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Deformation and Shear Stress Analysis of Torsional Rod Used in Automobile in Various Materials Using Solidworks and Ansys: A Review

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Abstract: Deformation and shear stress analysis are pivotal considerations in the design and performance evaluation of mechanical components, particularly in the automobile industry. The behaviour of torsional rods, critical load-bearing elements in many automotive systems, necessitates meticulous assessment to ensure optimal functionality and longevity. This review delves into the comprehensive study of deformation and shear stress analysis of torsional rods employed in automobiles. The investigation harnesses the capabilities of two industry-standard simulation tools, SolidWorks and ANSYS, to explore a spectrum of materials commonly used in automotive engineering. The juxtaposition of SolidWorks and ANSYS serves as a comprehensive approach to examining the behaviour of torsional rods across various materials, offering valuable insights for both researchers and practitioners. Through illustrative case studies and comparative analyses, this review sheds light on the unique attributes of different materials and simulation platforms, contributing to the advancement of automotive component design and analysis methodologies. Based on previous research the objective of this review paper is "Deformation and Static Stress Analysis of Torsional Rod Using Various Materials"

Based on previous research the objective of this review paper is "Deformation and Shear Stress Analysis of Torsional Rod Using Various Materials"

Keywords: Torsional rod, Deformation, Shear stress analysis, SolidWorks simulation, ANSYS finite element analysis, Performance optimization.

I. INTRODUCTION

In numerous automotive systems, torsional rods are vital parts that transmit rotational forces. Engineers must understand torsional deformation and shear stress distribution in order to achieve effective design and use, as these aspects might affect the structural integrity and material reliability[1].

Computer-aided design capabilities are provided by SolidWorks, while advanced finite element analysis methods are offered by ANSYS for challenging situations. Engineers can examine material responses to various loads and mimic real-world behaviour with the aid of these technologies[2]. The review focuses on materials often used in the automobile sector and tries to address deformation and shear stress analysis of torsional rods in great detail. It explores the benefits and drawbacks of using SolidWorks and ANSYS for analysing torsional rods in a variety of materials, combining theoretical explanations, case studies, and comparative analyses[3]–[5].

Overall, the information obtained from this review can be useful for making wise decisions about the design of automotive components, the choice of materials, and performance enhancement, ultimately leading to safer and more effective automobiles[6].

The variables to be considered in the analysis are:

1) Design considerations - It's the entity the unit in charge of design variable analysis.[1]
2) Objective purpose - The real- valuable function whose value is to be either minimized or maximized, subject to the constraint[2]
3) Numerical restrictions- these are the parameter that must be achieved to find the purpose of objective function. [3]
4) Geometric restrictions - consistency of outcomes. Relate for any furthermore, undeclared limitations on design.[4]

For Example: The design responses, the design remedies, for illustration, are mass and stress if the aim is to lower mass while remaining over a maximum stress.

Additionally, the design space can be constrained to prevent material from being taken away from any vital domains, and many objective function variables that can be weighted according to their relative significance to the issue can be introduced.[4]

II. LITERATURE REVIEW

The various researches have been study for the performance of the torsional rod, some of them are**:**

1) *Prateek Shrivastava D, Ruchika Saini, Abhishek Kumar (2020)[1]*

This research evaluates different torsional rod designs in automotive suspension systems to reduce vibrations on uneven roads and enhance driving comfort. Using software like CATIA and ANSYS, the study analyses shear stress, deformation, and strain energy for three rod types: stepped taper rods, tapered rods, and uniform stepped rods with specific length of 110mm and 130 mm. Tapered rods endure the least stress, while uniform stepped rods experience the highest. Stepped tapered rods with uniform steps deform the most. Uniform stepped rods store the highest strain energy. The study suggests employing stepped rods with particular parameters, such as L1 = 60 mm, L2 = 50 mm, D1 = 4.21 mm, and D2 = 4.02 mm, for both 110mm and 130mm length rods, in order to effectively dampen vibration in car suspension systems. Shear stress, deformation, and strain energy properties of stepped rods were favourable.

2) *Nan, Jijun Feng (2022)[2]*

The study focuses on the variables that lead to incidents involving off-road vehicles (orvs) having fractured torsion bars. The research analyses samples of fractured torsion bars and determines that the fractures occur at the junction of the spline end and take the form of a ratchet pattern with a 45-degree fracturing vector to the bar axis. All failed components exhibit the same fracture patterns and initiation sites, suggesting to a shared cause of failure. The failure reason was identified using a variety of techniques, including scanning electron microscopy (SEM), metallographic inspection, hardness testing, and spectral component analysis. Results suggested that the fractures were caused by fatigue cracking, which started from the spline junction as it was too brittle. An experiment using a tempering simulation validated the investigation's conclusion that the brittleness was caused by insufficient tempering following the quenching process.

3) *K. Radhakrishnan, A. Godwin Antony, K. Rajaguru, B. Sureshkumar (2019)[3]*

This study aims to enhance driver comfort in off-road vehicles by reducing vertical vibrations. It proposes a unique torsion bar mechanism with adjustable stiffness through a control arm system. Using ANSYS, the research analyses size, stiffness, deflection, and shearing stress. The goal is to minimize vertical vibration transmission from the driver to the wheels, improving comfort on long off-road trips. The study identifies fatigue cracking due to improper tempering as a key issue and recommends extending tempering time. It suggests specific rod specifications for automotive suspension systems to achieve effective vibration damping and performance enhancement.

4) *Z.R. Lu, M. Huang, J.K. Liu, W.H. Chena, W.Y. Liaob (2009)[4]*

The composite element method (CEM) is used in this study to analyse the free and forced vibrations of beams with various cross-sectional steps. The findings of the standard Rayleigh-Ritz approach, the receptance function, and the new method are compared. The CEM's natural frequencies and forced vibration responses are validated using data from experiments and other methodologies. Without the necessity for partitioning into uniform pieces, the approach produces precise results and can handle beams with a range of cross-sections. The study proves that the composite element method is accurate and useful for assessing the vibrations of stepped beams in engineering applications.

5) *Rajashekhar Sardagi, Dr. Kallurkar Shrikant Panditrao (2014)[5]*

The torsion bar, an essential part of the suspension system for passenger cars, is designed and optimized in this work. The major goal is to provide the best suspension system possible while also enhancing the car's comfort and stability. We examine the torsion bar as a crucial component in achieving these objectives. The study suggests using nylon instead of steel for the torsion bar in an effort to lighten the unsprang mass and, as a result, lower fuel consumption. The goals of the paper include performing torsion tests on Mild Steel (MS) and Nylon specimens, examining their characteristics, and contrasting their results. Modelling and failure analysis are done using ANSYS software. The calculations and test outcomes reveal that Nylon demonstrates promising qualities, making it a feasible material. It is emphasized that Nylon has exceptional abrasion resistance, high strength-to-weight ratio, and good flexibility. According to the study, nylon could work well as a torsion bar material, lowering suspension system weight and enhancing vehicle performance. The study supports the potential use of nylon as a substitute material for passenger automobile torsion bars, to sum up.

The findings show that it has advantages over conventional mild steel, especially in terms of weight savings and potential increases in fuel economy. The study's conclusions might inspire improved suspension systems for cars, improving comfort and stability.

6) V. Vijayan, T. Karthikeyan. (2014)[6]

In this research, compliant mechanisms are applied to passive vibration isolation systems. To regulate displacement transmission and lessen unwanted vibrations, a compliant mechanism with an isolator is used. The mechanism's compliance is added to regulate the transfer of force at various frequencies. ANSYS software is used to do structural optimization to establish the mechanism's topology, shape, and size. It is suggested to use a library of compliant components that can be put together to lessen transmitted force and vibration. This method is contrasted in the study with a conventional coil spring isolator. Both mechanisms' displacement amplitudes and force transmission are evaluated using harmonic analysis. The findings show that the compliant mechanism offers more effective vibration isolation, with better isolation efficiency at a particular frequency as compared to the coil spring isolator.

Table 1. Result comparison table.

Author/year	Material used	Type of system	Outcomes
Prateek Shrivastava D, Ruchika Saini, Abhishek Kumar	SAE5160H Length of bar=130mm,110mm Torque=17600N-mm Modulus of Rigidity=80X103N/mm² Young's Modulus=207X103N/mm²	Following boundary condition are being consider. 1. Bigger end of rod is fixed. 2.Moment of Magnitude:17600N-m at smaller end of rod.	[i] the strain energy was found to be maximum for uniform stepped torsional rod with values 108.64 mj and 99.965 mj. [ii] Uniform stepped torsional rod underwent maximum deformation for both length 110 mm and 130 mm with values 1.8842 mm and 1.9456 mm respectively. Stepped taper rod exhibited minimum deformation among the uniform stepped rod, taper rod, and stepped taper rod.
Nan Nan, Jijun Feng	45crnimova	10000~100000 Cycles of cyclic torsion	[i] Visual Inspection on the Fracture Surface: fractures initiated from the same place at the fillet part of the spline and ultimately failed under alternating torsion. [ii] SEM Analysis: The possibility of surface processing damage. [iii] Hardness Test: shows that the hardness of S1 Ranges from HV1496.03 to HV1524.26
K. Radhakrishnan, A. Godwin Antony, K. Rajaguru, B. Sureshkumar	SAE 5160H, SAE 6150H, UNS H15621	(i)fixed rear end (ii)rotational motions at end of two diameters D1 & D2 respectively (iii) Load of Fy = 220 N	(i)On length of 110 mm rod: - Equivalent Stress: - 3.2367Pa Shear Stress: - 1.134 Pa (ii) on length of 130 mm rod: - Equivalent Stress: - 3.431pa Shear Stress: - 9.974pa
Z.R. Lua, M. Huanga, J.K. Liua, W.H. Chena, W.Y. Liaob	Case 1: Material has Case 2: Simply supported beam with three step Vibration analysis. Case 3: cantilever beam studied. Case 4: forced vibration analysis for the stepped is investigated	Case 1: mass density of 2830kg/ 2830 kg/m3.young modulus of E= 71.1Gpa. Case 2: mass density= 2830 kg/m3 and E = 34 gpa. Case 3: E= 60.6Gpa Mass density= 2664kg/m3. Case 4: E = 69.6 gpa	Case 1: 291, 1165 and 1771 Hz, respectively. Case 2: 291.9, 1176.2 and 1795.7 Hz respectively. Case 3: 10.758 and 67.553 Hz

		Mass Density=2700kg/m3.	
Rajashekhar Sardagi, Dr. Kallurkar Shrikant Panditrao	(i)Nylon – Dia =25mm (ii)Mild Steel – Dia =25mm	(i)torque of 150N-mm. (ii) one end of rod is fixed.	On Nylon: Max Shear Stress: 6.66 N/mm2 Torsional Rigidity 102.89 N/mm2. On Mild Steel: Max shears Stress: 1.01 N/mm2. Torsional Rigidity: 86.89 N/mm2

III. CONCLUSION

1) In the presented studies, the common objective was to enhance the performance and comfort of automotive components, specifically torsional rods.
2) The investigations utilized simulation tools like ANSYS and SolidWorks to evaluate the behaviours of these components under various conditions.
3) The studies also highlighted the importance of understanding deformation and shear stress distribution for optimizing the design and reliability of torsional rods.

Advantages and disadvantages of each material

a) Mild Steel (MS): Mild steel is widely available and cost-effective.

It provides decent strength and stiffness for many applications.

Mild steel has relatively high density, which can contribute to increased vehicle weight.

It might not provide the highest performance in terms of specific strength and weight.

b) Nylon: Nylon has exceptional abrasion resistance.

It offers a high strength-to-weight ratio, contributing to weight reduction.

Nylon's flexibility can contribute to improved damping characteristics. Nylon’s stiffness might be lower than metals like steel.

Its behaviour under extreme loads and harsh conditions might differ from metals.

c) Composite Materials: Composite materials can be tailored for specific stiffness and strength requirements.

CEM offers an accurate and efficient way to analyse complex beam geometries.

Disadvantages:

Designing and manufacturing composite materials can be more complex and costly.

Composite behaviour might be more sensitive to variations in manufacturing processes.

IV. FUTURE SCOPE

1) Advanced Materials: Explore high-tech materials like carbon fibre composites and titanium alloys to improve strength-to-weight ratios and performance.
2) Multidisciplinary Optimization: Consider economic and environmental factors alongside mechanical ones for well-rounded designs.
3) Dynamic Analysis: Investigate how torsional rods respond to vibrations and impact forces for enhanced comfort and safety.
4) Nonlinear Analysis: Use advanced techniques to account for material behaviours under extreme conditions.
5) Real-world Testing Validation: Validate simulation results through actual testing to bridge the simulation-reality gap.
6) Application-specific Optimization: Tailor designs for specific vehicle systems like suspension and steering.
7) Smart Materials: Integrate materials that adapt to changing conditions for improved performance.
8) Multi-objective Optimization: Combine weight reduction, stress minimization, and cost optimization for balanced designs.
9) Machine Learning and AI: Use data-driven insights to identify patterns and correlations in large datasets.
10) Real-time Monitoring: Develop methods to monitor torsional rod performance during vehicle operation for predictive maintenance.
11) Environmental Impact: Study how environmental factors affect material behaviour and durability.
12) Vehicle Dynamics Integration: Examine how torsional rods influence overall vehicle stability and manoeuvrability.

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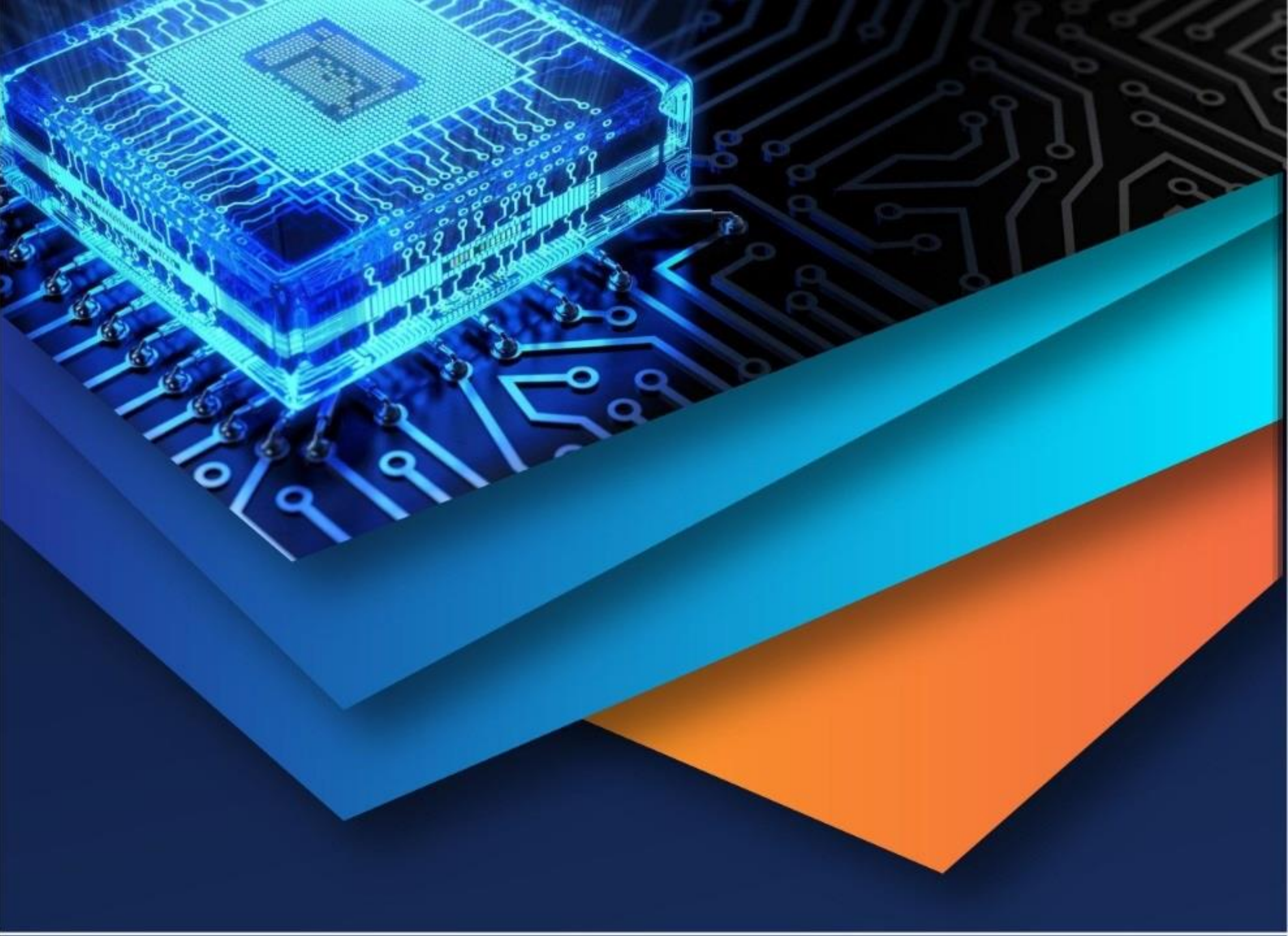

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