Design and Optimization of Car Battery Tray

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Abstract: The battery tray or mounting is used for holding the battery in position in automotive sytem.The existing battery tray can corrosive due acid overflow and undergoes the earlier failure and fatigue. In today automotive industry, it is big issue about the earlier failure of battery tray. In this paper the failure analysis and optimization of the existing battery tray is carried with help of finite element analysis. The cast iron is replaced with new material like aluminum and glass fiber also different thickness was considered for the presented research study. The different results were obtained on the three different materials under the study. It is found that the glass fiber material is best suited for replace the existing material with thickness of 3 mm.The aluminum material also shows the good results comparatively with cast iron. Overall for maximum strength to weight ratio and reduction in exiting weight of battery tray glass fiber is the best recommendation in future. The computational analysis of the components is carried out with ANSYS and modeling of is carried out with CATIA software.
Keywords: Battery Tray, Aluminum, Glass fiber, ANSYS, CATIA.

1. INTRODUCTION

A battery is a device that stores chemical energy and releases it as electrical energy. It is comprised of two electrodes joined by an electrolyte, and it is the chemical reactions that take place between these components that generates electricity. In the case of a “primary cell”, the battery components are consumed during use; however, in a “secondary cell” the reaction can be reversed by applying a current to the cell, thereby recharging the battery.An improvement in the design generally uses surface or geometrical modifications by incorporating additional surfaces modifications in the existing design. The weight optimization, design optimization or materials optimization depends upon various parameters and customers or companies requirements such as its shape, size, type and arrangement.The numerous of study were carried out on the design of battery tray. The different material is used in automotive industries in order to develop the new product design. Cengiz Yildiz et.al. carried research work on the interactive design of a truck battery box with material selection to improve quality. In this work the different material for design the car truck battery box are studied [1].Andreas Vlahinos et.al. addresses work on the body-in-white weight reduction via probabilistic modeling of manufacturing variations. The Parametric Deterministic study of design the new battery tray was carried out, the six sigma design approach and for determining the response distribution Monte Carlo and response surface sampling techniques are implemented for determining the results [2]. V.S.Kathavate implemented the ANSYS tool for design the engine mounting bracket the results are developed on the basis of current natural frequency of engine mounting bracket and found that the self excitation frequency of bracket[3]. Meishi Zhou et.al.were carried out the research work on the fatigue life analysis of the battery bracket. To verify the battery bracket fatigue life of electric bus, the finite element model of the battery bracket is built, and the equivalent stress distribution of the frame was got. Multi-body dynamics vehicle model was built in ADAMS/Car [4]. P. Ravinder Reddy et.carried out the vibration analysis of a torpedo battery tray using FEA.The vibration analysis is used for concluded the results of the study [5]. A. Subba Rao et.al.were presented research work on the DoE and stochastic study analysis of a battery mounting structures in Mahindra & Mahindra Ltd. The research paper Objective of this paper is using DOE screening first find the thickness parameters which have more influence on the system performance like natural frequencies and structural strength of the battery tray and its mounting brackets[6]. S.V.Gopala Krishna et.al.were carried out the research work on the Design and Analysis of Mounting Bracket for Aero Space VEHIVLES.In this Aluminium alloy- 6061 and Graphite Epoxy Composite is used. The results concluded that graphite epoxy shows best results compared with aluminium [7]. Jianong Wang et.al.were carried out the research work on the modal analysis of battery box based on ANSYS. This paper is based on ANSYS. By using the finite element theory, it is to analyze the modal characteristics of the battery box and frequency vibration characteristics [8].

2. CAR BATTERY TRAY

Currently used battery box is a combination of different parts like right, left plates, front and bottom parts. Elements of the case and the assembly are shown at Figure 1.

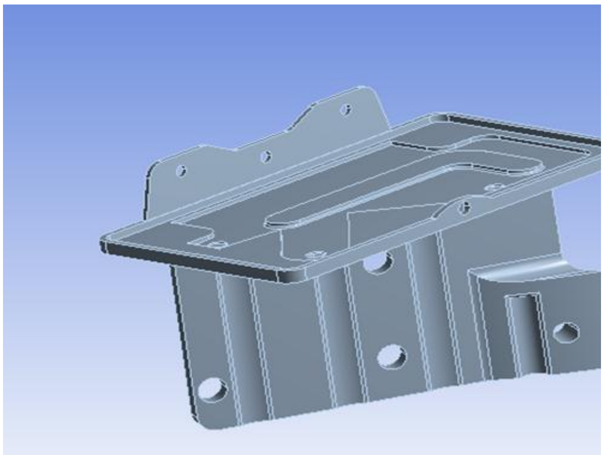

Figure 1 - Components of the currently used battery box

Currently used battery box material is structural steel and total weight is approximately 2-3 kg.The structural steel has technical specifications, tensile strength is in the range of 400-500 MPa, yield strength is 460 MPa and elongation is nearly 22% [1].

The existing structural stability of the battery tray is carried out with consideration of technical conditions with respect to requirements. The analytical calculations, the battery can be considered as a load of 49.05 N. Moreover, both of them can be assumed as distributed loads to ease the calculations. In addition, it has to service in dynamic state in order to support the other external loads and vibrations. Selection of a new and suitable material for the box was the following research and development step. The modeling of the battery tray design carried out with CATIA software which has been utilized for design, optimization and manufacturing modelling.

3. MATERIAL SELECTION

The current battery tray material is structural steel and this has been implicit before. Apart from that, the other common materials that are used in automotive manufacturing industry, especially automotives factories were noted, according to extensive technical research.

The material selection is carried out on the basis of application. The structural steel is replace with the material like glass fiber and aluminium.The selection of different material is based on the simple decision matrix with consideration of requirement like light weight, rigidity, corrosion and cheaper in cost. The criteria is made for the all three material with requirement it is found that the glass fiber is best suited with requirement.

Table 1.1 –Properties of Battery Tray Materials

Material	Density(g /cm^3)	Yield Strength (MPa)	Tensile Strength, (MPa)
Steel	7.86	200	300
Aluminum	2.71	275	295
Glass Fiber	1.50 ~ 1.57	269 ~ 448	280 ~ 810

4. DESIGN AND OPTIMIZATION

Nowadays, lots of quality definitions and requirements exist. One of them is defined as “fitness for purpose”. Furthermore, it is implied that final output involves process quality, which some attributes are robustness, flexibility and effectiveness [5].Therefore, design must be interactive to improve feature by making it robust, effective and flexible. To get the better quality, the battery tray must be designed and optimized according to the newly selected material properties by change its shape and dimensions so that the process leads to a stronger and a cheaper design and product that meet the quality recruitment. Three design drafts were considered for optimizing results. The following is the design for battery tray design.

- **The dimensions of battery i.e. to be mounted on the brackets are:**
  Length of battery = 210mm
  Width of battery = 125mm
  Height of the battery =190 mm
  Weight of the battery = 3 kg
- **The initial dimensions of the mounting bracket:**
  Length of bracket = 250 mm
  Width of the bracket = 140 mm
  Initial thickness = 3 mm (based on shear and bending stress)
  Guide Height= 20 mm

- **Loading Conditions:**
  The static load of the battery = 5 kg
  (Considering the maximum loading)
  Accelerated load =5*9.81=49.05 N

- **Total Area of Mounting Bracket**
  A=L*B=35000 mm^2

- **Volume of Bracket**

V=L *B*H =35000*20=700000 mm^3

- **Mass of bracket for Aluminum Material**
  Mass= density*volume=2800*700000=1.96 Kg

- **Mass of bracket for Glass fiber Material**
  1600*700000=1.12 Kg

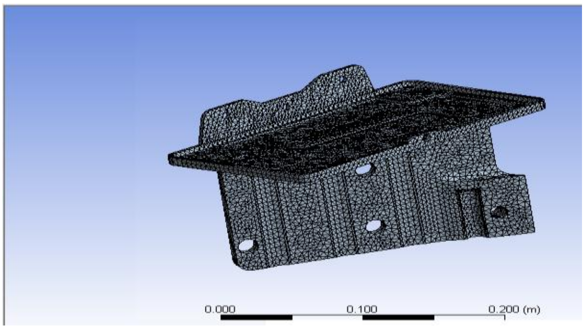

Fig.1.2 Meshing Model of battery Tray

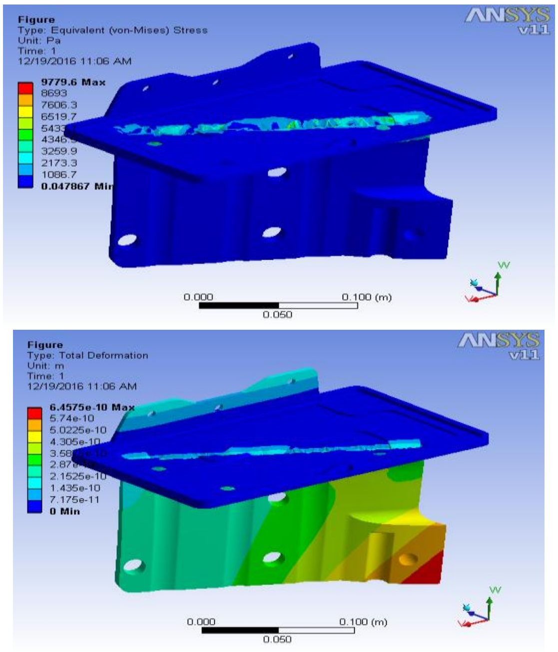

Fig.1.3 (a,b) Structural Analysis of Existing Material Battery Tray for 3.5 mm Thickness

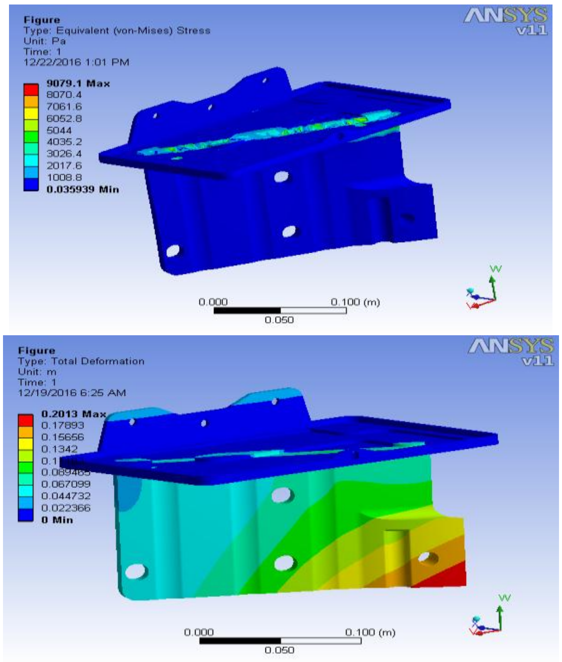

Fig.1.4 (a,b) Structural Analysis of Aluminium Material Battery Tray for 3.5 mm Thickness

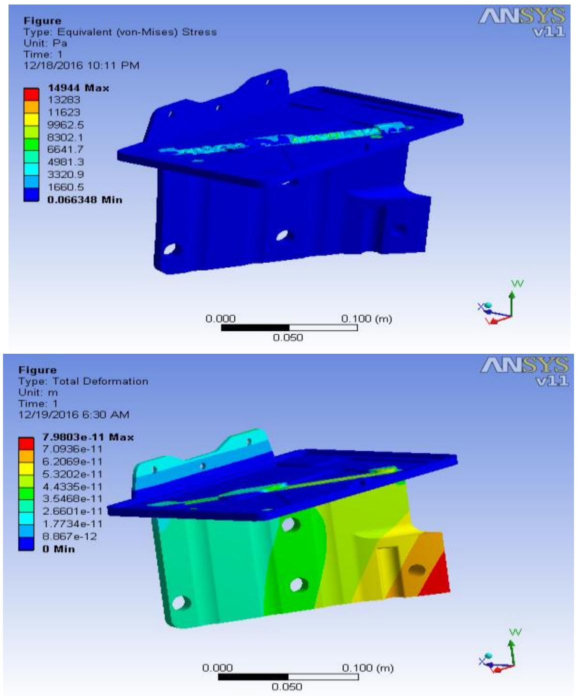

Fig.1.5 (a,b) Structural Analysis of Glass Fiber Material Battery Tray for 3.5 mm Thickness

Table.1.2: Results Summary of Structural Analysis of Battery Tray

Parameters	Cast Iron Battery Tray (Existing Tray Design 4.00mm)
Total Equivalent Stress (Pa)	9779.66
Total Deformation (mm)	6.4575
Aluminum Battery Tray with 3mm thickness (Optimize Design)	
Total Equivalent Stress	1443.6
Total Deformation	2.013
Aluminum Battery Tray with 3.5 mm thickness (Optimize Design)	
Total Equivalent Stress	9079
Total Deformation	0.8555
Glass Fiber Battery Tray with 3mm thickness (Optimize Design)	
Total Equivalent Stress	1002
Total Deformation	1.77e-9
Glass Fiber Battery Tray with 3.5 mm thickness (Optimize Design)	
Total Equivalent Stress	14994
Total Deformation	7.99 e-11

The structural analysis of all three materials is shown in fig.1.3 to 1.5. From the structural analysis of different available results, it is clear that the aluminum and glass fiber shows good material properties than cast iron and can best alternative for replacing existing materials of battery tray in the future.

5. CONCLUSION

In the present study, design and optimization of battery tray is performed with the aim to reduced the weight and improve strength of battery tray. As a first step the effect of different configurations of battery tray are considered with respect to thickness.

a. Initially the design of battery bracket is carried out for the existing dimension and thickness. The thickness in the initial case for existing geometry was 4 mm and for minimizing the weight the two different thicknesses are considered. It is clear from the present study the glass fiber with thickness of 3 mm can withstand with loading condition and later on the aluminum also shows the good results.
b. The stress on the battery tray shows more for exiting design with thickness of 4 mm, while the aluminum and glass material shows less amount stress induced with the impacted load of battery with reducing in the thickness.
c. The deformation for the cast iron is found to be maximum comparatively with aluminum and glass fiber material. The glass fiber shows minimum deformation with thickness of 3 mm.
d. The results obtained computationally with used of ANSYS software is good matches with analytical results. It is clear from the research study the methods applied for optimizing the battery tray is helpful for predicting nature of automotive components through FEA approaches.
e. The glass will be best alternative for existing material cast iron. The glass fiber with thickness of 3.5mm gives the best result comparatively with aluminum and cast iron.

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