



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 7, July 2023

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

 9940 572 462

 6381 907 438

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 www.ijirset.com

To Examine the Effectiveness of Existing Component of Front End Module of Vehicle under Front Impact Loading Condition and Stress Scenarios by FEA Analysis

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ABSTRACT: Front-end modules of vehicles play a crucial role in ensuring passenger safety during impact events. This study aims To Examine The Effectiveness Of the existing front-end module of a vehicle under various impact loading conditions and stress situations utilizing FEA (Finite Element Analysis) techniques. The analysis focuses on understanding the structural behavior, stress distribution, and deformation patterns of the front-end module when subjected to different impact scenarios, such as frontal collisions and pedestrian impacts. The first step involves developing a detailed three-dimensional model of the front-end module using CAD software. The material properties, boundary conditions, and loading parameters are defined based on real-world conditions and regulatory standards. Subsequently, FEA simulations are performed to subject the model to various impact scenarios with different magnitudes and directions of forces. Afterward, the simulation results are examined to determine structural integrity and identify potential failure areas in the front-end module. The findings from this FEA analysis will aid in enhancing the safety and reliability of the vehicle's front-end module. By identifying critical stress areas and potential failure points, Engineers are capable of making wise choices to improve the module's design and material selection, ultimately leading to better occupant protection and reduced repair costs after collision.

KEYWORDS: vehicle Front end Module, FEA, stress distribution, CAD software.

I. INTRODUCTION

Plastic/Metal Hybrid technology was conceived in the late 1980s. The name of this technology is taken from the Greek word "hybrid", which refers to the differing origin and properties of the materials. Utilizing our expertise, General Motors developed a prototype instrument panel support structure. Today, automobile companies such as Audi, Ford, and Nissan use LANXESS Plastic/Metal Hybrid technology for the construction of parts ranging from front-end structures to seating and more. It provides strength, rigidity, and energy absorption with weight reduction for fuel efficiency.

The front-end modules were mostly designed and fabricated with heavy steel materials. However, in recent years, lightweight composite materials, like polypropylene, glass mat thermoplastic, long fiber thermoplastic (LFT), direct LFT aluminum, etc. are used in manufacturing front-end modules. The demand for lightweight materials from automakers has significantly increased over the decade, owing to the enactment of stringent emission standards. As lightweight auto parts decrease the general weight of the vehicles, it can, in turn, reduce CO₂ emissions and cost. Experimenting with front-end module materials in auto parts has predominately contributed to achieving 20%-30% of vehicle weight reduction.

To make cars, the automotive industry requires a huge variety of materials, including copper, steel, glass, rubber, aluminum, steel, and many others. Over the years, these materials have undergone significant development, improving in sophistication, quality of construction, and safety. They have evolved as more cutting-edge methods of using them have been developed throughout time in the automotive manufacturing industry. The introduction and use of contemporary materials in the automotive industry are the focus of this article, which is devoted to organizing information on such topics.

As relatively novel materials, composites currently lack a widely acknowledged definition.

By combining two or more different materials, composites are created. While the compound exhibits entirely new qualities and properties, their basic elements each have their own unique traits material. This substance's peculiar, novel, and distinctive characteristics relate to constitutive elements. This material compounding's purpose is to enhance structural, chemical, thermal, tribological, or other material characteristics. Constitutive elements don't mixing and dissolving one another, resulting in the presence of two or more phases in the composite. material.



Fig. Front end Module of Vehicle

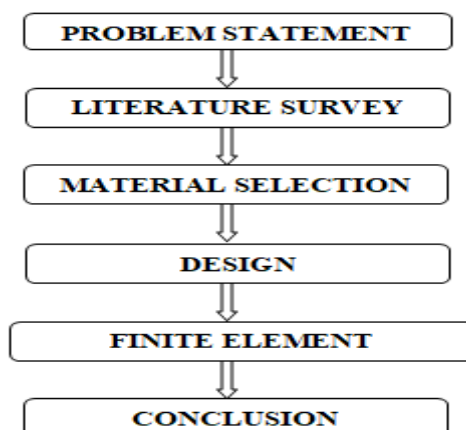
II. PROBLEM STATEMENT

The auto industry has consistently been striving to improve vehicle performance, fuel efficiency, and safety while reducing overall weight and manufacturing costs. One promising approach is the integration of metal-plastic hybrid components in various parts of the vehicle. Metal-plastic hybrids combine the strength and rigidity of metals with the lightweight and design flexibility of plastics. Nevertheless, there are still substantial challenges and uncertainties associated with the implementation of these hybrid materials in critical automotive applications.

III. OBJECTIVES

- To examine the effectiveness of existing component of front end module of vehicle under front impact loading condition
- Analyzing how metal-plastic hybrid components can enhance vehicle safety by absorbing impact forces better and minimizing injuries in case of accidents.

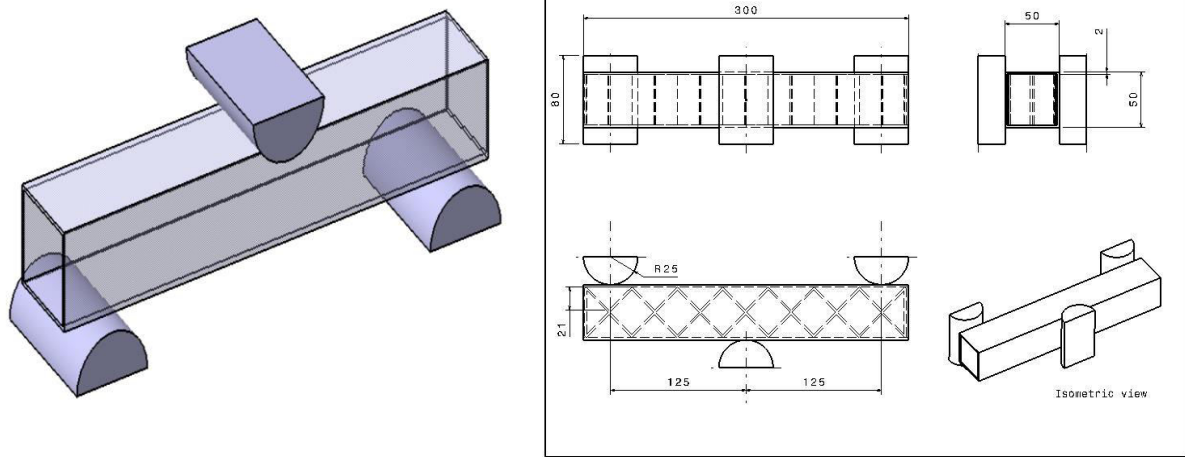
IV. METHODOLOGY



V. MATERIAL SELECTION

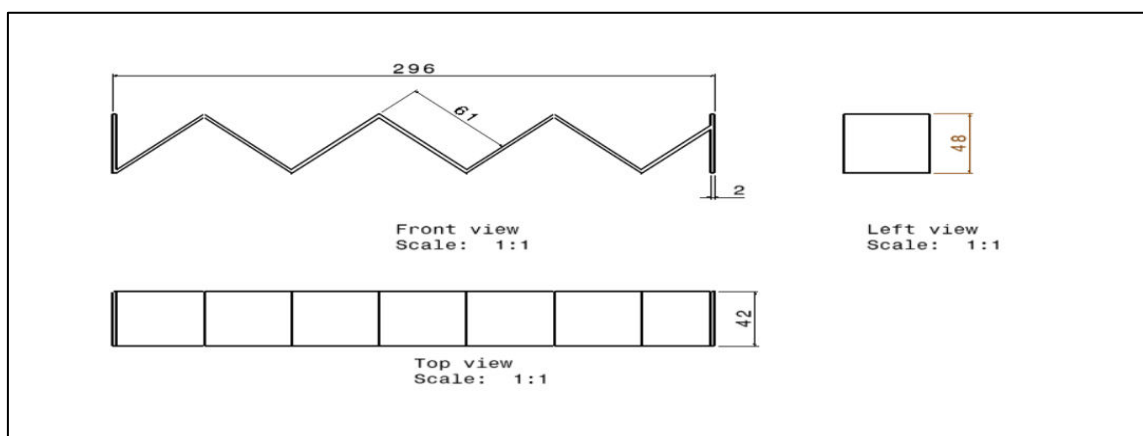
The use of metal-plastic hybrids presents an attractive solution to achieve these objectives. This material section outlines the selection, properties, and experimental methodology for investigating metal-plastic hybrids in the automobile industry. For our study the specimen which is existing component of vehicle is made up of structural steel having properties density 7850 kg/m^3 , Young' modulus $2 \times 10^{11} \text{ pa}$, poisson's ratio 0.3, bulk modulus $1.66 \times 10^{11} \text{ pa}$, shear modulus $1.69 \times 10^{11} \text{ pa}$. The plastic material which we have selected is of ABS material. Purpose of choosing ABS for plastic structure which will be reinforced in existing component is, it utilized in 3D printing technology. Having properties density 1040 kg/m^3 , Young' modulus $2.39 \times 10^{11} \text{ pa}$, poisson's ratio 0.39, bulk modulus $3.94 \times 10^{11} \text{ pa}$, shear modulus $8.54 \times 10^{11} \text{ pa}$.

VI. DESIGN



Design and Drafting of Existing component

In design we have designed base component which having dimensions as given in figure. Accordingly we have designed the zig-zag structure for the existing component for recommendation.



Design of zig-zag structure

VII. FINITE ELEMENT ANALYSIS

1. Pre-processing: In pre-processing we have to supply information for study of both the structures. First step is to provide material details. As discussed above the material of specimen or existing component is structural

steel and the plastic component which is to be made is of ABS material. The properties of both the material are already available in software. For design purpose we are using CATIA V5 and for FEA we are using Ansys software.

- After providing material details next step is to import the geometry from existing folder in Ansys. After importing geometry and meshing the same we have to apply boundary conditions. Then ansys workbench is ready to analyze the given component for given boundary conditions. The inputs and results of the analysis is shown in following screenshots which are taken from ansys software.

Properties of Outline Row 3: ABS				Properties of Outline Row 4: Structural Steel			
	A	B	C		A	B	C
1	Property	Value	Unit	1	Property	Value	Unit
2	Material Field Variables	Table		2	Material Field Variables	Table	
3	Density	1040	kg m ⁻³	3	Density	7850	kg m ⁻³
4	Isotropic Elasticity			4	Isotropic Elasticity		
5	Derive from	Young's Modulus and Po...		5	Derive from	Young's Modulus and Poisso...	
6	Young's Modulus	2.39E+09	Pa	6	Young's Modulus	2E+11	Pa
7	Poisson's Ratio	0.399		7	Poisson's Ratio	0.3	
8	Bulk Modulus	3.9439E+09	Pa	8	Bulk Modulus	1.6667E+11	Pa
9	Shear Modulus	8.5418E+08	Pa	9	Shear Modulus	7.6923E+10	Pa
				10	Specific Heat, C _p	434	J kg ⁻¹ C ⁻¹

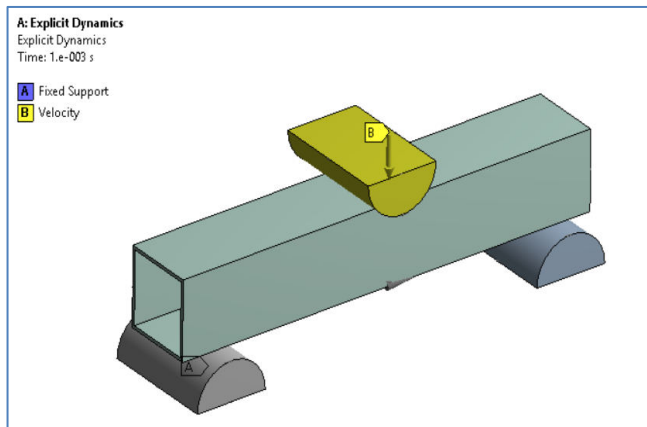
Material properties for structural steel

Material properties for plastic



Statistics	
<input type="checkbox"/> Nodes	72288
<input type="checkbox"/> Elements	52680

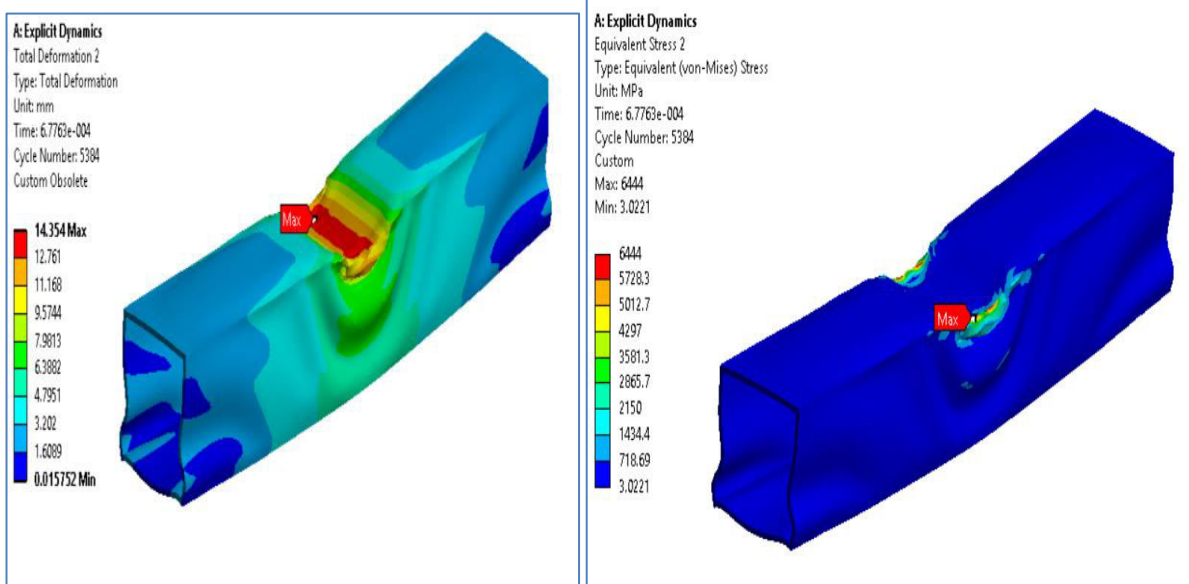
Meshing details



Details of "Velocity"	
Scope	
Scoping Method	Geometry Selection
Geometry	1 Body
Definition	
Type	Velocity
Define By	Components
Coordinate System	Global Coordinate System
<input type="checkbox"/> X Component	0. m/s (step applied)
<input type="checkbox"/> Y Component	-17.777 m/s (step applied)
<input type="checkbox"/> Z Component	0. m/s (step applied)
Suppressed	No

Boundary condition

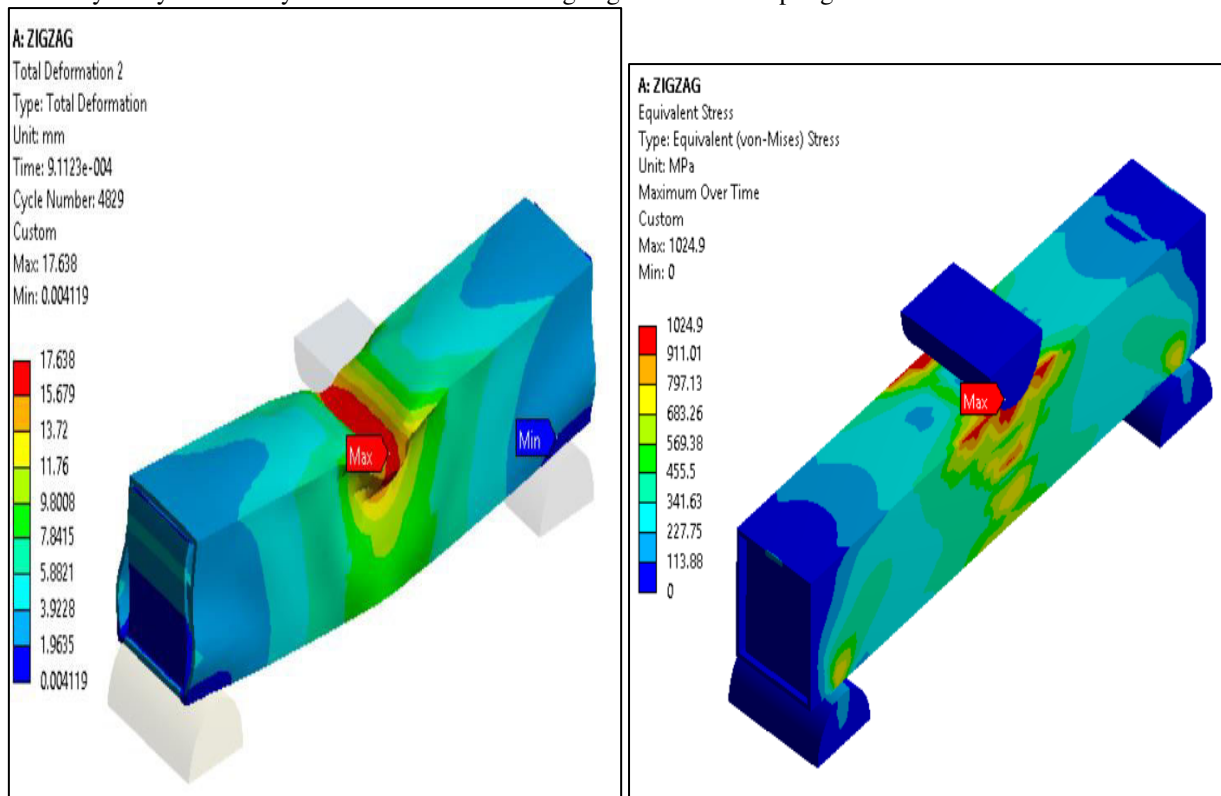
As per Global NCAP crash test, the average speed of car during crash is 35 to 40 miles per hrs. So we convert this velocity to m per s and applied boundary condition. Also we have gave the two supports at two ends of the object.



Total deformation of specimen

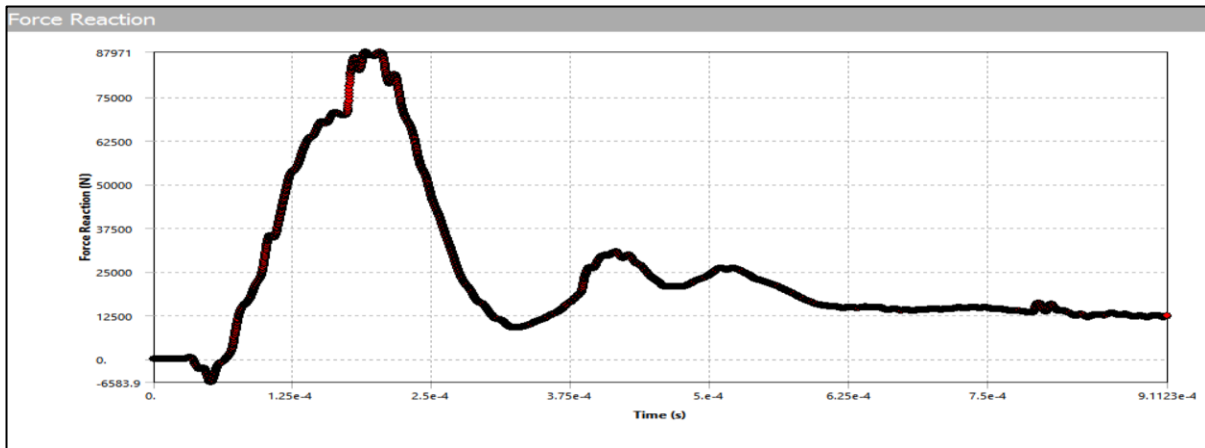
Equivalent stress on specimen

For similar boundary condition and procedure the we can also investigate the zig zag structure. Firstly the plastic zig zag structure is assembled with given specimen for our analysis purpose and geometry is prepared using CATIA V5 followed by analysis on Ansys. The outcomes of the zig zag structure is as per given below



Total deformation of Zig zag structure

Equivalent stress on Zig zag structure



Force reaction at fixed support

VIII. CONCLUSION

Sr. No.	Type of Structure	Deformation	Max. equivalent Stress
1	SPECIMEN STRUCTURE	14.35 mm	6444 Mpa
2	ZIG ZAG	17.63mm	1020.9 Mpa

- After investigating the performance of existing component in FEA at impact of 17.77 m/s the maximum stress induced in component is 6444 MPa and deformation is 14.354mm. the stresses induced in existing components consist of more than hybrid components.
- We also investigate the zig zag structure reinforced with existing component the maximum deformation of after impact is 17.63mm and maximum equivalent stress is 1020.9Mpa. Hence the zig-zag structure made of plastic enhance the strength of existing component.

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Impact Factor: 8.423



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