Design, Analysis & Fabrication of Wing Structure of Al 7075-T6

N. Tulasi Ram[1]

[1]Assistant Professor, Department of Mechanical Engineering

[1]St. Martin's Engineering College, Hyderabad, TS, India

Abstract: **The structure of an airframe speaks to probably the best case of a base weight design in the field of auxiliary building. Shockingly such a proficient design is accomplished by the utilization of basic "strength of-material" approach. Airplane has two significant parts, which are fuselage and wing. For a wing of an airplane the essential burden conveying capacity is required in bowing. A regular aluminum material 7075-T6 is picked for the design. A four-seater airplane wing spar design is considered in the flow study. In the present task the spar is considered as a pillar with discrete burdens at various stations. The design is done according to the outer bowing minute at each station. A limited component approach is utilized to ascertain the burdens created at each station for a given twisting minute. A few pressure analysis emphases are completed for design improvement of the spar bar. Straight static analysis is utilized for the pressure analysis. The spar bar is designed to yield at as far as possible burden. Weight streamlining of the spar will be completed by presenting helping patterns in the web district. The outcomes from the customary design approach and the streamlined design are thought about. Weight sparing through design improvement is determined. Static testing of the spar will be completed to approve the design and stress analysis results.**

Keywords: **airframe, wing, structure, aircraft, design.**

I. INTRODUCTION

In a fixed-wing airplane, the spar is normally the most help of the wing, running range shrewd at right edges to the body. The spar conveys flight loads and furthermore the heaviness of the wings though on the base so it is imperative to make it to withstand the curving burden since that causes the disappointment if the material soon [1]. Elective basic and shaping individuals like ribs are additionally associated with the spar or spars, with focused on skin development conjointly sharing the heaps any place it is utilized need to withstand practically a wide range of stacking activity like twisting, torsion, pliable and pressure. There is additionally very one spar during a wing or none in any regard. The wing spar gives the heft of the heap backing and dynamic burden honesty of cantilever monoplanes, for the most part notice the quality of the wing 'D' box itself. Together, these two auxiliary components or segments set up offer the wing unbending nature required to change the airplane to fly securely [3]. The spar conveys flight loads and the heaviness of the wings while on the ground. Different structures, for example, ribs may likewise be connected to spars. There might be more than one spar in a wing [4]. Be that as it may, where a solitary spar conveys most of powers on it, is known as fundamental spar. Generally speaking, a wing has two spars. One spar is at times settled near the front of the wing, and along these lines the option with respect to regular part of the hole toward the wing's edge. Regardless of kind, the spar is that the most noteworthy a piece of the wing [5].

II. MATERIALS AND METHODS

A. *Design of Wing Structure*

This section centers around the point by point design of Spar. The spar might be considered as the significant segment of an airplane wing, since it conveys 80% of the absolute burden on the wing. Since the Spar geometry and its highlights are affecting all other wing segments, we start the nitty gritty design process by Spar design [. The essential capacity of a Spar is to convey the bowing burden following up on the wing [2]. A Spar is a shaft which reaches out from wing root to tip conveying the compressive, shear and malleable burdens. In the present undertaking, the spar is considered as a bar with discrete burdens at various stations. The design is done according to the outer twisting minute at each station. The design counts incorporate determination of materials; estimation of geometrical qualities. Spar is designed for the current airplane and its setup [6].

B. *Material Selection*

A Spar for the most part comprises of an aluminum sheet Spar networks and tops which is welded or bolted to the top or base of the sheet to forestall clasping on utilization of burdens [7]. Most usually utilized materials are aluminum combinations. In the present venture, the material chose is aluminum 7075-T6 in light of its following properties:

Table I: Properties of Aluminium 7075-T6

Mechanical Properties	
Hardness, Brinell	150
Hardness, Knoop	191
Hardness, Rockwell A	53.5
Hardness, Rockwell B	87
Hardness, Vickers	175
Ultimate Tensile Strength	572 MPa
Tensile Yield Strength	503 MPa
Elongation at Break	11 %
Elongation at Break	11 %
Modulus of Elasticity	71.7 GPa
Poisson's Ratio	0.33
Fatigue Strength	159 MPa
Fracture Toughness	20 MPa-m½
Fracture Toughness	25 MPa-m½
Fracture Toughness	29 MPa-m½
Machinability	70 %
Shear Modulus	26.9 GPa
Shear Strength	331 MPa

C. *Cross Sectional Shape of Spar*

The state of the Spar is chosen in the further degree of the design procedure. I-area state of spar is considered after all the contextual analysis of various shapes. Stress and diversion for I-segment is less when contrasted with different areas since snapshot of idleness for the segment is more [8]. Since it is bowing, state of the cross area will have crucial job in figuring of pressure and deflection of beam.

D. *Design Process*

Considering the bending moment acting in that cross section we find out the normal forces acting in the flange of I section. After finding the normal force acting on the flange the areas of flanges are determined and are shown in table II.

Table II: Dimensions of Each RIB

RIB No	Load (Kg)	Total I Section Dimensions (mm)		RIB No	Load (Kg)	Total I Section Dimensions (mm)	
		Width	Depth			Width	Depth
R1	19.16	170	160.32	R9	65.39	47	131.11
R2	38.95	152	156.67	R10	67.22	35	127.46
R3	46.13	134	153.02	R11	69.06	23	123.81
R4	50.98	117	149.37	R12	70.57	16	120.16
R5	57.96	100	145.71	R13	72.1	9	116.51
R6	58.02	84	142.06	R14	73.4	4	112.86
R7	60.84	68	138.41	R15	74.52	3	109.21
R8	63.14	60	134.76	R16	75.64	1	105.56

From the above table, it is seen that, the rib width is being diminished from rib area 1 to 16. Since it is hard to produce the rib of littler measurements and considering harm resistance, riveting procedure, the lower measurement are not considered.

Table III: Dimensions of Rib Section for design

RIB No	Load (Kg)	Total I Section Dimensions (mm)	
		Width	Depth
R1	19.16	170	160.32
R2	38.95	152	156.67
R3	46.13	134	153.02
R4	50.98	117	149.37
R5	57.96	100	145.71
R6	58.02	84	142.06
R7	60.84	68	138.41
R8	63.14	60	134.76

The table III shows the dimensions of considered scale down model and according to that dimensions over the length of spar is modelled using Pro-E.

Fig 1: Model of Spar (Wing Structure)

E. ***Stress Analysis***

The Pro-E model is then imported to the ANSYS with supporting .igs record of the model and it is set for default measurements and extraction of mid surface has been done for cross section [9]. A fine and great quality cross section is created on each piece of the structure. Figure 2 speaks to the fit model of spar. Fine cross section is improved outcomes.

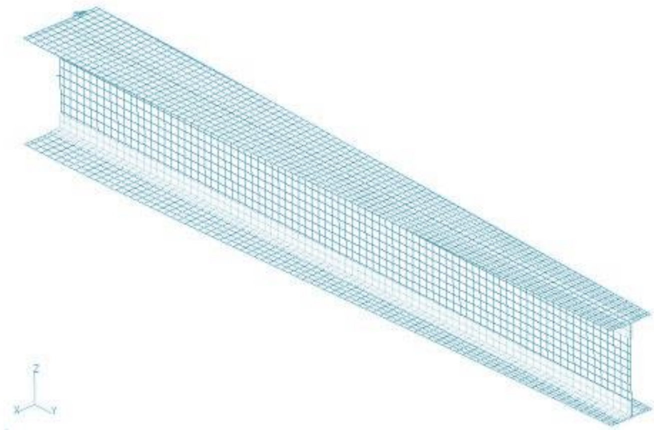

Fig.2 Meshed spar model

The boundary conditions are now applied to the spar model. Since the model considered is a cantilever beam, one end is fixed, ie., all the six degrees of freedom are constrained and at the free end load is applied.

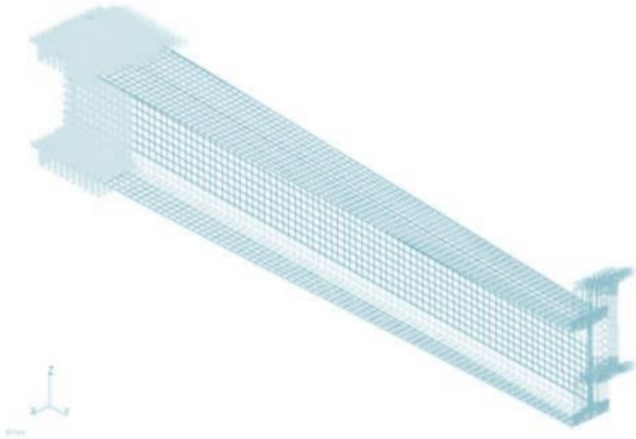

Fig. 3 Boundary conditions

The loads are applied. Due to the application of load, the deflection is observed and also the stress at each section is obtained. Maximum Deflection = 38.4 mm

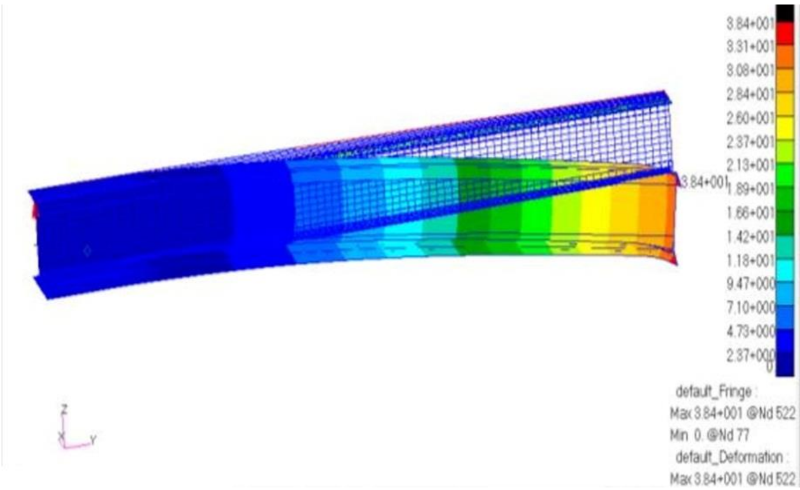

Fig. 4 Deflection of the spar

Maximum stress = 29.2 kg/ mm^2

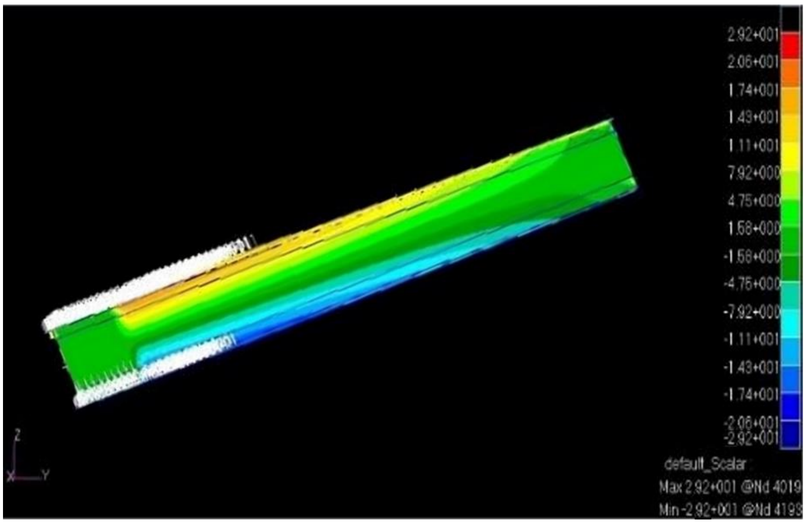

Fig. 5 Maximum stress of the spar

F. Fabrication & Testing Setup of Wing Spar

Metal fabrication is the way toward assembling metal structures by cutting, bowing and amassing forms. At first aluminum 7075-T6 metal sheet of 4mm (Flange) and 3 mm (Web) thickness are utilized for the creation the structure of I-area as per the dimensions. Test rig is required to test the manufactured spar. Spar length of 1800 mm out of which 180 mm is for fixing the model on the arrangement. The decided burden is applied on the free finish of the spar, correspondingly the redirection is noted for every interim of burden application. At long last, test results which are acquired approves the consequences of determined and analysis.

Fig. 6 Test rig with spar

In the scale down model, the calculated bending moment magnitude should be at the fixed end, so the load acting on the spar is calculated by the formula. Load applied on the spar at free end is obtained as follows:

⇨ Bending moment = load x length of spar

⇨ 2673465.32 kg-mm = P x 1500

Therefore, P = 1782 kg

The avoidance at a tip of structure is resolved while testing with the utilization of 1782kg burden at the free end. The yield pressure estimation of the material is 29kg/mm^2, which is normal at the heap of 1782kg. Since, the spar should be considered for additional investigations, a cognizant choice was taken not to stack the spar up to yielding level.

Results and Discussion

The testing was done to a load at 1400kg peak value and the corresponding results are tabulated in Table IV.

Table IV: Tested Results

Load (Kg)	Deflection (mm)
200	4.86
400	9.36
600	11.56
800	13.86
1000	16.16
1200	18.56
1400	22.51

Total Weight of spar =8.67kg

The results of the wing spar comparison can be seen in the graph Fig 7.

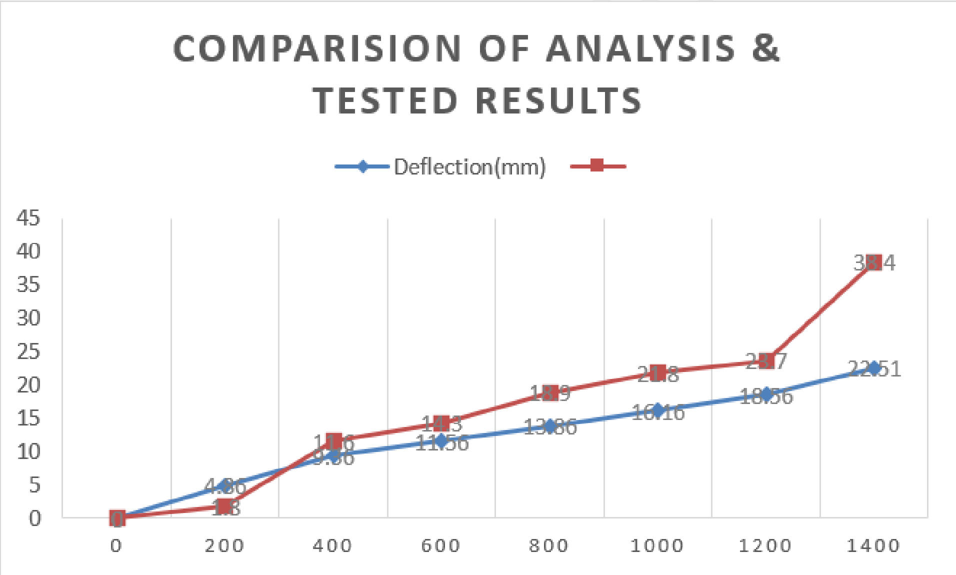

Fig 7: Comparison of Result (Load Vs Deflection)

Maximum deflection of a spar:

Reslut	**Analysis result(mm)**	**Tested result(mm)**
Value	**38.40**	**22.51**

Maximum stress of a spar:

Calculated result(kg/mm^2)	**Analysis result(kg/mm^2)**
24.45	**29.8**

III. CONCLUSION

Wing spar design was done by utilizing quality of material methodology. Limited Element Analysis approach was utilized for pressure analysis of the structure. Iterative analysis was completed to accomplish least weight for the structure. The most extreme pressure got from the limited component analysis is 29.8 kg/mm2. The most extreme avoidance at the tip is 38.40 mm. Consistent level lift load condition was considered for the design. The spar was manufactured dependent on the design setup. Airplane standard material Aluminum combination 7075-T6 material is utilized for the creation of the spar. It is a development. Spar web and ribs are associated by utilizing L-edges which are thus associated utilizing bolts. Static testing of the spar is done. A test rig was designed and created. Vertical avoidance of the spar was estimated at a few areas. A decent co-connection between stress analysis and test outcomes was watched. In current examination the weight streamlining is done through design process, not many cycle are done by differing the components of spar and model is settled with the measurements which has less weight. The concluded structure which is in decreased structure.

Future Scope

The weight can also be reduced by introducing cut- outs in the web of the spar model. Fatigue damage calculation for crack initiation and damage tolerance design can be carried out.

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