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DESIGN AND STRUCTURAL ANALYSIS OF GOODS VEHICLE CHASSIS FRAME BY USING COMPOSITE MATERIALS

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Abstract: The demand for efficient and sustainable transportation systems has prompted the exploration of innovative materials and design strategies for goods vehicle chassis. This research focuses on the integration of composite materials to optimize the structural performance of the chassis while simultaneously reducing its weight. The objective is to enhance fuel efficiency, decrease emissions, and improve overall vehicle performance. The study begins with an in-depth literature review, providing insights into the current state of goods vehicle chassis design, materials used, and the challenges faced in achieving weight reduction without compromising structural integrity. The research then proposes a comprehensive methodology that encompasses material selection, design optimization, and structural analysis. Composite materials, known for their high strength-to-weight ratio, are chosen for their potential to replace conventional steel in selected sections of the chassis. The material selection process involves considering various factors such as mechanical properties, cost, and manufacturing feasibility. Finite Element Analysis (FEA) is employed to simulate and evaluate the structural behaviour of the proposed composite chassis under different loading conditions, ensuring compliance with safety standards and regulations. Parametric studies are conducted to optimize the design parameters, including fiber orientation, layer stacking sequence, and thickness distribution. The results are compared with those of a traditional steel chassis to assess the weight reduction achieved and the impact on structural performance. The outcomes of this research contribute to the understanding of how composite materials can be effectively integrated into goods vehicle chassis design to achieve weight reduction without compromising safety and performance. The findings are expected to guide future developments in the design and manufacturing of lightweight and sustainable goods vehicle chassis, with potential applications in the broader automotive industry.

***IndexTerms* - Goods vehicle chassis, Composite materials, Automotive industry.**

I. INTRODUCTION

The automotive industry is constantly evolving with a primary focus on enhancing performance, fuel efficiency, and sustainability. In this context, the chassis of goods vehicles plays a crucial role in determining overall vehicle performance and efficiency. Traditional vehicle chassis are typically constructed using materials such as steel or aluminum, chosen for their strength and durability. However, advancements in materials science have opened up new possibilities for improving vehicle design through the incorporation of composite materials. Composite materials, which are combinations of two or more distinct materials, offer a unique set of properties that can be tailored to meet specific engineering requirements. These materials often exhibit superior strength to weight ratios, corrosion resistance, and design flexibility compared to traditional metals. By utilizing composites in the construction of goods vehicle chassis, it is possible to achieve significant weight reduction without compromising structural integrity. Tubular section frame chassis designs are commonly used in various applications, including off-road vehicles, racing cars, motorcycles, and even some bicycles. The choice of frame design depends on the specific requirements of the application, considering factors such as performance, safety, and manufacturability. A tubular section frame chassis refers to a type of chassis or frame structure used in vehicles, machines, or other structures, where the main structural elements are tubular sections. Tubular sections are hollow cylinders or tubes that are often made of materials such as steel or aluminum. These tubes are welded or otherwise connected to form a frame structure. A chassis is the framework that supports a vehicle's components and body. It provides structural strength and serves as the foundation for mounting various parts, including the engine, suspension, and body panels.

Fig.1 Conventional frame

II. PROBLEM IDENTIFICATION

The present study involves finding the best suitable material for existing goods vehicle chassis frame. The study of several literatures was many problems we are identified. It should be strong enough to uphold the low shock, twist, vibration and other stresses. Different parts of the chassis bear different kinds of loading, mainly tensile, compressive, shear and fatigue and therefore have tendency of failure. This is because of the fact that a single material/correction is not suitable with all kind of loadings. Different loadings can be encountered using either different materials or different corrections of materials. There should be a clear idea about the material selection process and application procedure for applying material in the frame. The material has to be selected on the basis of weight reduction criterion and various mechanical properties. The proper study of materials including mechanical properties like load carrying capacity, stress distribution, deformation have to be properly done. This project outlines weight reduction optimization and structural optimization of heavy vehicle chassis with constraints of maximum stress, strain and deflection of different chassis material. Our work is to design and analyze the heavy vehicle chassis to reduce weight and calculate stress-strain and deflection by testing the several materials. The transportation industry, particularly the goods vehicle sector, is under increasing pressure to enhance efficiency, reduce emissions, and improve overall performance. One critical aspect influencing these factors is the weight of the vehicle chassis. Traditional materials like steel, while robust, often contribute significantly to the overall weight of the vehicle, thereby impacting fuel efficiency and environmental sustainability. The objective of this project is to address the challenge of weight reduction in goods vehicle chassis by employing composite materials. Composite materials offer a promising alternative due to their high strength-to weight ratio, corrosion resistance, and customizable

2.1 Proposed model

CAD model of chassis was designed in SOLID WORKS and analysis was carried out in ANSYS workbench. Meshing was done in Hypermesh software by using Hexa and Tetra elements. 978684 numbers of elements were formed as fine meshing was used. Meshed file was imported in Ansys. The results of static structural and modal analysis were compared with original and modified model of chassis. A static structural analysis was used to calculate displacements, stresses, strains and forces in a structure due to the application of load. Here loading condition was assumed to take place in an equilibrium condition whereas load and structures response was varied with respect to time. Modal analysis was used to determine the vibrational characteristics of a structure. It calculates natural frequencies along with its mode shape. Natural frequencies and modes shape obtained in modal analysis were provided as input parameters for a transient and harmonic analysis. Static as well as dynamic analysis of frame was carried out by considering factor such as weight, velocity and road profile. The three materials are used as ASTM A710 (Steel), ASTM A302 (Alloy Steel), Aluminium alloy 6063-T6

III. PROCESS METHODOLOGY

This project aims to develop a methodology that encompasses the following key aspects: Material selection and characterization, Chassis design optimization, Meshing, Ansys, Manufacturability and cost analysis, Performance validation.

Evaluate various composite materials suitable for chassis application based on mechanical properties, durability, cost-effectiveness, and manufacturability. This involves understanding the behaviour of different composite types (e.g., carbon fiber, fibreglass) under loading conditions relevant to goods vehicle operation. Develop innovative design concepts that leverage the unique properties of composite materials to achieve weight reduction while meeting performance requirements. This includes exploring geometric configurations, joint designs, and load distribution strategies tailored to goods vehicle applications. Structural Analysis and Simulation utilize advanced computational tools such as finite element analysis (FEA) to simulate the behavior of composite chassis designs under various loading scenarios, including static, dynamic, and fatigue conditions. This analysis should assess stress distribution, deformation, and failure modes to ensure structural integrity and compliance with safety standards. Evaluate the practical feasibility of manufacturing composite chassis components at scale, considering factors such as molding techniques, assembly processes, and associated costs. The analysis should aim to identify opportunities for cost optimization and scalability without compromising quality. Conduct experimental testing and validation of the optimized composite chassis design to verify its performance characteristics under real-world conditions. This involves physical testing of prototypes to validate structural integrity, durability, and functional requirements such as load carrying capacity and stiffness.

3.1 Frame Calculation

Model - Tata super ace
Length of vehicle = 4340 mm
Width of vehicle = 1565 mm
Height of vehicle = 1858 mm
Wheelbase = 2380 mm
Track width = 1320 mm
Length of chassis = 4201 mm
Width of chassis = 808 mm
Dimensions of side bar = 100mm x 36mm x 5 mm
Dimensions of cross bar = 90 mm x 90 mm
Gross vehicle weight (G.V.W) = 2180 kg Kerb weight = 1180 kg

3.2 Design of Chassis Frame

After calculation of chassis frame, the sample chassis of goods vehicle mini truck frame is designed using SolidWorks software. The design procedure was based on creating a model, viewing it, assembling parts as required, and then generating any drawings which are required. The original chassis of Goods Vehicle is designed for structural analysis of steel frame. For Analyzing composite section, the chassis design is modified. Instead of original C-channel section ladder frame, rectangular box section type ladder chassis is designed. The dimensions of both side bars and cross bars of modified sections are kept same.

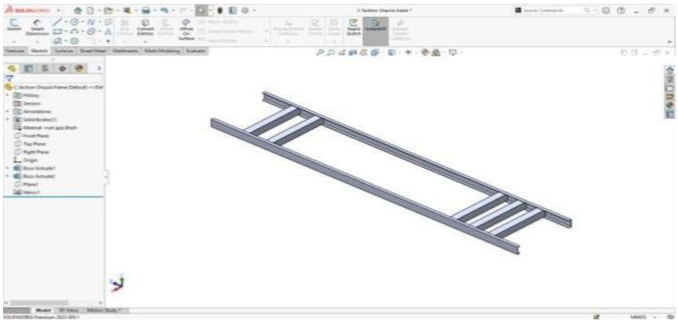

Fig.2 C-Section original chassis frame

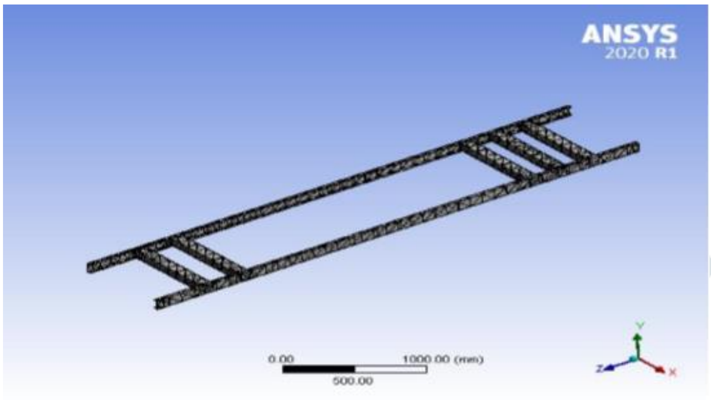

Fig.3 Mesh view of chassis

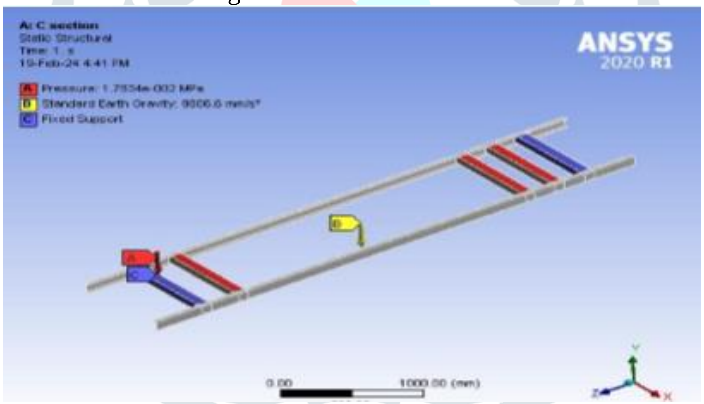

Fig.4 Boundary conditions

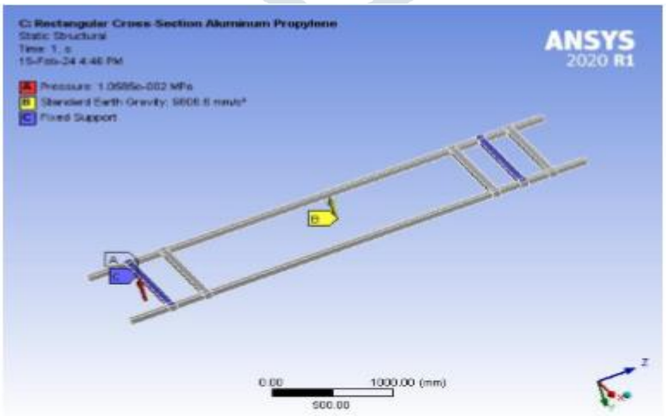

Fig.5 Equivalent stress in structural steel C-section chassis

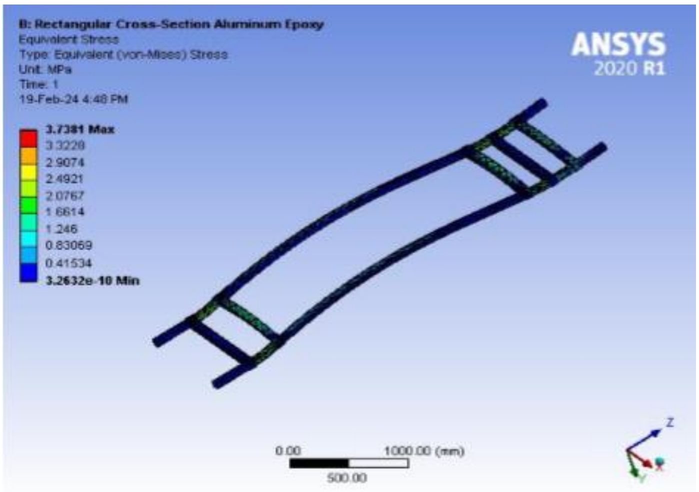

Fig.6 Equivalent stress in modified aluminum epoxy chassis

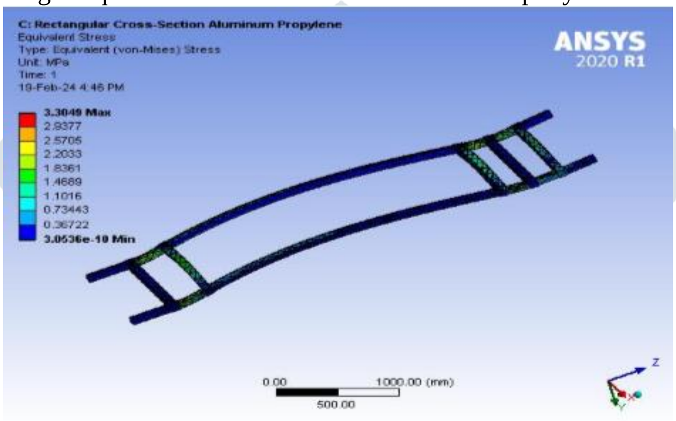

Fig.7 Equivalent stress in modified aluminum propylene chassis

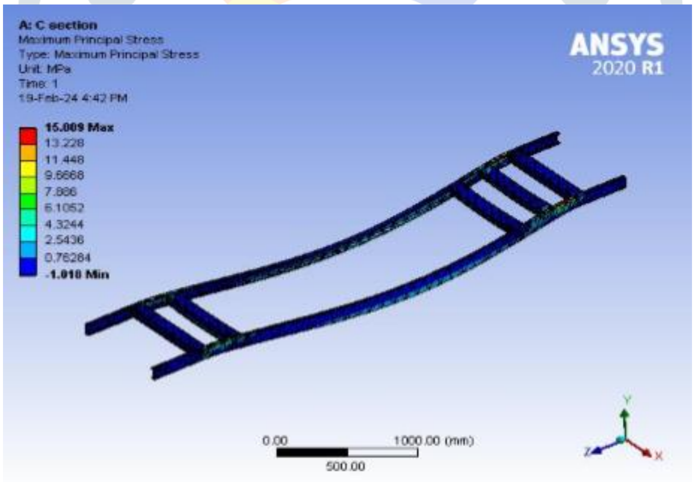

Fig.8 Maximum principal stress in structural steel C-section chassis

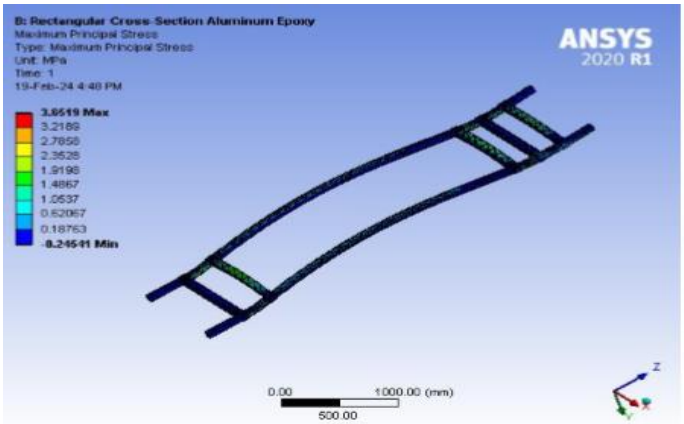

Fig.9 Maximum principal stress in modified aluminum epoxy chassis

Fig.10 Maximum principal stress in modified aluminum propylene chassis

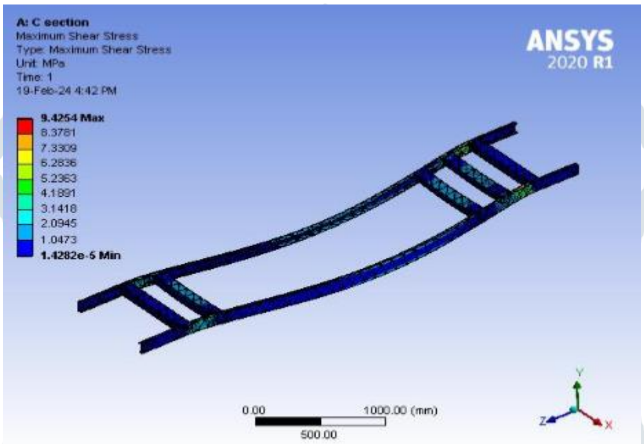

Fig.11 Maximum shear stress in structural steel C-section chassis

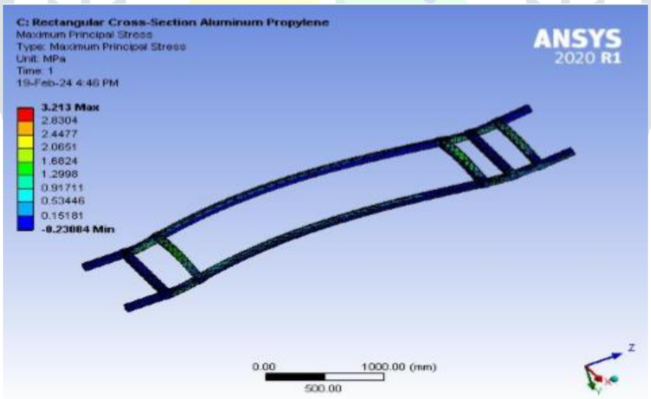

Fig.12 Maximum shear stress in modified aluminum epoxy chassis

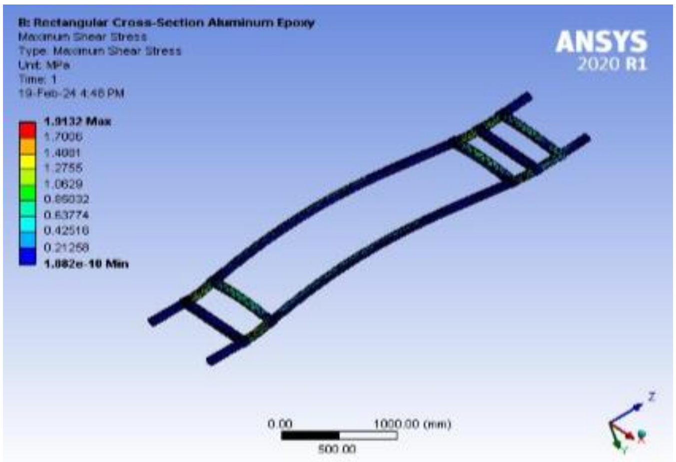

Fig.13 Maximum shear stress in modified aluminum propylene chassis

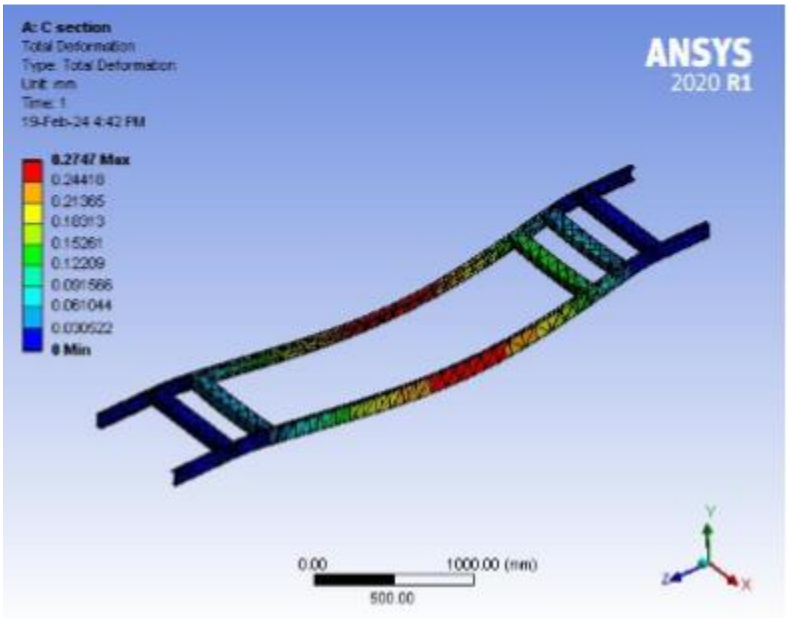

Fig.14 Total deformation in C-section steel chassis

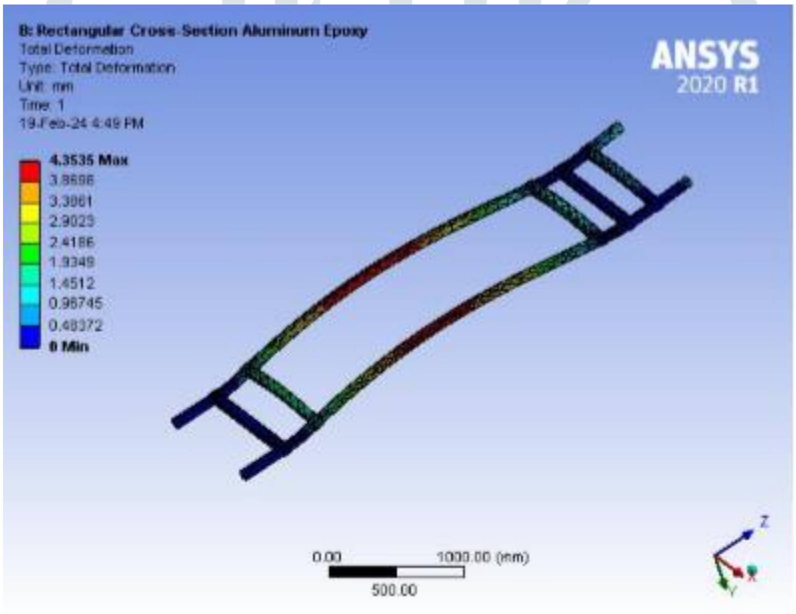

Fig.15 Total deformation in modified aluminum epoxy chassis

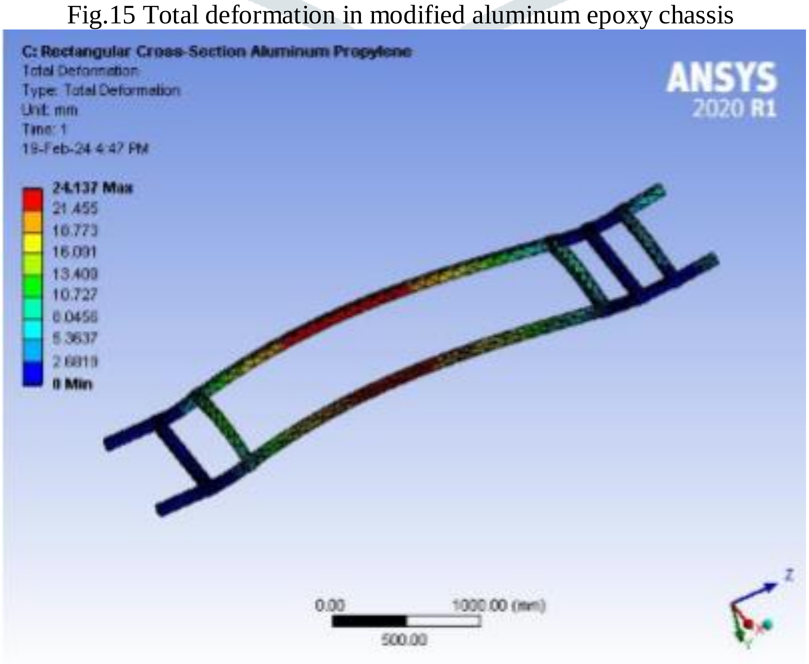

Fig.16Total deformation in modified aluminum polypropylene chassis

IV. RESULTS AND DISCUSSION

Discuss the structural analysis results of the original chassis design compared to the new composite material design. Highlight any improvements in strength, stiffness, or other relevant parameters. Present the weight reduction achieved with the composite material design compared to traditional materials like steel. Quantify the percentage reduction and discuss its implications for fuel efficiency, payload capacity, and overall vehicle performance.

Table 4.1: Result comparison table

Chassis	C-section	Aluminum Epoxy	Aluminum Polypropylene
Equivalent stress (MPa	18.689	3.732	3.3049
Maximum Principal Stress (MPa)	15.009	3.6519	3.213
Maximum Shear Stress (MPa)	9.4254	3.213	1.9132
Total Deformation (mm)	0.2747	4.3535	24.137

V. Acknowledgment

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