

# Design and Analysis of AC mounting bracket using Composite Material

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**Abstract** — Parameter like fee of car and fuel efficiency within the primary introduced about thru the use of weights of the automobile inside the car industries as consistent with the safety desired that is very critical to layout moderate weight hassle. The air conditioners applied in cars are set up on a bracket in the bonnet. This task intends to investigate the bracket and optimize the burden with the aid of retaining the same fabric of the bracket. Weight good deal will now not absolutely restrict the raw fabric price, but additionally increase the overall performance, even despite the truth that very minute. The discover approximately of the topology optimization is finished as in line with the requirement of the bracket layout. This contemporary paper highlights the factors for the failure of the mounting bracket and the impact of the optimization through manner of various assessment. In this task, we've got were given designed an ac mounting bracket. Through the use of modelling software software the modelling of the bracket is finished and analyzed the usage of ansys. The glass fiber bracket is designed using format of experiments and analyzed in ansys.

**Key Words:-AC mounting bracket, ANSYS, Design Of Experiments**

## I. INTRODUCTION

On the identical time as designing the automobile form it is very difficult method to achieve the better stiffness and electricity and moreover decrease the weight of the detail. Compressor mounting bracket is the bracket used to mount the air conditioner compressor in the vehicle. A. Styles of brackets

1. Engine mounting bracket of vehicle engine mounting bracket of the automobile is the bracket used to mount the engine from the once more facet. It is made of metal. The massive face of the bracket is attached to the engine on the equal time as the small surrender of the bracket is connected to the car shape for taking load and vibrations. If there are a few exclusive problems associated with the car form, then there are large opportunities of failure of the engine mounting bracket. Crack in the bracket is the primary failure due to high stresses generated in the bracket.



Fig.1: Engine mounting bracket of a car [8]

## 2. Aero plane engine's continental engine mounting Bracket

A mounting bracket having a flat upper surface is used as a base member and an elongated shoulder extending upward from the base surface. The mounting bracket consists of bracket member having an upper surface adapted to support a component and a flat lower bracket surface. The other part of bracket is connected to the engine and the base is connected to the plane structure, which takes most of the load. It is made up of aluminum casting.



Fig 2: Aero plane engine's continental engine mounting Bracket [8]

Harshal Bankar and P. Baskar [2] In this study the researchers have said that simulation plays very important role in the Automotive industries for the higher levels of quality, better cost effectiveness and quick market response. In this paper, the use of dynamics analysis technique is used for the simulation of the compressor mounting bracket for various vibration loads. The results showed that resonance in the dynamic analysis is the major cause for the failure of the compressor mounting bracket, under static analysis, under the same magnitude of load resonance cannot be predicted. Thus, dynamic analysis gives best results for design validation of the compressor mounting bracket. William Nadir and Kim Yong presented a paper

Additional work is still needed to complete this research project. R. P. Kumar, Dr. K Rambabu [6] Studied the parameters like cost of vehicle and fuel efficiency are mostly influenced by the weight of the vehicle in the automotive industries. As per the safety standards this is very important to design the light weight component. The study of the topology optimization is done as per the requirement of the bracket design. This study also highlights the factors for the failure of the mounting bracket and the effect of the optimization by various analysis M. Singh, D. Singh and J. S. Saini [3] Analysed the automotive air-conditioning industry aiming at higher levels of quality, cost effectiveness and a short time to market, the need for simulation is at an all time high. In this work, the use of dynamics analysis is proposed in the simulation of the automobile air conditioning condenser assembly for the vibration loads. The condenser assembly has been analyzed using the standard testing conditions. Pushpendra Mahajan [5] In this the researcher have said that NVH is one of the major factors impacting quality for household appliances like refrigerators. In refrigerators, compressor is the main source for vibrations and noise. Compressor is attached to compressor mounting plate which is then attached to refrigerator body. Compressor being dynamic component also exerts harmonic exciting forces on the mounting plate. If compressor operating frequency matches with natural frequency of plate then resonance would occurred leading to excessive vibrations and noise. Hence the plate should have natural frequency beyond the operating range of compressor. Natural frequency and static state deflection of a compressor mounting plate are analyzed using FEA software, ANSYS. Further two methods of improving and optimizing the design to increase the natural frequency are illustrated and analyzed. A.S. Adkine, [1] "Static Behaviour of Engine Mounting Bracket" Mallikarjun B Patil,

## II. PROBLEM SPECIFICATION

Weight optimization of the components mounted on the automobile is one of the measure area of study in today's engineering studies. We need to design the compressor support bracket for Ashok Leyland 220 Bus, using different materials including conventional as well as

composite materials. We need to find out optimum solution for this application's support bracket even considering material and manufacturing costs.

## III. MATHEMATICAL CALCULATIONS

Compressor is installed on the bracket with the help of bolts, which allows us to change the width of the bracket which can be less or more than the width of the compressor. Bolts and base of the compressor may have shape which will help us bolting the compressor to the plate. This leads to shape of side closed L bracket, Dimension of the bracket will be 446 mm in length and 150 mm in width.

Following stress needs to be checked Shear Stress.

Direct and Bending Stress Weight on the bracket is 17.4kg.

Steel is used for manufacturing of bracket. Forces acting on the component installed on automobile are as follows 3g loading in all three directions independently acting on the component when applied on the compressor.

Area of the plate under compressor is 450mm by 150mm For DOE of design calculations as sample calculations are considered.

Plate dimensions under the compressor is as follows:

$$A=450 \times 150=6750 \text{MM}^2$$

$$\text{acting load} = 17.4 \text{ kg} \times 3 \times \text{Gravetational acceleration}$$

$$\text{Load acting } L=512.08 \text{ N}$$

$$\text{Stress direct} = 512.08 \div 67500$$

$$\text{Stress direct} = 0.0079 \text{ Mpa}$$

So direct stress is negligible.

Design thickness of plate according to shear limit.

Small area under the shear

$$\text{Ash ear} = W \times t$$

$$\text{Force} = 512.08 \text{ N}$$

$$\text{Shear stress} = F / A_{\text{Shear}}$$

$$\text{Shear stress} = 512.08 / (150 \times t)$$

$$\text{Shear stress all} = 0.5 \times S_{yt} / \text{FOS}$$

Factor of safety selected as 2

$$\text{Shear stress all} = 92.5$$

Hence

$$t = 3.41 / 46.20$$

$$t = 0.035 \text{MM}$$

38 gauge sheet should be selected which is approx 0.152 mm thick. Also we must check thickness according to bending stress.

Bending forces acting on base plate are on the centre of compressor or acting downwards.

512 N downward causes couple with distance of 75mm frame support at cross-section B just near the support

bending stress will be caused by 512 N as follows  $M=F \times (W/2)$

$M= 38.400$

According to bending moment we know that  $(M/I)-(\sigma/Y)-(F/R)$

$\sigma$  is maximum when  $Y = \max$

Where

$Y=t/2$

$I=bd^3/12$

$\sigma_{all} = M.Y/I$

$=38400 \times 6 \div (150 \times t^2)$

$\sigma_{all} = 370/2$

$t^2=8.30$

$t = 2.88 \text{ mm}$

According to these calculations different materials are selected and DOE is performed to select the best alternative for the design for the compressor support system links.

TABLE.1  
VARIOUS DESIGN FOR MATERIALS AND WEIGHT

Mc(kg)	F(N)	L(mm)	W(mm)	Mt(N-mm)	FOS	Material	Yield Strength	E (Mpa)	Density (kg/m <sup>3</sup> )	Allowable Stress	t
17.40	512.08	450.00	150.00	38406.15	2.00	MS (AISI 1018)	370.00	205	7.87E-06	185.00	2.88
17.40	512.08	450.00	150.00	38406.15	2.00	SS 304	205.00	193	8.00E-06	102.50	3.87
17.40	512.08	450.00	150.00	38406.15	2.00	304 L	170.00	193	8.00E-06	85.00	4.25
17.40	512.08	450.00	150.00	38406.15	2.00	304 H	205.00	193	8.00E-06	102.50	3.87
17.40	512.08	450.00	150.00	38406.15	2.00	SS321	205.00	193	8.03E-06	102.50	3.87
17.40	512.08	450.00	150.00	38406.15	2.00	SS 310	205.00	200	8.00E-06	102.50	3.87
17.40	512.08	450.00	150.00	38406.15	2.00	SS 316 H	205.00	193	8.00E-06	102.50	3.87
17.40	512.08	450.00	150.00	38406.15	2.00	SS 420	345.00	200	7.80E-06	172.50	2.98
17.40	512.08	450.00	150.00	38406.15	2.00	SS 309	310.00	200	8.00E-06	155.00	3.15
17.40	512.08	450.00	150.00	38406.15	2.00	AL 6063	90.00	60	2.70E-06	45.00	5.84
17.40	512.08	450.00	150.00	38406.15	2.00	AL 2014	414.00	72.3	2.80E-06	207.00	2.72
17.40	512.08	450.00	150.00	38406.15	2.00	AL 6351	150.00	75	2.70E-06	75.00	4.53
17.40	512.08	450.00	150.00	38406.15	2.00	GFRP	200.00	35	1.7E-06	100.00	3.92

TABLE.2  
COST OF VARIOUS MATERIALS

Material	Weight (kg)	per Kg cost	Material cost
MS (AISI 1018)	4.08	60.00	244.93
SS 304	5.57	175.00	975.59
304 L	6.12	175.00	1071.33
304 H	5.57	175.00	975.59

SS321	5.59	205.00	1146.70
SS 310	5.57	310.00	1728.19
SS 316 H	5.57	300.00	1672.45
SS 420	4.19	94.00	393.85
SS 309	4.53	290.00	1314.70
AL 6063	2.84	250.00	709.91
AL 2014	1.37	400.00	549.21
AL 6351	2.20	270.00	593.88
GFRP	1.2	200	240

From material list table 1 we selected MS (AISI 1018) as design material. This is used to manufacture the steel design. Calculations are repeated for GFRP material. And values for cost and weight are calculated. Best selected steel has weight of 4.1 kg and costs around 245 Rs for material, as shown in the graph. When designed using GFRP material. Allowable stress for material is 100 MPa, and cost per kg for GFRP material is 200 Rs. Values for the GFRP are put in the calculations and thickness for the bracket is calculated. Where  $\rho$  - Density of GFRP material which is  $1.70 \text{ E-6 kg/mm}^3$  so design of GFRP with 4 mm is selected as the weight reduction alternative which only costs 240 Rs, which is similar as material cost of the steel which provides around 70 % weight reduction

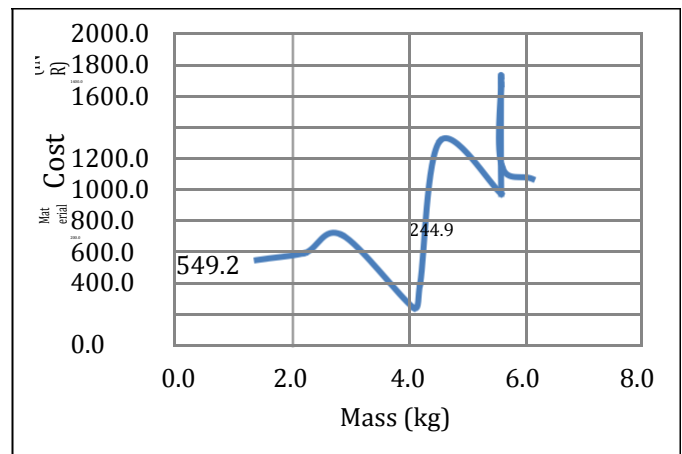


Fig.3. Weight of design Vs Material cost for bracket

The above graph shows relation between material cost and weight of the material. On X axis, the weight of the material is plotted. On Y axis, the material cost is plotted. The above graph is plotted with help of table no 2.

#### IV. FINITE ELEMENT ANALYSIS

Finite Element Analysis is simulation method to solve the real world physics problems using numerical analysis techniques and finite element shapes. In this current work we focus on static structural analysis of the steel bracket for compressor support of the Ashok Leyland Bus and we also run the analysis on the bracket with different materials that is using run analysis and design.

Compressor support bracket model is created using CAD software and analyzed in ANSYS software

A. Steel Bracket

Steel bracket of AISI 1018 material as selected from the design chapter will be used

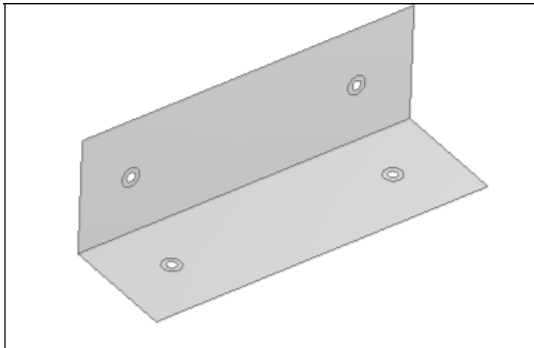


Fig.4. Geometry of compressor support bracket

Meshing is performed on the bracket using shell elements of 2D with element type Shell 181. Rectangular mesh elements are used to create the grid. Image of the meshing module for the same is shown Fig.4 Total of 0.13 million elements and approximately same number of nodes are used to create the meshing.

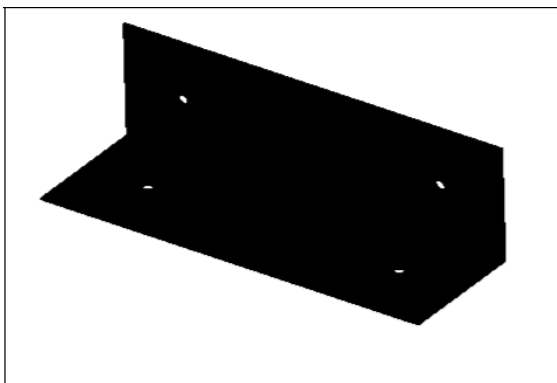


Fig.4. Meshing Compressor mounting bracket

512 N load due to 3 gram acceleration of the compressor assembly towards the base. Total mass of the bracket is around 4 kg.

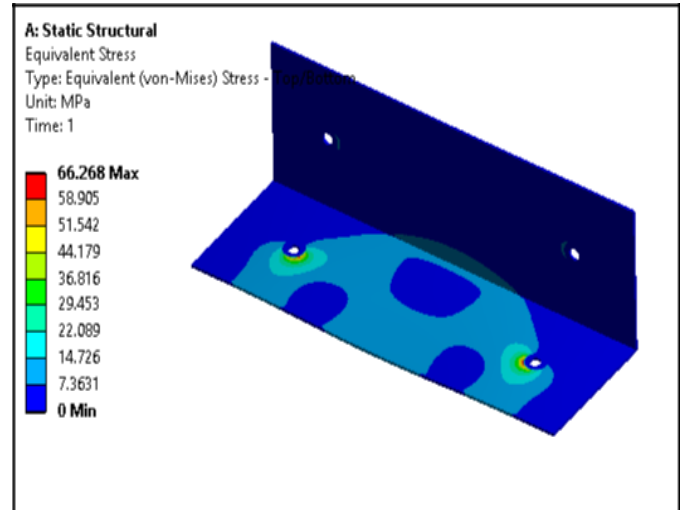


Fig.6. von Mises stress of Compressor mounting Bracket

Von Mises stress plot shows that maximum stress at the steel bracket of compressor due to 3 gram loading is 66.27 MPa which is well within the acceptance criteria of 185 MPa .

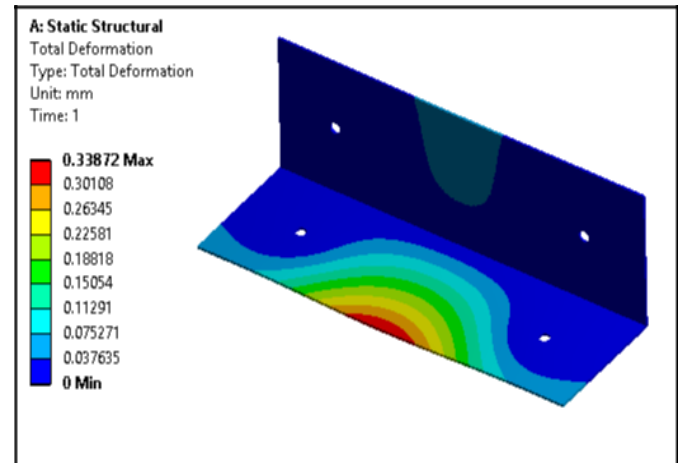
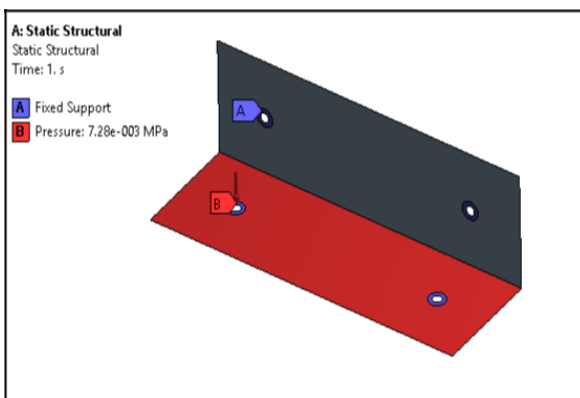


Fig.7. Total deformation of Compressor mounting Bracket



Boundary condition and loading for the static analysis are shown in the Fig 5. It shows that total of 0.00728 MPa pressure is applied on the surface to simulate

Total deformation of the steel bracket in fig.7 the maximum deformation in the bracket observed as 0.34 mm which is negligible considering only 1/3 of the load is applied continuously on the bracket in actual conditions

**B. GFRP design bracket**

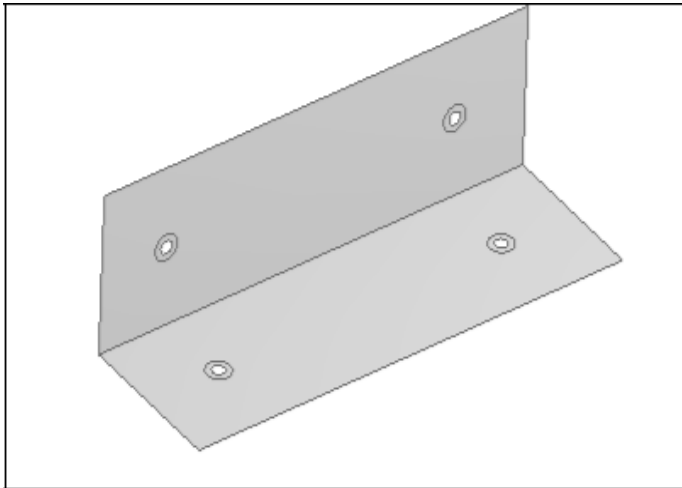


Fig.8. Geometry of GFRP compressor support bracket

Surface is extracted from the model to create compressor support bracket using GFRP material. This will be assigned with good meshing size and thickness in terms of ply material properties in Advance Composite Preprocessor of ANSYS.

Fabric 2,a=0.0, t=0.25
Fabric 2,a=0.0, t=0.25
Fabric 1,a=0.0, t=0.25
Fabric 1,a=0.0, t=0.25
Fabric 2,a=0.0, t=0.25
Fabric 1,a=90.0, t=0.25
Fabric 1,a=0.0, t=0.25
Fabric 2,a=0.0, t=0.25
Fabric 2,a=0.0, t=0.25
Fabric 2,a=0.0, t=0.25
Fabric 1,a=90.0, t=0.25
Fabric 1,a=0.0, t=0.25
Fabric 2,a=0.0, t=0.25
Fabric 1,a=90.0, t=0.25
Fabric 1,a=0.0, t=0.25
Fabric 2,a=0.0, t=0.25

Fig.9. Ply model for ANSYS ACP

In the plies model as shown in the fig.9 Fabric 1 is of uni directional Glass fiber properties and fabric 2 is made of Epoxy Resin used to bind Glass fiber cloth together. Alternate cloth layer of glass fiber is given the angle of 90 degrees which means it is the woven cloth with 90 degree inclination of fibers in between. Polar material properties created due to lay up formation are shown in the fig.10.Total 4 mm thickness for GFRP material is created using this layup technique. Total weight of the component using GFRP material is 1.2 kg.

Fabric 2,a=0.0, t=0.25
Fabric 2,a=0.0, t=0.25
Fabric 1,a=0.0, t=0.25
Fabric 1,a=0.0, t=0.25
Fabric 2,a=0.0, t=0.25
Fabric 1,a=90.0, t=0.25
Fabric 1,a=0.0, t=0.25
Fabric 2,a=0.0, t=0.25
Fabric 2,a=0.0, t=0.25
Fabric 2,a=0.0, t=0.25
Fabric 1,a=90.0, t=0.25
Fabric 1,a=0.0, t=0.25
Fabric 2,a=0.0, t=0.25
Fabric 1,a=90.0, t=0.25
Fabric 1,a=0.0, t=0.25
Fabric 2,a=0.0, t=0.25

Fig.10. Material Properties and plies of GFRP

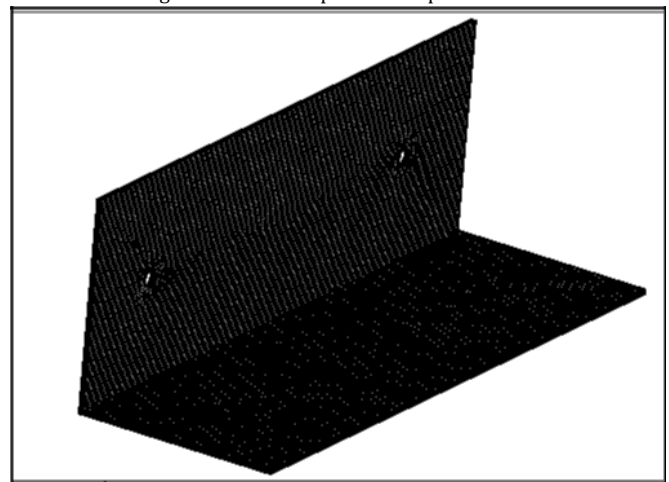


Fig.11. Meshed model

Fig. Eleven shows the meshed version for grfp compressor aid bracket. Nodes are utilized in meshing is 5 lakh and factors are round five lakh 33 thousand elements are used. Stable version created in preprocessing module for acp ansys is imported within the static analysis module of the ansys. Following boundary conditions are implemented at the model.

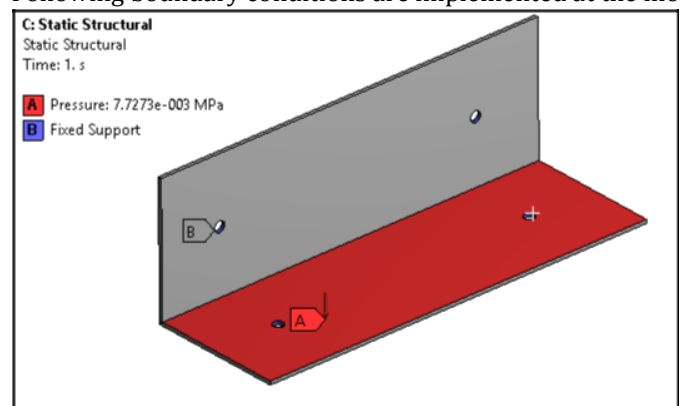


Fig.12.Boundary Conditions on the GFRP bracket

Fig. 12 indicates that boundary situations at the compression mounting bracket. Horizontal face is applied with the pressure of 0. 007723 mpa to simulate the 512 n pressure

carried out because of three g loading of the burden of compressor meeting. Loading calculations are accomplished in the design bankruptcy. Load is thought to be allotted all alongside the surface of the bracket. Constant levels of freedom are implemented to all 4 holding locations wherein bracket is bolted to the chassis. From fig. 13 show that the outcomes for the analysis ran on the gfrp bracket the usage of these boundary situations.

Maximum von mises strain determined in gfrp design is 81. Forty three mpa that's factor pressure. Strain is within the recognition standards of 100 mpa used in layout. Most deformation plot for gfrp design suggests us as 3. 46 mm. That is desirable deformation that's in the applicable limit at 3gram loading. In phrases of gravitational load 1. Five mm. Gfrp being less stiff cloth that metal the results are as in line with expectation.



Fig.16 Mould creation using ply wood

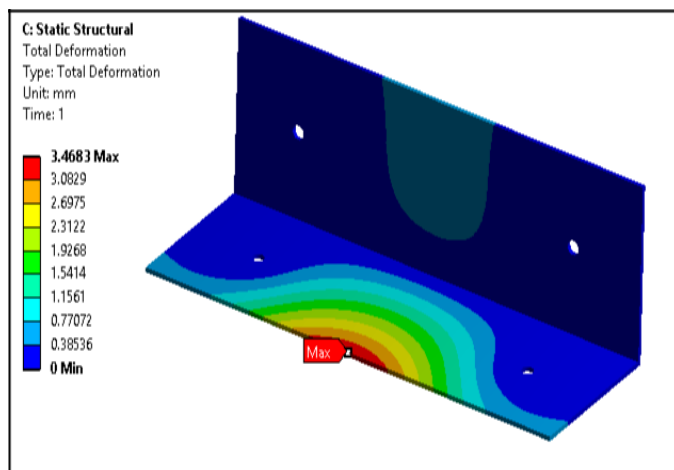


Fig.14. Maximum deformation plot for GFRP design

### V. EXPERIMENTAL VALIDATION PLAN

For experimental validation of gfrp cloth bracket is to be synthetic for the layout dimensions. Production technique used for the gfrp bracket fabrication is hand layup approach in which, glass fiber cloth is reduce using scissor inside the required shape of the factor. Mildew is created the usage of metallic or timber for the required shape of the thing. Resin and hardener are blended within the ratio as in step with recommendations to create epoxy adhesive. Release agent is applied to the mildew before starting the fabrication. After that adhesive layers are carried out on the pinnacle and bottom of each glass fiber cloth. As soon as the required thickness is achieved, mould is closed with the second one a part of it. Strain is implemented on the mildew the usage of bolting or through applying external load. Mold is saved under that strain during curing time.

### VI. RESULTS AND DISCUSSION

FEA results table 2 below shows that us the comparison of FEA results between steel and GFRP material designs of bracket. Following observations are made from the analysis results table (2).

TABLE.3  
FEA RESULTS SUMMARY

Iteration	FEA Max Stress(MPa)	FEA max deformation (mm)	Weight (grams)	% material Removed
Steel	66.27	0.3387	4008	0
GFRP	81.43	3.47	1200	70.06%

Fea result precis desk 3 shows that the most strain determined within the metallic bracket is 66. 27 mpa that's well in the attractiveness criteria for the metallic design. Gfrp layout fea that the maximum stress located within the bracket is eighty one. Forty three mpa which is inside the reputation criteria.

Gfrp material. Total deformation located within the metallic and gfrp designs in fea are zero. 34 mm and three. 47 mm respectively. Despite the fact that deformations located in gfrp material design are pretty high they may be nicely within the acceptance criteria for the ordinary loading of the bracket so effects for fea are desirable restrict. Weight of the metal bracket changed into located to be 4. 1 kg in even as gfrp bracket design for the identical utility weighs only about 1. 2 kg. Universal 2800 grams weight is decreased.

Graph of steel material AC mounting bracket stress vs deformation in FEA shows that maximum stress of 66.27 MPa is observed at maximum deformation of 0.3387 mm.

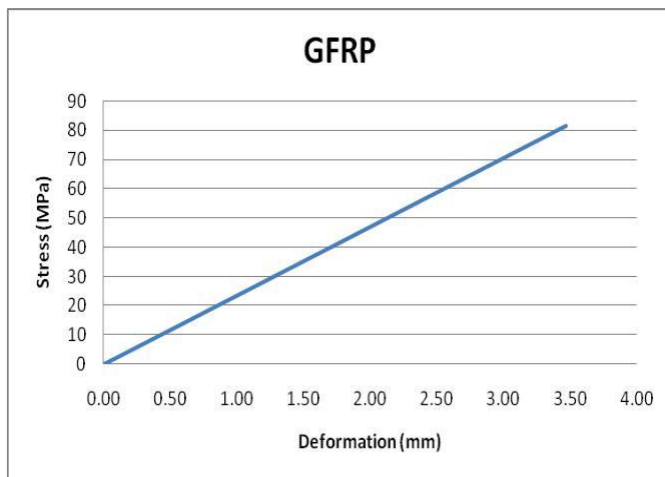


Fig.18. Stress vs. Deformation for GFRP bracket of FEA result

Graph of pressure vs. Deformation for gfrp cloth indicates that the most pressure of eighty one. Forty three mpa is observed within the fea of gfrp bracket at maximum deformation of 3. 47 mm. In assessment it may be actually visible that metallic bracket deforms a great deal decrease than the gfrp bracket for identical loading conditions but pressure and deformation each are in the reputation standards

## VII .CONCLUSION

From work done in the design, FEA and testing chapters of the project it can be concluded that best suitable steel for the manufacturing of the compressor support bracket with least material price is AISI 1018 MS for which weight of the bracket design is 4.1 kg. Best alternative material to save weight of the steel bracket is GFRP material to replace the steel as bracket design material. Using GFRP when designed for the same application bracket weighs 1.2 kg which is 70 % less weight than the steel design.

With same material cost and may be slightly increased manufacturing cost we can achieve 70 % weight reduction in the conventional steel design of the bracket which is calculated in the design chapter and verified by performing FEA on the bracket geometry.

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