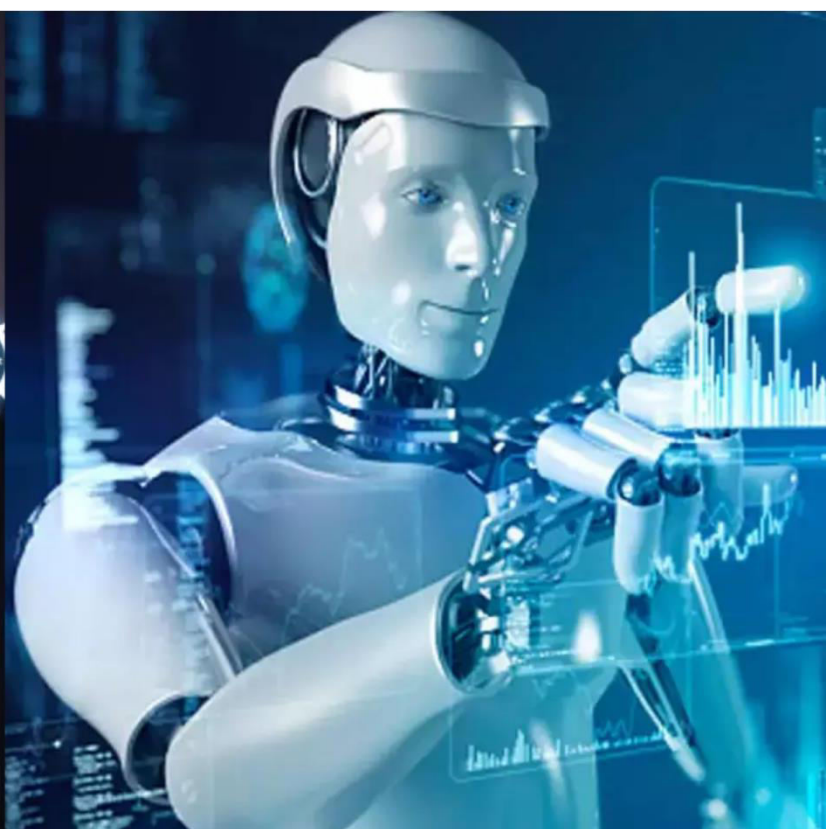




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Study and Comparison of Different material Automotive Drive Shaft for Bending Buckling Analysis

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ABSTRACT: The Drive shaft is made of heavy duty steel due to its tremendous amount of strength and applicability. But to overcome this strength, the material quantity is increased which affects the torsional stability of the component, thereby affecting the power transmission capacity. Hence, in this case, an attempt is made to design analysis and optimize the drive shaft which is made of steel. Alternate replacement material for composite is designed so as to maintain the strength and reduce the weight criteria. In the current research work, the drive shaft is made of SMC45 Carbon steel. The material is been optimized using Alloys of aluminium of Al2014 and Al7075. The finite element modelling has been done in Creo software and model is exported in Ansys. In Ansys, the torsional analysis and buckling analysis of the shaft has been done for all the three materials.

KEYWORDS: Drive shaft, Torsional, Buckling behaviour.

I. INTRODUCTION

Driveshaft, driving shafts, tail shafts, and Cardan shafts are all names for these shafts. The driveshaft is used to transfer torque between components that are not directly connected due to distance or the need for relative motion. The driveshaft is prone to torsion or shear stress because it transports torque. As a result, they must be robust enough to withstand the strain while avoiding gaining too much weight, which will increase their inertia. Different configurations of driveshaft are employed in different vehicles, including front-wheel drive, four-wheel drive, and front-engine rear-wheel drive in automobiles. Driveshaft can also be found in motorbikes, locomotives, and naval vessels

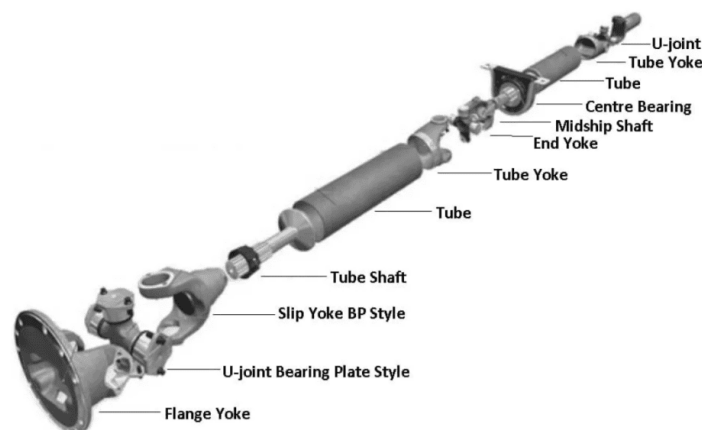


Figure.1. Constant Velocity Drive Shafts [2]

Drive shafts are mechanical components that are widely used in vehicle powertrain systems to transmit torque and rotation between different components which are not in line or cannot be connected directly. During operation, drive shafts are usually subject to torsion and shear stress depending on the input torque and the external load. As key components carrying torque, they must be strong enough to bear the stress for short term loading, the stress state is quasi static and the drive shaft should be designed to prevent plastic deformation; for long term loading, the stress state is dynamic therefore the shaft must be designed for millions of stress cycles.

The general Functions of Drive Shafts are :

- It must transmit the torque from transmission of Differential Gear Box.
- It should be capable of rotating at fast speed as required by the vehicle.
- It must operate through constantly changing angles between the transmission, differential and axels.
- The Length of shaft must be capable of changing while transmitting torque.
- It should be capable of transmitting the torque for forward and reverse.
- The shaft must provide a smooth, uninterrupted flow of power to the axles.
- Maintain the co-axiality of the wheels with drive.

II. METHODOLOGY

1. Selection of Component
2. Study of Aesthetics and Material Properties of shaft
3. FEA of Generalized Material for Shaft
4. Material Optimization
5. FEA of Material Optimization of Shaft

Table 1 Specifications of Maruti Omni

Parameter	Value
Max Power	8.04 bhp @ 3400 rpm
Max Torque	6.1 kgm @ 3000 rpm
Overall Length (mm)	3310
Overall Width (mm)	1410
Overall Height (mm)	1640
Kerb Weight (Kgs)	785 Kg
Gross Vehicle Weight (GVW)	1385 Kg
Body Option	Multi-Purpose Vehicle
Mileage (Diesel Fuel)	19 kmpl

In this project, Maruti Omni car drive shaft is taken for study and is shown in fig.2 for the understanding loading and boundary conditions. The Current Shaft is made of Steel SM45C. SM45C Steel is a high quality Quenched and Tempered Carbon Structural steel, It belong to the high quality low carbon, Low carbon chromium, molybdenum, nickel case.



Figure.2. Drive Shaft for Case Study

Table 2 Material Properties Sm45c [1]

Parameter	Value
Ultimate Tensile Strength	420 MPa.
Yield Strength	370 MPa.
Young's Modulus	207 GPa.
Shear Modulus	80 GPa.
Poisson Ratio	0.3
Density	7600 Kg/m ³

III. FINITE ELEMENT ANALYSIS

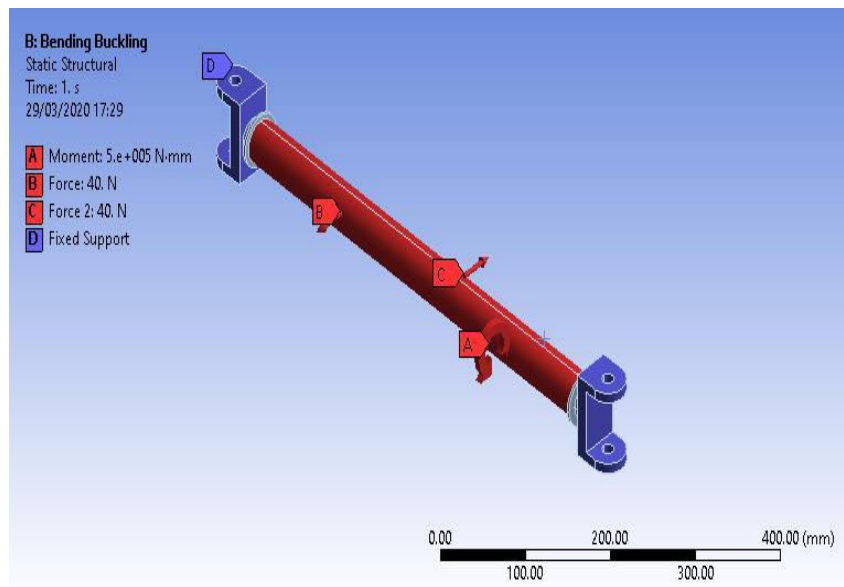


Figure.3. Ansys Setting for Bending and Buckling Analysis

a. Torsional Moment :

As the maximum engine speed is 3400 rpm, hence, the maximum power transmitted by the engine is 6KW, the torque transmitting capacity of the engine is 59.82N.m, hence the same is considering as applied torque.

b. Torsional Force:

The torsional force is the force which is required to produce the estimated torque. Hence Torsional Force (F1) generated by engine during running is 2790N to a margin considered as 3000N (Safety). The surface area of application of torsional force is stated in figure 3.

c. Rotational Velocity :

It is the speed of the shaft which is running to transmit the speed. As the engine speed is 3400 rpm, the rotational velocity is considered the same. The Angular Velocity (ω) subjected to the shaft is 356.04 Rad/Sec.

d. Shaft Subjected to Bending Moment :

Considering the shaft subjected to its self-weight of 4 Kg which is equivalent to 40 N. Hence Bending Moment, (M) is considered as 5 x 10⁵ N.mm.

e. Torsional Buckling :

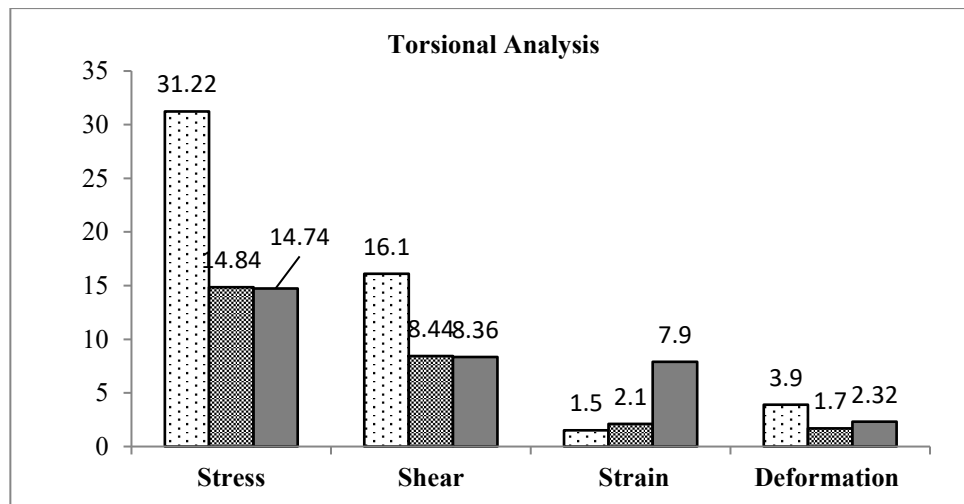
Torsional buckling (ϕ) capacity of shaft Torsional buckling (ϕ) capacity of shaft as 433 N.mm

IV. RESULT AND DISCUSSIONS

a). Comparison of Results for Torsional Loading :

Table 4 Comparison of Result For Torsional Analysis

Criteria	SM45C	Al2014	Al7075
Stress (MPa)	31.22	14.84	14.74
Shear (MPa)	16.1	8.44	8.36
Strain	1.5	2.1	7.9
Deformation (mm)	3.9	1.7	2.32



Graph.1.Result Analysis for Torsional Analysis

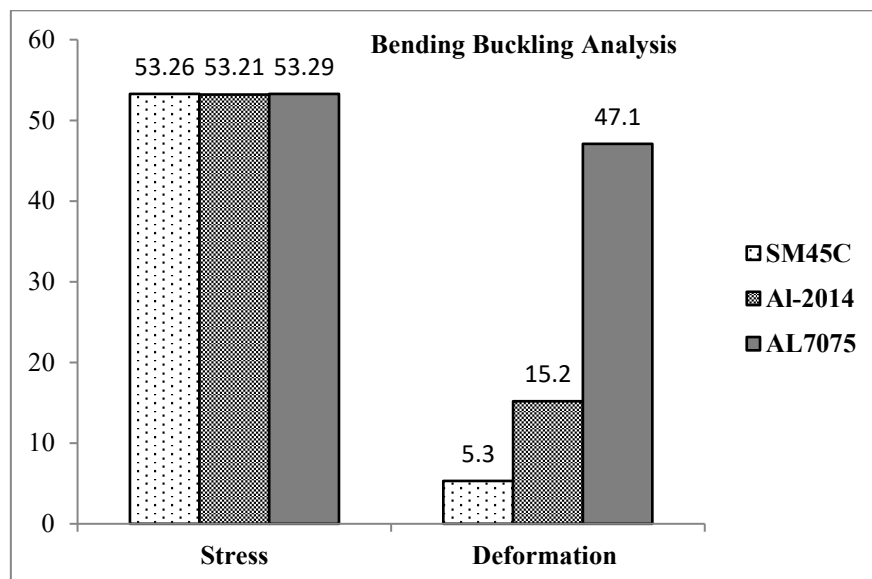
- The resultant stress produced is lesser for all Aluminium Matrix and Polymer Matrix materials. Hence, in strength criteria for equivalent stress, the optimized materials of Al2014 and Al7075 satisfy the condition.
- The Shear stress produced is lesser for Al2014 and Al7075. Hence, in shear strength criteria the optimized materials of Al2014 and Al7075 satisfy the condition.
- The deformation produced is lowest in case of Al2014 and moderate in case of Al7075. The deformation is found highest in Steel material.
- Strain is the change in shape of object. With respect to the above graph, the strain is maximum in Polymer material, but as the deformation is low here, hence we can consider that the change in shape will also be moderate.

b). Comparison of Results for Bending Buckling :

Table 5 Result Analysis For Bending Buckling

Criteria	SM45C	Al-2014	AL7075
Stress (MPa)	53.26	53.21	53.29
Deformation mm	5.3	15.2	47.1

- As we can see from the above graph, for all the loading conditions, the stress produced for steel, Al2014 and Al7075 is similar. Hence, we can say that, with respect to bending load, the strength of shaft will be same for all the material.
- Referring to table 5, the deformation is lowest in steel due to elasticity property of steel. The deformation in other two materials of Al2014 and Al7075, even though, more than the steel, but it is less than the magnitude of 1. Hence with respect to bending, the material satisfies the deformation criteria.



Graph.2. Result Analysis for Bending Buckling

V. CONCLUSION

- In this paper, the material optimization of shaft made SMC45 Steel is done with the replacement of aluminum and polymer matrix components.
- All the loading constraints have been studied and applied to determine the loading conditions that can be used for FEA.
- For finite element analysis, the ultimate loading condition of 1.2 Factor of safety has been considered.
- FEA is done in Ansys software for determination of Equivalent Stress, deformation and strain produced in the material for all the loading conditions.
- The optimized material of Aluminum and Polymer matrix satisfies the strength criteria of Stress and shear, hence can according to this condition the experiment is successful.
- Use of Al-Matrix and Polymer matrix material is also optimal as it reduced the cumulative weight as reduction of 40% with improvement in strength.
- This reduction in weight of vehicle can lead to economic value of product as the raw material and manufacturing cost can be reduced

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