Vibration Fatigue Analysis of Sheet Metal Fender Mounting Bracket &
It's Subsequent Replacement With Plastic

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Abstract

With the increasing need for improved vehicle fuel economy, the automotive industry is optimizing designs to reduce vehicle body weight by means of thickness reduction of frame/body panels and use of alternative materials. However, modified design must meet several performance criteria including stiffness, strength and fatigue life requirements.

This paper describes an investigation of the suitability of FE analysis as a means to determine the stiffness and fatigue life of load carrying member. This investigation is carried out in two parts - Virtual Simulation and Physical Test. The test is carried out on the front fender mounting bracket of a scooter. Two sets of CAE simulations were carried out.

In the first set, sheet metal bracket is validated for the vibration fatigue strength analysis with design improvements using Altair Hyper works tools like Radioss, OptiStruct etc. Then, the equivalent stress history is extracted using the modal transient response analysis which can be easily used in FEMFAT TRANSMAX application for further life estimation.

In the second set, the fender mounting bracket made-up of plastic is used for the analysis which gives weight reduction of 0.12kg. Thus Concept level Design Optimisation is achieved. Also, we are able to meet the strength and life requirements with the application of plastic. The physical test validation results are also comparable with simulation technique. It gives the benefits of Light-weighting, eliminating secondary operations and corrosion resistance making it more durable.

Keywords: Vibration Fatigue, Fender, Plastic, Scooter.
Introduction

The automotive industry is poised to make the lightweight designs to get the cost and weight benefit along with customer delight. So main emphasis is given on the thickness reduction of frame/body panels and use of alternative materials. In this regard, our intention is substitute the metal bracket of fender mounting into the plastic one. In this paper, our main objective is to investigate the fatigue life of the fender mounting bracket under the shaker table test conditions & replacement of the metal bracket into the plastic one. This is very challenging initiative as this bracket is main load carrying member of the front fender.

The following Figure 1 shows the front fender assembly & Figure 2 shows the Sheet Metal Design of fender mounting bracket having material CRCA GR.D.

Process Methodology

With this Sheet Metal Design following parameters are evaluated & subsequently compared for the new proposals and plastic design of bracket.

1) Stiffness Analysis
2) Durability Analysis

The approach used for the above mentioned parameters is mentioned below,

1) Stiffness Analysis

Figure 3: Load Application points of stiffness test
Main objective is to check the assembly for deformation when it is subjected to external load of 60N on fender as shown in Figure. This is to ensure the subsequent plastic bracket design does not look flimsy or delicate.
2) Durability Analysis

It is performed as per JIS D1601 test standard for the Front fender assembly. Test specifications are as mentioned below:

1) Freq. 20-150-20 Hz,
2) 6 min./ sweep
3) 4.4‘g’ constant acceleration.

Fender mounting bracket is validated for the vibration fatigue strength analysis. The stress history against time is extracted using the direct transient response analysis for a one cycle time of 6min. It can be easily used in FEMFAT TRANSMAX application for further life estimation.
Results & Discussions

1) **Stiffness analysis:**

The deformation of mounting bracket is shown in *Figure 7* (Sheet Metal Design) and *Figure 8* (*Plastic Design*). This is to ensure the subsequent plastic bracket design does not look flimsy as compared to metal design.

**Figure 6:** Load Application points stiffness test

**Figure 7:** Deformation plots for Mid portion Load of Metal Bkt Design

Max. Disp. = 2.8mm

**Figure 8:** Deformation plots for Mid portion Load of Plastic Design

Max. Disp. = 4.07mm
The strain energy plots are shown in Figure 9 in which it is suggested to update the section in order to improve the stiffness of the proposed plastic fender bracket. The deformation of plastic mounting bracket is shown in Figure 10.

Results summary:

Table I clearly shows that displacement in plastic bracket is at par with the metal one.

<table>
<thead>
<tr>
<th>S.N</th>
<th>Load (60N) Application Region</th>
<th>Displacement in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Front Fender</td>
</tr>
<tr>
<td>1</td>
<td>Top</td>
<td>4.46</td>
</tr>
<tr>
<td>2</td>
<td>Mid (Critical)</td>
<td>7.09</td>
</tr>
<tr>
<td>3</td>
<td>Front Face</td>
<td>7.06</td>
</tr>
</tbody>
</table>
2) Durability Analysis

a) Strength analysis of Sheet Metal Bracket

As shown in Figure 11, in vibration test the max induced stresses are within the acceptance limit at peak frequency of 53Hz.

Test Observations:-
No failure is observed in mudguard mounting bracket with sheet metal design. (10hrs completed)
b) **Strength analysis of Plastic Design**

As shown in Figure 12, in vibration test the induced stresses are well within the acceptance limit at peak frequency of 31Hz.

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**Figure 13:** von Mises Stress plots of Plastic Design

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**Figure 14:** Test photograph of Plastic Design

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Test Observations:-

No failure is observed in mudguard mounting bracket with plastic design. (10hrs completed)
Fatigue life plots are shown for the various designs as given below,

a) Sheet Metal Design:

For the shaker table test conditions, the estimated life of fender mounting bracket with sheet metal design is $4.23 \times 10^6$ cycles.

![Figure 15: Life plots of Sheet Metal Design](image)

b) Plastic Design:

For the shaker table test conditions, the estimated life of fender mounting bracket with plastic design is $1.38 \times 10^9$ cycles.

![Figure 16: Life plots of Plastic Design](image)
Results Summary:

*Table II* clearly shows that Plastic design not only gives the benefits of Light-weighting but also it is it more durable.

**Table - II: Fatigue Life summary of fender mounting bracket**

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Design Details</th>
<th>Life</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CAE Simulation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(No of cycles)</td>
</tr>
<tr>
<td>1</td>
<td>Sheet Metal Design</td>
<td>4.23E+06</td>
</tr>
<tr>
<td>2</td>
<td>Plastic Bracket Design</td>
<td>1.39E+09</td>
</tr>
</tbody>
</table>

**Benefits Summary**

The fender mounting bracket made-up of plastic is used for the analysis which gives weight reduction of 0.12kg. Thus concept level Design Optimisation is achieved satisfying the stiffness and durability requirements with the application of plastic. It gives the benefits of Light-weighting, eliminating secondary operations and corrosion resistance making it more durable.

**Conclusions**

Based on results of this study, the fender mounting bracket can be easily replaced with plastic without any detrimental effect on the basic characteristics like stiffness and strength of the bracket. Plastic design not only gives the benefits of Light-weighting, eliminating secondary operations but also it is it more durable as the estimated life of fender mounting bracket with metal design is 4.23E+06 cycles whereas life with plastic design is 1.38E+09 cycles. The physical test validation results are also comparable with simulation technique.

Hence, there is huge scope to explore the possibility of replacement of metals into plastics.

**Future Plans**

The approach used in this current application is direct transient response analysis, it can be further extended to modal superposition technique in which the mode shapes are typically computed as part of the characterization of the structure as modal transient response is a natural extension of a normal modes analysis. This will be more cost efficient to apply in the complete plastic panels of the vehicle.

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REFERENCES


