Design and Analysis of A320 Wing using E-Glass Epoxy Composite

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***Abstract*— The paper includes the Design and Analysis of A320 wing with E-Glass Epoxy Composite. Here initially we will configure the actual dimensions of the wing and design the same using AUTOCAD software. After that we have divided the wing into various sections and calculated the loads acting on various sections. Then developed the bending moment diagram for it by replacing the pressure loads with some point loads using Strength of materials approach and calculated the moments at each section. Thickness at each station is calculated and ply drop offs are decided. Analysis is done in Nastran and Patran software, where factor of safety for the wing is calculated with ply drop offs. It has been concluded that factor of safety values are much higher using E-Glass Epoxy Composite with varying thickness along span wise length of the wing.**

Keywords— E-glass fabric; factor of safety; pressure loads; ply drop-offs.

I. INTRODUCTION

The aircraft wings are the primary lift producing device for an aircraft. The aircraft wings are designed aerodynamically to generate lift force which is required in order for an aircraft to fly. Besides generating the necessary lift force, the aircraft wings are used to carry the fuel required for the mission by the aircraft, can have mounted engines or can carry extra fuel tanks or other armaments. The basic goal of the wing is to generate lift and minimize drag as far as possible. When the airflow passes the wing at any suitable angle of attack, a pressure differential is created. A region of lower pressure is created over the top surface of the wing while, a region of higher pressure is created below the surface of the wing.

The use of composite materials in commercial aircraft has continued to increase over the past 30 years. Composites materials are intended to be used more extensively as an alternative to aluminum material in aircraft and aerospace applications. This is due to their attractive properties such as high strength-to-weight ratio and flexibility [1]. Number of plies and geometry of the composite structure have significant impact on the strength and reliability of the structure [2]. The composite material is a material that consists of two or more physically distinct phases suitably arranged or distributed, the continuous phase is referred to as the matrix while the distributed phase is called the reinforcement [4, 5].

Epoxy resin are those resins prepared from compounds containing an average of more than one epoxy group per molecule and capable of being converted through these groups to useful thermosetting products. The advantages of the epoxy resins are low shrinkage, high adhesive. Many factors must be considered when designing a fiber-reinforced composite. Glass in the forms used in commerce has been produced by many cultures since the early Etruscan civilization. Glass fibrous usage for reinforcement was pioneered in replacement of metals and used for both commercial and military use [4].The aim of this work is to Design and Analysis of A320 wing which was fabricated by using E-Glass Epoxy composite, Design was carried out using Auto cad 2014, Analysis by using Nastran and Patran 12.0.

II. METHODOLOGY

A. Geometric Scaling Of Airbus A 320 Wing: Overview Of Airbus A 320 Wing

The original scaled dimensions (1:5) of the A320 wing are shown in Table 1. We know the values of root and tip chord lengths, sweep angles at the leading and trailing edges. The A 320 wing AutoCAD drawing is shown in Fig 1.

TABLE 1: SCALED DIMENSION OF WING

Semi Span	3000mm
Root Chord	1180mm
Tip Chord	192sq.mtrs
Wing Area	763mm
Mac (Location From Root)	250
Sweep Angle L.E	0^0
Sweep Angle T.E	170^0
Twist Root	3.7^0
Twist Tip	0.8^0

By using AutoCAD software wing is designed according to required specifications. We have divided the wing into 15 stations at a distance of 200 mm. The very purpose of the division of wing is to give varying thickness at each division. AutoCAD drawing is shown in the Fig1.

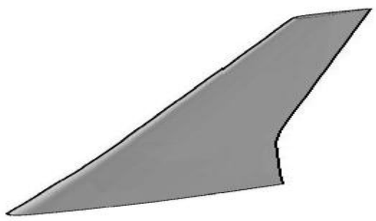

Fig.1 Final shell model of wing

Chord length, maximum thickness and pitch of aerofoil's at each station are noted from the AutoCAD drawing at each station and shown in Table 2.

TABLE 2 CHORD, THICKNESS AND PITCH AT EACH STATION

S.No	Chord (mm)	Thickness (mm)	Pitch (Degree)
0	1186.6	141.98	3.7
1	1083.029	130.17	3
2	979.42	118.61	2.96
3	875.3	105.24	2.56
4	783	94.11	2.095
5	740.56	89.69	1.5
6	698.1	83.91	1.187
7	656	78.85	1.148
8	613.5	73.76	1.109
9	571	68.6	1.032
10	529.1	63.58	0.993
11	486.2	58.44	0.954
12	444	53.36	0.916
13	401.5	48.26	0.877
14	359	43.211	0.839
15	192	23.07	0.8

The area in between two stations is calculated. The maximum wing loading is 600 kg/m2. The wing loading multiplied by surface area gives load at that particular area shown in Table 3.

TABLE.3 AREA AND LOADS

S.No	Area (m^2)	Load (KN)
A1	0.22696399	1.33591005
A2	0.20624543	1.21396057
A3	0.1855234	1.09200212
A4	0.16501327	0.97126809
A5	0.15245646	0.89735871
A6	0.14397035	0.84740947
A7	0.13549279	0.79751054
A8	0.12702132	0.74764748
A9	0.11855089	0.69779055
A10	0.11007609	0.64790787
A11	0.10159511	0.59798879
A12	0.0931126	0.54806074
A13	0.08463426	0.49815707
A14	0.0761611	0.44828426
A15	0.06287316	0.37007143

The maximum thickness of wing as per design is known, to get the composite thickness we have used Strength of materials approach.Fig.2 shows the wing loading, Fig 2.1 and Fig 2.2 shows shear force and bending moment calculations are done by using obtained data.

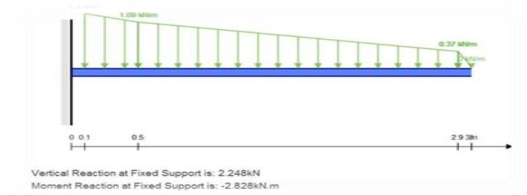

Fig 2 Load distribution on the Wing

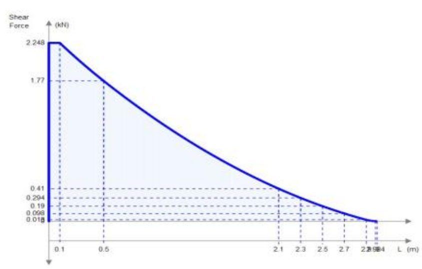

Fig 2.1 Shear force diagram

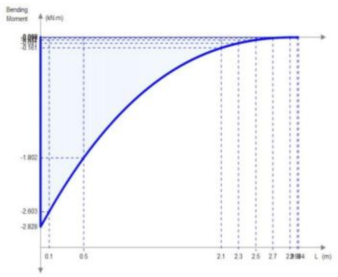

Fig 2.2 Bending moment diagram

By using Bending equation i.e.,

$$\frac{M}{I} = \frac{F}{Y}$$

M = Bending moment
F = Flexural strength
I = Moment of inertia
Y = Distance from neutral axis

For the purpose of design rectangular section was considered in the each section of the aerofoil wing. The moment of inertia at each station is calculated, which is the function of t (composite thickness). We will get equation in terms of t, composite thickness is obtained after solving the equation. Span-wise wing thickness is obtained. The estimated composite thickness for one ply from previous results is 0.5. Therefore to get 7.5 thickness 15 plies are used. Span-wise plies are shown in the Table 4.

TABLE .4 SPAN WISE PLY NUMBERS

PLY STATION	No of plies
S0	15
S1	15
S2	15
S3	15
S4	14
S5	14
S6	14
S7	13
S8	13
S9	13
S10	12
S11	12
S12	12
S13	10
S14	10
S15	10

Plies are designed by using above data. Finally for the ease of analysis we have taken the shell thickness for all stations as 7.5mm (15plies).

III. FINITE ELEMENT ANALYSIS OF WING SKIN

An aircraft wing geometry in 3d is created using AutoCAD cad tool is exported to patran for discretization.

A.Meshing

The A 320 wing meshed model was created by using Patran 2012 analysis software and shown in Fig 3.

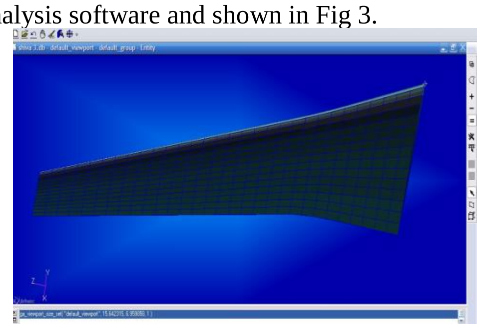

Fig .3 Meshed wing model

B. Material properties

Young's modulus of lamina in fiber direction,
E_1 =47.807 X 10^9 N/m^2
Young's modulus of lamina in transverse direction,
E_2=7.54 X 10^9 N/m^2
Poisson's Ratio, v12 = 0.263
Rigidity Modulus, G_{12}=0.208 X 10^{10} N/m^2

C. Boundary conditions & loads

Since aircraft wing is considered as a cantilever beam, root aerofoil section is applied constraints as All DOF = 0.The pressure applied on the wing is P = 600 Kg/m^2.After applying the boundary conditions and loads we solved the model using linear static analysis.

The various result plots obtained are as follows: Fig .4 shows the von misses stress plot, Fig. 5 shows the maximum principal stress plot and Fig. 6 shows the maximum displacement plot.

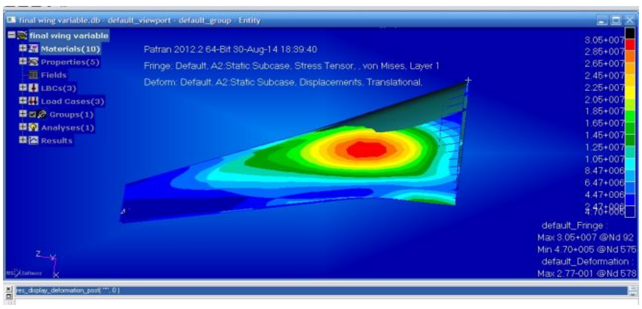

Fig .4 Von Misses stress plot

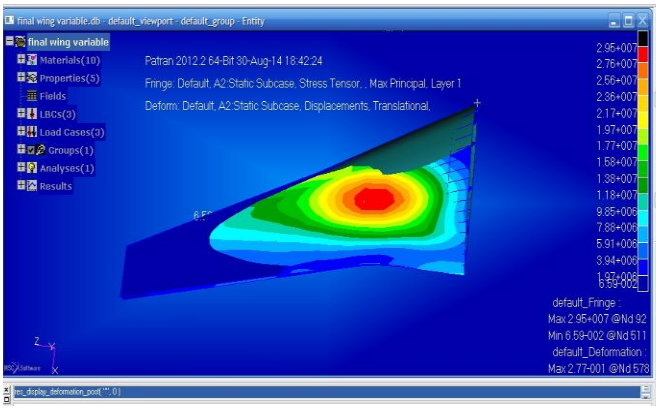

Fig .5 Maximum Principal stress plot

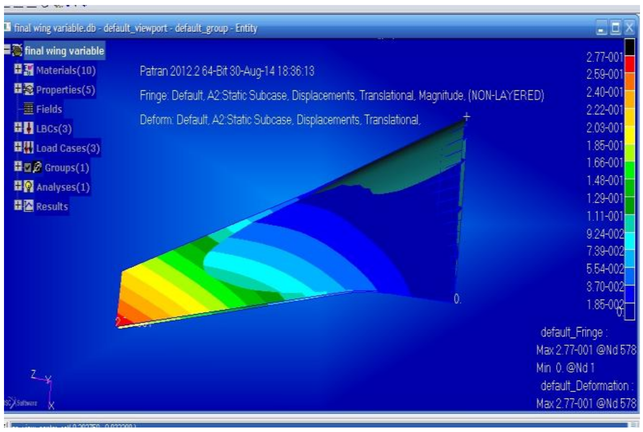

Fig .6 Max displacement

IV. RESULTS AND DISSCUSION

In the study we have calculated factor of safety by using two different types of Theories of failure they are

a) Von misses criteria
b) Max principal stress criteria

In both the criteria the ultimate a stress is found to be same and the max stress is slightly higher in maximum Vonmises stress. The data are shown in Table.5

In both the theories the factor of safety is greater than 2, which is an acceptable value for A320 wing. The optimum factor of safety value is 1.5 but in the study we got factor of safety value greater than 2. This clearly reveals that for this wing there is a scope to increase maximum load.

TABLE 5: FACTOR OF SAFETY(FOS) CALCULATION

S.N0	Types of Stress	Max Stress (MPa)	Ultimate Stress (MPa)	Fos
1.	Vonmises	30.5	80	2.6
2.	Maximum principal stress	29.5	80	2.7

V. CONCLUSION

The design and analysis of a scaled airbus A320 wing using composites for its skin is done. The geometry considered is obtained by scaling the A320 original wing dimensions and the loads are assigned by structural stimulation thus applying pressure loads and the analysis is done for obtaining the displacement. The final obtained displacements and stresses developed are within the limits of selected material capability. By using ply drop offs we can reduce the weight of the composite there by we can decrease cost.FOS is greater than 2 so there is a scope to increase the load.

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