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Virtual Testing of Plastic-Based Composite Shelf Comp, Tray by Using FEA Method

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Abstract

Increasing competition and innovation in the automobile sector tend to modify the existing products with new advanced plastic-based composite materials. In the present work, Shelf Parcel Tray used in passenger cars is replaced with a composite Shelf Parcel Tray made of a plastic-based composite. The Shelf Parcel Tray is the shelf inside the car, behind the rear seats. The Main Application of Using a Shelf Parcel Tray is to have lightweight items on it.

This paper presents a finite element procedure for the analysis of the fully coupled thermo-elastic-plastic response of Plastic-Based Composite and compares the results with conventional Shelf Parcel Trays under Extreme Thermal and mechanical loading Conditions. Evaluate the Factors like resilience, damage, and thermomechanical response are plotted for the composite Shelf Parcel Tray and the resilience performance is predicted using stress and strain data. Therefore, the objective of this paper is to present a design and validate the design via a simulation study on the durability performance of plastic-based composite Shelf Parcel Tray through the finite element method.

The reliability of the validation methods is based on FEA simulation and correlation with lab experimental data.

Introduction

The Shelf parcel tray is the shelf inside your car, on the Back side of the rear seats. It is usually removed and it is used to store some lightweight items. The shelf parcel tray also supports and installs the rear speakers. The shelf parcel is capable to store the speaker's weight.

The shape and size of Shelf parcel trays change according to car model. Mostly shelf parcel trays made of thick cardboard with fabric cover. The shelf parcel tray divides the boot and passenger area into two parts.

A Shelf parcel tray help to cover your bags from simple sight. It is also helpful to store lightweight items and equipment and protect the luggage bag and items from direct sunlight and heat. In India, most Vehicle users use the Shelf parcel tray for storing items such as tissue boxes, tender toys, and cushions.

In the starting manufacturing not using PP composite for the Shelf parcel tray. They use common PP material. But the weight of the vehicle increases due to using Polypropylene. After a few year's the manufacturer start using pp composite for Shelf parcel trays. The current FEA and Experimental study check the strength and durability of pp composite by using ANSYS and experimental method. The different types of PP composite available in the market. In our study-specific type of mix, PP composite was used for the Shelf parcel tray.

Working on shelf parcel tray

The Shelf parcel tray typically sits on dedicated panels with grooves on either side of the boot. Most sedans offer non-detachable shelf parcel trays. Generally, Shelf parcel trays are used to mount Speaker grilles and Centre high mounted stop lights.

Some cars like hatchbacks and SUVs Provide shelf parcel trays with springs attached to the boot lid. This type of shelf parcel tray swings during the boot is opened. The loading capacity of a shelf parcel tray with spring is better than another type of parcel tray and is also capable to store tall items such as a large briefcase.

Conversely, some SUVs with large trunks offer a polyester cover that keeps items in the trunk and out of sight. These covers are rolled onto a pole just behind the rear seats. With this configuration, you can hide the luggage by pulling the lid backward and hooking it into the available grooves or slots in the trunk. Such blankets cannot support much weight. Therefore, they only hide your luggage and protect it from direct sunlight.

Demerits and Merits of shelf parcel tray

The Merits of a shelf parcel tray are:

- The shelf parcel tray provides storage space for small items.
- The shelf parcel tray divides the passenger area and boot area into two parts.
- It provides good space for a speaker and amplifier.

The Shelf parcel tray has the following Demerits:

- Poorly made luggage trays will sag over time or break if you use them as a shelf.
- Shelf parcel tray made of nonsound-absorbing material Can cause of noise when riding.
- Shelf parcel tray May affect the loading and unloading of luggage.

Methodology

Material and Methodology

In this study, Check the durability of the shelf parcel tray by using the experimental method and FEA method.

Experimental Procedure

For the Experimental setup equivalent fixture was designed according to vehicle design. The experimental setup performs in serval steps.

In this first setup install the shelf parcel tray on the fixture properly. And mount strain sensors at 7 locations for check deflection and 7 locations. Figure. 1 show the white color structure is a fixture for the experimental setup. [1]

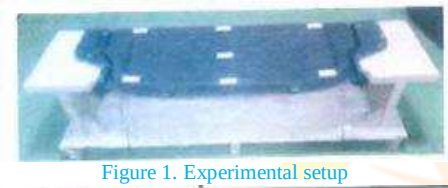

Figure 1. Experimental setup

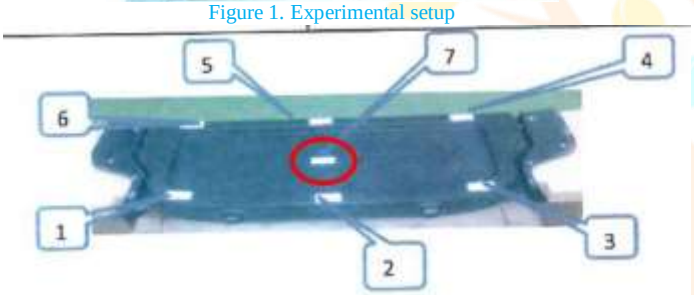

Figure 2. Stain Sensors locations

Strain sensors are used for measuring stress, torque, pressure, deflection, and many other measurements. in the study 7 stain sensors are used for calculating displacement and stress.

In the second step measure initial height without load. And check all sensors and gaps and tolerances.
After checking the experimental setup then apply an 80N load (according to customer spec.) on the shelf parcel tray at the center of the shelf parcel tray shown in figure 3.

In the final step measure deflection on the center and check the test requirement. The experiment was done on a number of parts for accuracy. After a number of experiments calculated the correlation factor.

Figure.3: Load location

FEA simulation Methodology

For FEA simulation using ANSYS Workbench R21 and for CAD model NX. In this study Two type of test was performed. In the test first load apply at Centre position of the shelf parcel tray. And in test second load 80N at Centre of rear edge of the shelf parcel tray.

First developed CAD model for FEA analysis's import cad model in ANSYS work bench.

Figure.4: CAD MODEL FOR FEA.

In the second step developed FEA model by using the NX cad model. For any type of FEA analysis, Meshing is required. Discretization is a process to develop the FEA model. The Shelf parcel tray body by dividing it into 248314 elements and 123959 Nodes shown in figure: 5. [2]

Figure.5: FEA Model (Node:248314, Element:123959)

After completing the meshing process. Then apply material and loading conditions. For FEA analysis PP composite was used.
The tensile yield of the PP Composite is 24.73Mpa. And allowable stress is 20.6Mpa.

Table 1. PP Composite Mechanical Properties [6]

PP Composite Mechanical Properties	
Density	0.97 kg/m3
Flexural strength	24.77 Mpa
Tensile Yield	24.73Mpa

Third step of study apply 80N load at the center of the shelf parcel tray for durability test shown in figure.6.

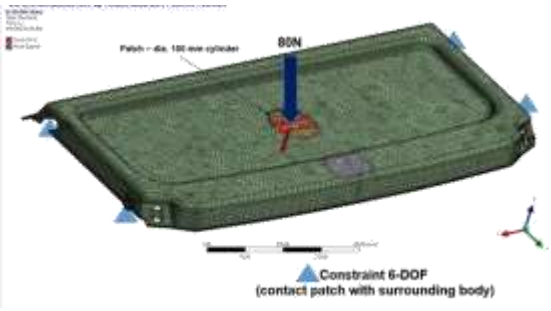

Figure.6: FEA Model (Node:248314, Element:123959)

In the figure.6 the blue triangle shows the constrain. The Shelf parcel tray body fixed at these four locations for durability test.

Results

In the current study brittle material was used for shelf parcel tray. Therefore, the maximum principal stress theory is a suitable approach for predicting the failure of brittle materials under tensile loads.
Figure 7 and figure 9 show the maximum displacement and figure 8 and figure 10 show maximum principle stress.

1.1 CAE Simulation at Load 80N : Centre Position : Displacement Plot:

The Maximum displacement show in the figure:7. The red color show maximum displacement area and blue color show minimum displacement area. The maximum displacement absorbs on center of shelf parcel tray.

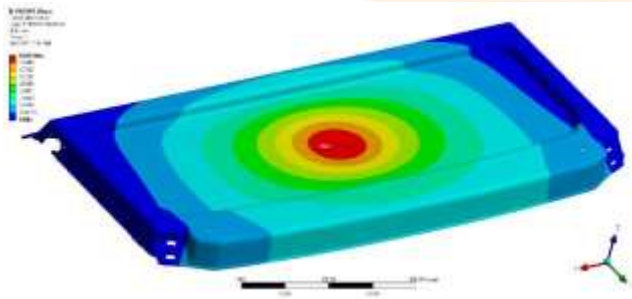

Figure.7: Test first Displacement plot

1.2 CAE Simulation Set-up at Load 80N: Centre Position : Stress Plot

The Maximum Stress show in the figure:8. The red color show maximum stress area and blue color show minimum stress area. The maximum stress absorbs near mounting area of shelf parcel tray,

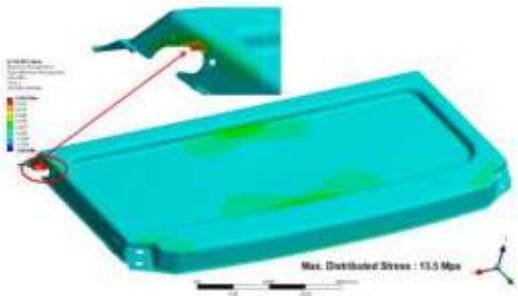

Figure.8: Test first Stress plot

1.3 CAE Simulation Set-up at Load 80N: Rear Centre Edge Position: Displacement Plot

In this case 100N load applied on rear Centre edge of shelf parcel tray. The maximum deformation absorbs on rear center edge of shelf parcel tray. The deformation value approx. 7.60mm.

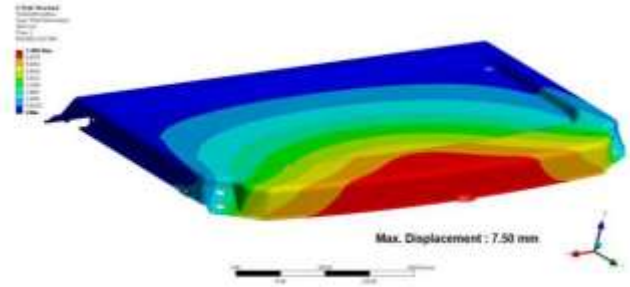

Figure.9: Test Second Displacement plot

1.4 CAE Simulation Set-up at Load 100N: Rear Centre Edge Position: Stress Plot:

In this case 100N load (According to customer spec.) applied on rear Centre edge of shelf parcel tray.
The maximum Stress absorbs on rear mooting area of shelf parcel tray. The Maximum Stress value approx. 9.80MPa

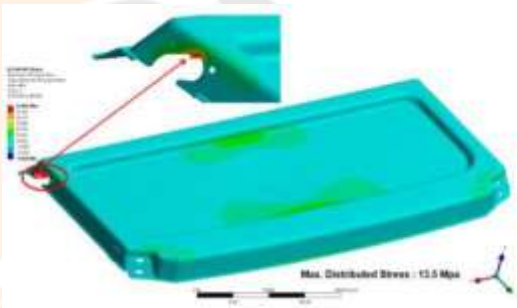

Figure 10: Test Second Stress plot

Table 2. Observation Table –Shelf Parcel Tray 20mm

Load Case	Load by dia. 100mm cylinder		Correlation Factor
	Centre Position	Centre of Rear Edge Position	
FEA Principle Stress (Mpa)	13.6	9.80	As per the correlation factor from shelf parcel Tray FEA Report for actualization a factor of 0.855 is used in CAE results.
Experimental Principle Stress (Mpa)	11.63	8.38	
FEA Maximum Displacement (mm)	8.68	7.60	
Experimental Maximum Displacement (mm)	7.42	6.50	
Tensile Strength (Mpa)	24.73		

Required Factor of Safety	1.2		
Factor of Safety	1.81	2.52	
Comments	Safe	Safe	

1.5 CAE Simulation Graph:

The below figure11. show the displacement comparison between experimental results vs FEA Results in Test first.
In Test first, the Experimental displacement value was 8.68mm and the FFA displacement value was 7.42mm.

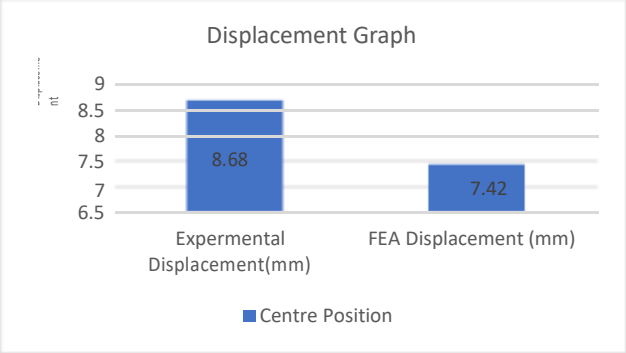

Figure.11: Test first Displacement Graph.

The below figure12. show the displacement comparison between experimental results vs FEA Results in Test first.
In Test second, the Experimental displacement value was 7.6mm and FFA displacement value was 6.5mm.

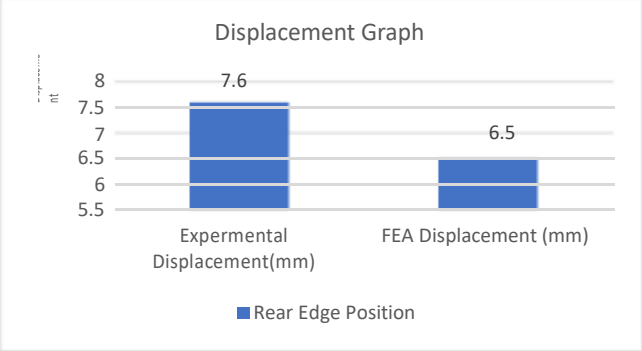

Figure.12: Test Second Displacement Graph.

The below figure13. show the Stress comparison between experimental results vs FEA Results in Test first.
In Test first, the Experimental stress value was 11.63Mpa and FFA displacement value was 13.6Mpa.

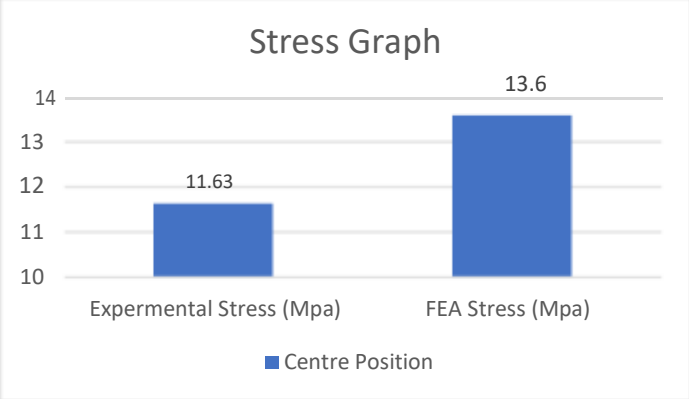

Figure.13: Test first center loading stress graph

The below figure14. show the Stress comparison between experimental results vs FEA Results in Test first.
In Test second, the Experimental stress value was 8.38Mpa and FFA displacement value was 9.8Mpa.

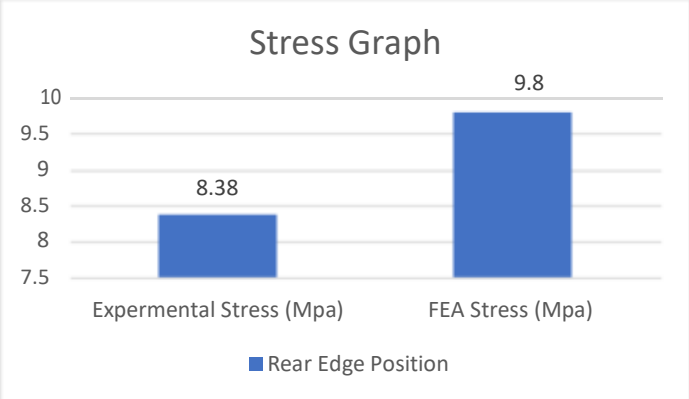

Figure.14: Test second rear center loading stress graph

Conclusion

The finite element analysis was used to simulate the durability test of the shelf parcel tray, and the stress distributions at the mounting area of the shelf parcel tray were obtained. The following conclusions are summarized.
(1) The finite element analysis was verified to effectively simulate the durability test of the shelf parcel tray.
(2) Both the model and experimental model and the FEA model show a 0.85 correlation factor.
(3) The maximum stress obtained near the mounting area of the shelf parcel tray. The stress value was lower than the allowable stress value.
be taken into consideration to correct the simulation results.
(4) deformation value was lower than the allowable defamation value. The shelf parcel tray passes at both tests.

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