wing i.e., fuselage was also made and incorporated with other control surface, elevator and rudder.

Further improvement in the existing model can be made by installing mechatronic system to make it airworthy. The system would include the servo mechanisms to link the various control surfaces, radio equipment, receiver and transmitter, to remotely control the flight of the bi plane.

The symmetrical wing is used in aerobatic aircrafts as the particular wing profile supports inverted flying and other aerobatic stunts

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