Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 7, July : 2023

MODELLING AND STATIC ANALYSIS OF TAPERED L- SHAPED BRACKET ADVANCED CASE

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ABSTRACT

In any manufacturing process, product quality and cost are the two critical, essential factors that need to be carefully selected by the company to maximize profit without compromising the product quality. This paper demonstrates the structural and optimization analysis of an L-shaped bracket suitable for any shelf support ranging from industrial equipment shelves, automotive brackets, aerospace and domestic applications. The structural analysis assesses the endurance of the bracket when subjected to both load and disturbance stress, along with the deformation characteristics. The optimization aspect deals with the removal of un-necessary portions/material from the structure without altering its specifications within the design constraints; this tends to minimize material wastages, hence, reducing cost and product weight. The stress analysis optimization was both carried out using ANSYS software.

Keywords: Strength analysis, Structural optimization, Finite Element Analysis (FEA), ANSYS

INTRODUCTION TO L BRACKETS:

A bracket is an architectural element: a structural or decorative member. It can be made of wood, stone, plaster, metal, or other mediums. It projects from a wall, usually to carry weight and sometimes too "...strengthen an angle". A corbel and console are types of brackets. In mechanical engineering a bracket is any intermediate component for fixing one part to another, usually larger, and part. What makes a bracket a bracket is that it is intermediate between the two and fixes the one to the other. Brackets vary widely in shape, but a prototypical bracket is the L-shaped metal piece that attaches a shelf (the smaller component) to a wall (the larger component): its vertical arm is fixed to one (usually large) element, and its horizontal arm protrudes outwards and holds another (usually small) element.

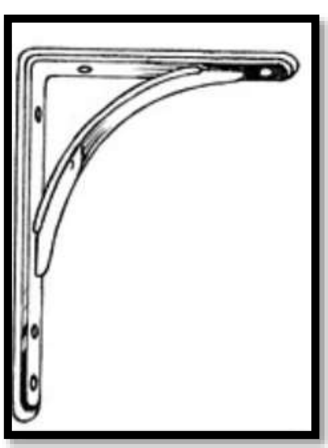

Figure 1 conventional l shaped bracket

This shelf bracket is effectively the same as the architectural bracket: a vertical arm mounted on the wall, and a horizontal arm projecting outwards for another element to be attached on top of it or below it. To enable the outstretched arm to support a greater weight, a bracket will often have a third arm running diagonally between the horizontal and vertical arms, or indeed the bracket may be a solid triangle. By extension almost any object that performs this function of attaching one part to another (usually larger) component is also called a bracket, even though it may not be obviously L-shaped. Common examples that are often not really L-shaped at all but attach a smaller component to a larger and are still called brackets are the components that attach a bicycle lamp to a bicycle, and the rings that attach pipes to walls.

Figure 2 L bracket with rib support

Brackets are meant for carrying loads, support structures, bearing that supports the shafts. Mounting Brackets are used in various fields such as Aerospace Industries, applications, etc. In the present work we deal with the Mounting brackets used in Aerospace industries, which are used to carry loads of Batteries, Electronic Goods, etc. As Minimum weight is the critical factor in Aerospace Industries we have optimized the weight of the Bracket by reducing the volume of the Bracket by giving number of cutouts and by changing materials of the Bracket such as Al Alloy and Graphite Epoxy Composite.

EVOLUTION OF MECHANICAL BRACKETS

1. Pin and tube appliance: by Angle3 in 1910, first time gave the axial control in tooth movement. The close fit between the pin on the arch wire and the vertical tube on the band provided axial control in all directions but permitted only limited mesiodistal crown displacement.

2. Ribbon Arch bracket mechanism4: given by Angle in 1916, provided the mesiodistal movement of the tooth, with lock pins snugly fit into the slot. Cleats were devised, which were soldered on the arch wire so at to contact the ribbon arch bracket, helping in holding the tooth in upright position. Also, cleats can be soldered at different locations to provide tooth movement.

3. Edgewise Bracket5: these were introduced in 1925, by E.H. Angle, by the name of “open face” or “tie-bracket”, but presently known as edgewise brackets. These were the first bracket system to have horizontal slot. Thus, giving more control over the tooth movement in all three planes as having the two-point contact. Dimensions of which were 0.022”x0.028.” The new appliance facilitated the movement of all malposed teeth into their correct axial inclinations in the “line of occlusion.”

DIFFERENT TYPES OF BRACKETS

- Wall brackets
- Mounting brackets:
- Pillar brackets:
- Drive bay mounting bracket:

WORKING PRINCIPLE OF MECHANICAL BRACKETS;

In mechanical engineering a bracket is any intermediate component for fixing one part to another, usually larger, and part. What makes a bracket a bracket is that it is intermediate between the two and fixes the one to the other. Brackets vary widely in shape, but a prototypical bracket is the L-shaped metal piece that attaches a shelf (the smaller component) to a wall (the larger component): its vertical arm is fixed to one (usually large) element, and its horizontal arm protrudes outwards and holds another (usually small) element.

This shelf bracket is effectively the same as the architectural bracket: a vertical arm mounted on the wall, and a horizontal arm projecting outwards for another element to be attached on top of it or below it. To enable the outstretched arm to support a greater weight, a bracket will often have a third arm running diagonally between the horizontal and vertical arms, or the bracket may be a solid triangle. By extension almost any object that performs this function of attaching one part to another (usually larger) component is also called a bracket, even though it may not be obviously L-shaped. Common examples that are often not really L-shaped at all but attach a smaller component to a larger and are still called brackets are the components that attach a bicycle lamp to a bicycle, and the rings that attach pipes to walls.

LITERATURE REVIEW

A composite material is defined as a material system which consists of a mixture or a combination of two or more distinctly different materials which are insoluble in each other and differ in form or chemical composition

[1] Thus a composite material is labeled as any material consisting of two or more phases. Many combinations of materials termed as composite materials, such as concrete, mortar, fiber reinforced plastics, and fiber reinforced metals and similar fiber impregnated materials. As the composite materials are considered to be having lighter weight compared to conventional materials, hence analysis of dynamic characteristics is quite important to understand the strength of these composite components. Especially for structural design in the critical environments, highly accurate dynamic analysis is required.

[2] The transient response of composite and sandwich plates using shear deformation theory and mode superposition method was developed by T. Kant et.al. Analytical solutions for laminated composite and

sandwich plates based on a higher order refined theory were given by T. Kant and K. Swaminathan

[3] Behavior of laminated composite plates under transverse loading based on First Order Shear Deformation Theory was studied by Junaid Kameran Ahmedet.al .

[4]. in the present paper, study on free and forced vibration behavior of L-shaped bracket made of conventional materials and composite materials is discussed. The finite element analysis using ANSYS has been carried out considering the element SHELL63.

[5].The results obtained from conventional material properties are compared with the results obtained from composite material properties considering same boundary conditions and loading conditions. For the analysis of composite component here we considered the SHELL99 element, used for layered applications of a structural shell model. The element has six degrees of freedom at each node: translations in the nodal x, y, and z directions and rotations about the nodal x, y, and z axes.

[6]. A wooden structure with a 90° bend was considered in reference .The structure was tested using a tension test similar to the test used in the literature previously mentioned. Experimental data and finite element analysis were used and compared to determine stresses within the structure. For each specimen tested, the analysis predicted failure to occur due to delaminating. The visual examinations of the specimens tested also showed that every specimen failed by delaminating.

[7] Investigated the interlaminar stresses of curved frame structures often seen in the internal structure in aircraft. Mason, Haftka, Johnson, and Farley used a finite element analysis combining two- and three-dimensional models to reduce the expense associated with the design of the frames. Frames with various design parameters and the tension test were considered.

[8] A response surface approach was then used to approximate the structural response of the frames as functions of the design variables, It is stated in reference that premature matrix failure due to bending can be controlled by varying the stacking sequence. However, the more critical delaminating failure mode has been found to occur regardless of stacking sequence.

[9] Sun and Kelly state that rather than controlling the stresses responsible for delimitation it is necessary to augment the interlaminar strength of the laminate. Their method of choice was to use adhesive films to toughen the delaminating-prone interfaces in the curved region. Experimental results indicated that the adhesive films could improve the load-carrying capacity of composite angle structures.

[10] Hervandil M. Sant'Anna and Jun S. O. Fonseca presented the problem of volume minimization of two-dimensional continuous structures with compliance and stress constraints. Here they conducted topology optimisation to check for optimal material distribution, where they cut down geometry into number of simple pieces, approximating the displacement methods. A first neighbourhood filter was implemented to minimize the effects of checkerboard patterns and mesh dependency, two common problems associated to topology optimization. Von-misesstress constrains was used for arriving at the final solution. As stress constrained problems have a difficulty of stress singularity, the feasible domain is modified using a mathematical perturbation technique, the epsilon-relaxation. From the exercise, they concluded that problems considering stress constraints require a more refined finite element mesh to obtain better solutions for engineering problems.

[11] Lars Krog et al in their paper, effectively demonstrated the application of energy based topology optimization methods for design of aircraft wing box ribs for airbus project. The work focused on use of both FE based global and local analysis approaches as the ribs are embedded inside the aircraft wing and subjected multiple loads like fuel pressure, structural loads etc. Here, the analysts considered alternate optimization formulation approaches like min -max formulation, energy measure based load case for achieving minimum weight of the component. [12] In the work by Lee et al, the authors tried to solve the structural topology optimization problem with stress constrain in place of regular compliance minimization in case of deign dependent loading. They compared the results from both methods for the same geometry and loading. It was concluded that topology obtained from these methods are vastly different and the sizing optimization of a compliance solution may not lead to an optimum.

Industrial Engineering Journal
ISSN: 0970-2555
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OVERVIEW OF PROJECT

Collecting data regarding the brackets and mechanical fasteners helps to leads a modifications in a brackets ad choosing of a proper material may helps to achieve a better mechanical behavior make interest towards to choosing this thesis work. The preparation of fully parametric 3D model of L-Shaped bracket using exact dimensions. Using SOLIDWORKS 2020 EXPLORER to develop the object with a file extension of SOLID PART (.sldprt). Later it gone a be saved with a file extension of .igs for the simulation. All simulations regarding L-Shaped bracket has been conducted on fully problem solving simulation tool of ANSYS 18.0.

The 100N maximum loading member of L-Shaped bracket was testing under Static structural analysis in order to getting the Equivalent stresses and Strains also total deflections acting on the component while applying maximum payload over it. The graphs after getting results may leads to choosing a suitable and better mechanical property L-Shaped bracket for usage. That helps make a better and cost effective L-Shaped bracket for the end user.

PROBLEM IDENTIFICATION & OBJECTIVES

Mechanical brackets are usually affected by several environmental and metal corrosive problems. In order to minimize these affects may help the end user for a long lasting usage of mechanical brackets. These are the some key objectives of our thesis work.

- To reduce the costs associated with brackets replacement by end user.
- To reduce the corrosion and seasoning affects on brackets with advanced materials.
- To design equipment that reduces human effort in production.
- Develop a mechanical equipment to remove unwanted fails of members.
- Make the brackets at the most cost-effective and affordable price.
- To make a use of mechanical brackets in a multiple applications.

METHODOLOGY

The project begins with a literature review and concludes with a result evaluation. The diagram depicts the design and development of project methodology.

Figure 3 methodology flow chart

MATERIALS USED

In this project totally we are using three different materials. The Aluminum alloy of AL 2024 grade is commonly used for L-Shaped brackets along with advanced CARBON FIBER [Hexcel AS4] and TITANIUM ALLOY [Ti-6Al-4V] are used. The mechanical properties of those materials have been discussed in following.

- AL ALLOY [AL 2024]
- TITANIUM ALLOY [Ti-6Al-4V]
- CARBON FIBER [Hexcel AS4]

DESIGNING OF THE MODEL:

A fully parametric model of L-Shaped bracket has been developed by using its standard dimensions as shown in below. After successful creation of component sketch later it will developed by 3D features called Extruded boss/base and Extruded cuts and Edge fillet options.

The sequential and complete modeling procedure of L-Shaped bracket has been show in following figures clearly,

Industrial Engineering Journal
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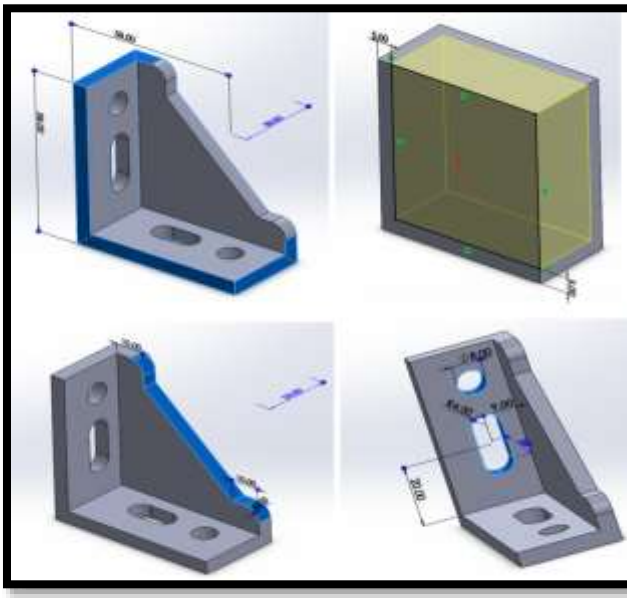

Figure 4 dimensions of l shaped corner bracket

The isometric and Multi view of L-Shaped brackets has been shown in following figures,

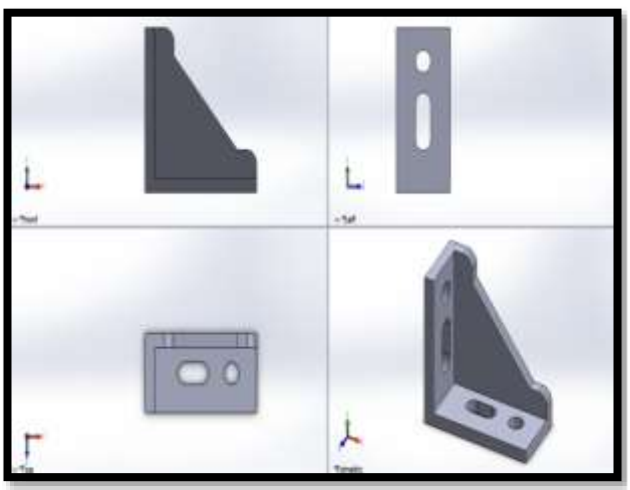

Figure 5 multi view of a l shaped corner bracket

STATIC STRUCTURAL ANALYSIS

The static structural analysis calculates the stresses, displacements, strains, and forces in structures caused by a load that does not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that the loads and the structure's response are assumed to change slowly with respect to time. A static structural load can be performed using the ANSYS WORKBENCH solver. The types of loading that can be applied in a static analysis include:

MESHING

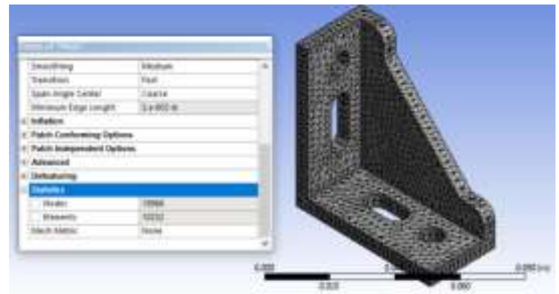

Figure 6 meshing (nodes: 18966; elements: 10232)

BOUNDARY CONDITIONS

Boundary Condition is a very important step. This was applied to the meshed model. The first condition was fixed wall side face support as shown in blue the bearing load was applied on another end of bracket in two direction only x and y which is shown in red tag. Consider this simulation at different loads conditions.

The force acting on the compressor L-Shaped wall mounted bracket of a general usage will be determined by the weight of the assembly.

Weight of optimal object = W Comp = 8 kg

Hence, force acting on the L-Shaped wall mounted bracket.

F = W Comp × g

F = 8 × 9.81

= **78.48 N**

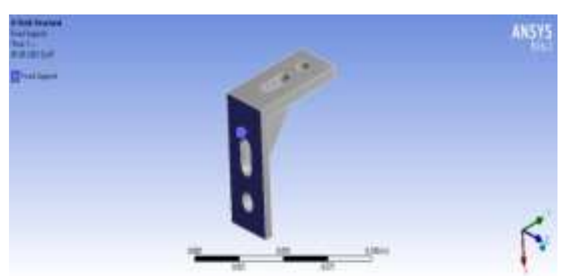

Figure 7 fixed support blue tag

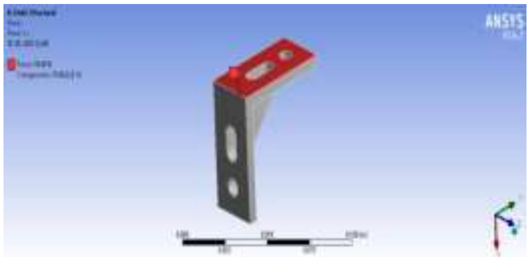

Figure 8 boundary condition of maximum force acting on component with red tag

RESULTS AND DISCUSSION

This analysis is performed to find structural parameters such as stresses, strain and deformation of farm tiller equipment using three materials namely CARBON FIBER [Hexcel AS4] ,TITANIUM ALLOY Ti-6Al-4V along with the exisisting AL 2024, finally observed results as shown below figures.

VON-MISES STRESS:

Here we have the final von misses stress results of CARBON FIBER [Hexcel AS4] ,TITANIUM ALLOY Ti-6Al-4V along with the exisisting AL 2024. Here we get maximum von misses stress value of 4.46e+6 Pa for the AL 2024 material and favorable lowest stress value for the advanced CARBON FIBER material value of 4.14e+6 Pa.

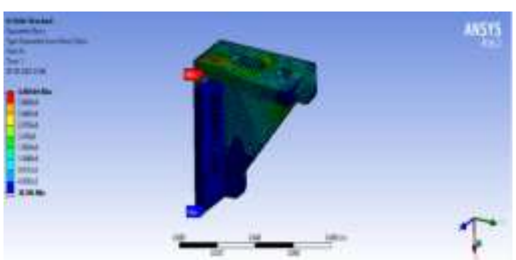

Figure 9 von-misses stress on AL 2024

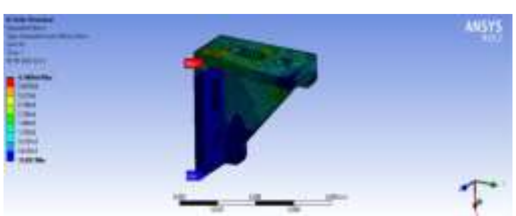

Figure 10 von-misses stress on HEXCEL AS4

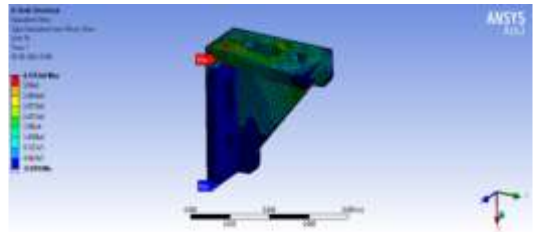

Figure 11 von-misses stress on TI-6AL-4V

EQUIVALENT STRAINS:

In this analysis point of view we are getting the final Strain results of CARBON FIBER [Hexcel AS4] ,TITANIUM ALLOY Ti-6Al-4V along with the exisisting AL 2024. Here we get maximum total deformation value of 4.66e-5 for the AL 2024 material and favorable lowest stress value for the advanced CARBON FIBER material value of 4.33e-5

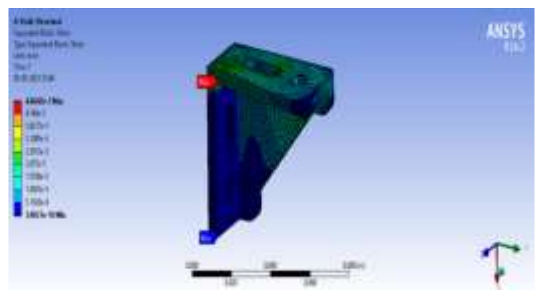

Figure 12 equivalent strains on AL 2024

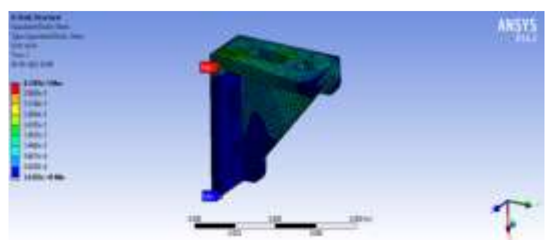

Figure 13 equivalent strains on HEXCEL AS4

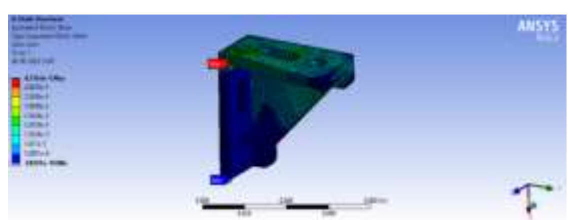

Figure 14 equivalent strains on TI-6AL-4V

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TOTAL DISPLACEMENT

In this analysis point of view we are getting the final total deformation results of CARBON FIBER [Hexcel AS4] ,TITANIUM ALLOY Ti-6Al-4V along with the exisisting AL 2024. Here we get maximum total deformation value of 6.66e-6 mm for the AL 2024 material and favorable lowest stress value for the advanced CARBON FIBER material value of 6.2e-6 mm

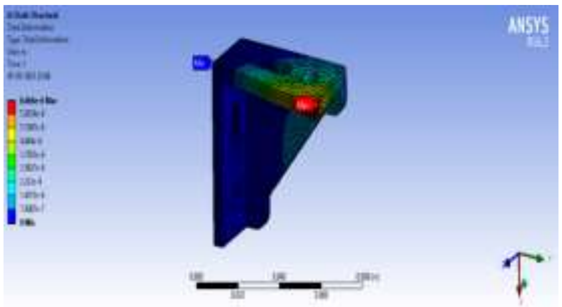

Figure 15 total displacement on AL 2024

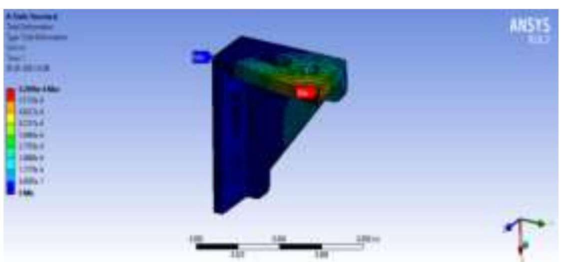

Figure 16 total displacement on HEXCEL AS4

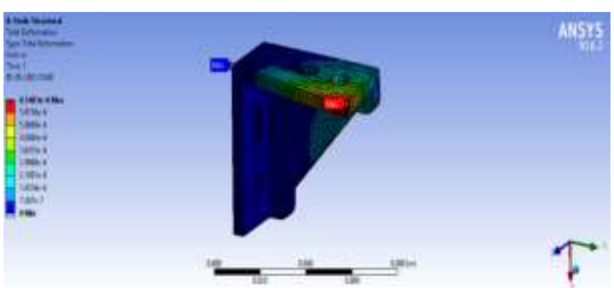

Figure 17 total displacement on TI-6AL-4V

STATIC STRACTURAL RESULTS TABLE

The following table illustrates the how a L-Shaped bracket with three different materials like CARBON FIBER [Hexcel AS4] ,TITANIUM ALLOY Ti-6Al-4V along with the exisisting AL 2024 will behave according to Von misses stress, Total displacements and Equivalent strain point of view. The CARBON FIBER [Hexcel AS4] despites the lowest values of stresses, strain and deformations while applying the maximum load whether the exisisting AL 2024 shows the maximum values.

MATERIAL	Von misses stress (Pa)	Total displacement (mm)	Equivalent strain
AL 2024	4.46e+6	6.66e-6	4.66e-5
CARBON FIBER	4.14e+6	6.2e-6	4.33e-5
Ti-6Al-4V	4.37e+6	6.54e-6	4.57e-5

Table 1 static structural analysis results

CONCLUSION

Designing of L-Shaped mechanical wall mounted fastener is done by using SOLIDWORKS Software and then the model is imported into ANSYS Software for Structural analysis on the L-Shaped mechanical wall mounted fastener to check the quality of materials such as exisisting AL 2024, along with advanced CARBON FIBER and Ti-6Al-4V. From the obtained Von-misses stresses, deformation and strain for these three materials, respectively Compared these materials with CARBON FIBER material posses have less stresses, deformations and strain values proven through maximum values with graphical representation. Finally among the exisisting AL 2024 based on results it is concluded that CARBON FIBER material is suitable material for L-Shaped mechanical wall mounted fastener.

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