IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, May 2026
Impact Factor: 8.2

Material Enhancement of Composite Drive Shaft and its Response to Torsional and Bending Stress

Suraj Bhagawan Virkar, Prof. Dr. A. D. Desai[2], Prof. Dr. S. D. Shinde[3], Mr. P. G. Sarasambi[4], Mr. S. P. Godase[5]
P.G. Student, Department of Mechanical Engineering[1]
Professor, Department of Mechanical Engineering[2]
Associate Professor, Department of Mechanical Engineering[3]
Assistant Professor, Department of Mechanical Engineering[4,5]
Shree Ramchandra College of Engineering, Lonikand, Pune, Maharashtra, India

Abstract: *Drive shaft is one of the important factors in transmission system of vehicles. nearly all motorcars have transmission shafts. The weight reduction and increase in strength of the drive shaft can have a certain part in the general weight reduction of the vehicle and is a largely desirable thing, if it can be achieved without increase in cost and drop in quality and trustability. It's possible to achieve design of compound drive shaft with lower weight to increase the first natural frequency of the shaft. This work deals with the relief of a conventional sword drive shaft with high strength light weight compound shafts for a machine operation. In this Study, the drive shaft of random vehicle considers for testing and analysis. The modelling and analysis are performed using CREO and ANSYS software independently. The analysis is carried out for both the accoutrements. The experimental disquisition is carried out for compound material to corroborate the reliance of result with simulations*

Keywords: Torsional Strength, Drive Shaft, Optimization, ANSYS, Matrix Composites

I. INTRODUCTION

Drive shafts are mechanical parts commonly utilized in vehicle powertrain systems to convey torque and rotational motion between components that are misaligned or cannot be directly linked. These drive shafts need elements like splines, gears, grooves, and oil channels to be installed or produced to transfer power or distribute lubricant. The shaft 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. It is a driveshaft that is designed for applications that call for increased horsepower, so you can hit the road with confidence. lighter overall weight and reduced rotating mass enhance driving performance and facilitate faster acceleration. the main purpose of shaft is that it must transmit the torque from transmission of Differential Gear Box. As its aim to transfer speed, 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. Due to its functional conditions, the shaft is subject to torsional and bending forces under operating conditions.

The demand for lightweight, high-strength, and energy-efficient mechanical systems has significantly increased in modern engineering applications, particularly in the automotive and aerospace industries. One critical component in power transmission systems is the drive shaft, which is responsible for transmitting torque from the engine to the wheels. Traditionally, drive shafts have been manufactured using conventional materials such as steel and aluminium Although these materials provide adequate strength, they are often associated with higher weight, which negatively affects fuel efficiency and dynamic performance.

In recent years, the development of Composite Materials has provided an effective alternative to conventional materials. Composite materials, such as carbon fibre reinforced polymers (CFRP) and glass fibre reinforced polymers

(GFRP), offer superior specific strength, high stiffness, corrosion resistance, and improved vibration damping characteristics. These properties make them highly suitable for replacing traditional metallic drive shafts.

A key advantage of composite materials lies in their directional properties, known as Anisotropy, which allows engineers to tailor material behaviour according to specific loading conditions. By adjusting fiber orientation and stacking sequence, the mechanical performance of a composite drive shaft can be optimized to withstand complex loading conditions.

Drive shafts are primarily subjected to Torsion, as they transmit rotational power. However, they also experience Bending stresses due to misalignment, dynamic forces, and operational conditions.

II. LITERATURE SURVEY

Godec M et al. (2019) Conducts the Investigation of the fracture of cars drive shaft. Cars drive shaft, machined from case-hardened steel that was carbo-nitride, quenched and tempered, ruptured at an early stage of its use. Both sides of the fractured shaft were delivered for an investigation in order to discover the cause of the rupture. The drive shaft was machined from a case-hardened steel (25CrMo4/27CD4) in the shape of a pipe 26.3 mm diameter with a wall thickness of 3.8 mm and then carbo-nitride, quenched and tempered. The chemical analyses of the steel shaft were performed using an inductively coupled plasma atomic absorption spectrometer ICP-AES.

Zhao G et al. (2019) in his research work the HHT-based AE characteristics of 3D braiding composite shafts. In this paper the Hilbert-Huang transform (HHT) was used to analyse the acoustic emission (AE) signals of 3Dbraidingcomposite shafts under tensile and torsion. First, tensile and torsion experiments were carried out on 3D braiding composite shafts with different braiding angles, and AE was used to monitor the damage evolution during the experiments. The specimens used in this paper are epoxy resin-based three-dimensional braided carbon fibre compos- ite pipe. The carbon fiber reinforced material is made of T700-12 k carbon fibre filament. The carbon fibre reinforced material is made of T700-12 k carbon fibre filament.

Zhao L et al. (2019) has research work in Failure and root cause analysis of vehicle drive shaft. This paper investigates the failure mode and root cause of drive shaft failure in a vehicle through examination of the macroscopic and microscopic morphologies of the fracture surface, the chemical composition, metallographic analysis, and mechanical properties of the material, and theoretical finite element calculations of the drive shaft. The major material of drive shaft used in vehicle industry is forged steel. To have an adequate strength, toughness and hardness for an expected long-term fatigue life, the material should be precisely controlled, and drive shaft should be well machined and properly heat-treated.

Hao W et al. (2019) Presents the study on Study on the torsion behaviour of3-D braided composite shafts. The structural parameters of three-dimensional (3-D) braided composites have important influence on their mechanical properties. The torsional properties of the 3-D braided composite shafts with braiding angles of 25, 35 and 45 were tested by MTS809. Fibre reinforced 3-D braided composites have the characteristics of impact resistance and fatigue resistance, which overcome the shortcomings of traditional laminated composites such as low interlinear strength and easy delamination. The ultimate torque and torsion angle are obtained by measuring the torsion performance of the specimen. In the model, the maximum stress criterion and hashing failure criterion are used for matrix and fibre bundle respectively. Since the matrix is regarded as isotropic brittle material, the maxi- mum stress intensity criterion is more suitable.

Gong L et al. (2018) in this research the Design on the drive shaft of 3D 4-Directional carbon fibre braided composites is done. In this paper, the method of designing a drive shaft with a 3D 4-Directional braided composite structure is proposed in this paper, the macro-meso-mechanics analysis is used to investigate the material properties, strength characterizations and mode behaviours of braided composite drive shaft, and the lightweight design of 3D 4-Directional braided composites drive shaft is described. Both the serrated and the glued connection between the metal universal joint and the composite materials are designed to reduce the damage and improve the reliability. Both the 3D braided carbon fibre composite tube and the metal universal joints are implemented between the different materials.

Elanchezian C et al. (2018) in his paper Design and comparison of strength and efficiency of drive shaft made of Steel and composite materials. In this paper, shaft made of SMC45 Steel is compared with the Kevlar fabric material. In this paper, steel and composite drive shafts are designed and optimized with respect to the weight and strength criteria. Theoretical and FEA is performed for hollow as well as solid shaft. The use of composites shafts provided the strength, but they are low in modulus. The fundamental natural frequency of composite shaft is high as that of steel shafts. The carbon fibre material has four-time stiffness as that of steel which makes it possible to manufacture it in single as well as two pieces.

Nadeem S et al. (2018) has presented a Review on the design and analysis of composite drive shaft. The objective of the paper is to review: (a) the work carried out on the composite drive shafts which are used in the automotive applications; (b)fabrication techniques and materials used in the fabrication of composite shafts
(c)finite element analysis on composite shaft and steel shaft. Modulus of elastic- it y is less in composite materials, as a result when torque reaches to its peak in the driveline, drive shaft may work as a shock absorber and stress is reduced on part of the drive train extending life. Different composite drive shaft materials like Carbon/epoxy, Glass/epoxy, Kevlar/epoxy and Boron/epoxy were analysed and compared with conventional steel drive shaft using ANSYS.

Prasad A et al. (2018) Conducts the Experimental Investigations on Static and Dynamic Parameters of Steel and Composite Propeller Shafts with an Integrated Metallic Joints. The overall objective is to design an optimal stacking sequence of the composite layers for the drive shaft and the design constraints being angle of twist and natural frequency. The Finite element analysis was carried out with full torsional load on 3-D model of composite propeller shaft for torque bearing capacity, stiffness, bending natural frequency. In the present work, Composite propeller shaft of E Glass/Epoxy is made identical as steel propeller shaft of same torque carrying capacity.

Liu Y et al. (2018) in his research work the Fracture failure analysis and research on drive shaft of positive displacement motor has been carried out. In this paper, microstructures and mechanical properties of the fractured drive shaft are investigated by visual inspection, metallographic analysis, scanning electron microscopy, and tensile and impact tests. The composition, structure and mechanical properties of the drive shaft materials are tested to meet the standards. The fracture surface is mainly characterized by dimples and a small amount of quasi-cleavage by microscopic analysis, which indicates that the fracture surface is dominated by ductile fracture.

Shokrieh M et al. (2018) has done Analysis of Light Vehicle Propeller Shaft. The steel propeller shaft is made in two sections connected by a support structure, bearings and U-joints and because of this over all weight of composite materials. Composite (made up of different things) materials (Glass Epoxy) were used and designed and analysed for their appropriateness in terms of torsional strength, bending natural frequency, torsional buckling and number of cycles by comparing. The Current Shaft is made of Stainless steel which has less damping ability (to hold or do something). Because of its higher density of molecules of stainless steel, its weight is very high.

III. PROBLEM DEFINITION

To design and analyse the automobile drive shaft by using matrix composite material so as to increase the torsional strength." 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.

IV. OBJECTIVES

1) Finite Element Stress and Deformation analysis to obtain the torsional strength of material.
2) Select the Best possible material so as to replace it with the Steel.
3) Determine the torsional strength of composite materials.
4) Reduce the weight of Shaft.
5) Increase the Strength of Shaft.

V. METHODOLOGY

1. Material Selection and Enhancement: Different composite materials are selected based on required mechanical properties such as strength, stiffness, and weight. Common choices include carbon fibre reinforced polymer (CFRP), glass fibre reinforced polymer (GFRP), and hybrid composites.

2. Geometric Design of Drive Shaft: A 3D model of the drive shaft is created based on standard dimensions Length, outer diameter, inner diameter, Thickness of composite layers. The design considers constraints such as torque capacity, critical speed, and space limitations.

3. Finite Element Analysis (FEA): Meshing the model (dividing into small elements), Assigning material properties (orthotropic composite data), Applying boundary conditions (fixed supports, applied torque, bending load).

4. Material Optimization: Fiber angles are adjusted; Hybrid combinations are tested & Weight vs strength trade-offs are analysed.

5. **Finite Element Analysis of Material Optimized Shaft (FEA):** Meshing the model (dividing into small elements), Assigning material properties (orthotropic composite data), Applying boundary conditions (fixed supports, applied torque, bending load).

6. Experimental Investigation: The experimental investigation is carried out to validate the performance of the composite drive shaft and to study its behaviour under real loading conditions such as torsional and bending stresses. This step helps verify the analytical and simulation results.

VI. COMPONENT SPECIFICATIONS

In this case study, the design and analysis of propeller shaft is considered. The Maruti Omni shaft is chosen for the case study. Maruti Suzuki Omni is 5 seating Capacity vehicles depending on the seating arranged. Specifications of car are given in Table 1. For this analysis, the drive shaft of a Maruti Omni car is selected for examination. For the understanding loading and boundary conditions. The Current Shaft is made of Steel SM45C. SM45C is quenched and tempered steel; it belongs to low carbon, low carbon chromium, molybdenum and nickel. The chemical composition and material properties are shown in Table 1, 2 and 3.

Table 1. Specifications of Maruti Omni

Sr. No.	Parameter	Value
1	Max Power	8.04 bhp @ 3400 rpm
2	Max Torque	6.1 kgm @ 3000 rpm
3	Overall Length (mm)	3310
4	Overall Width (mm)	1410
5	Overall, Height (mm)	1640
6	Kerb Weight (Kgs)	785 Kg
7	Gross Vehicle Weight (GVW)	1385 Kg
8	Body Option	Multi-Purpose Vehicle
9	Mileage (Diesel Fuel)	19 kmpl

IJARSCT
ISSN: 2581-9429
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Volume 6, Issue 3, May 2026
Impact Factor: 8.2

Table 2. Chemical Composition of SM45C

Material	C	S	Si	Cr	Mn	Ni	P	Cu
%	0.48	0.035	0.35	0.2	0.9	0.2	0.03	0.25

Table 3. Material Properties of SM45C

Sr. No.	Parameter	Value
1	Ultimate Tensile Strength	420 MPa.
2	Yield Strength	370 MPa.
3	Young's Modulus	207 GPa.
4	Shear Modulus	80 GPa.
5	Poisson Ratio	0.3
6	Density	7600 Kg/m3

VII. FINITE ELEMENT ANALYSIS

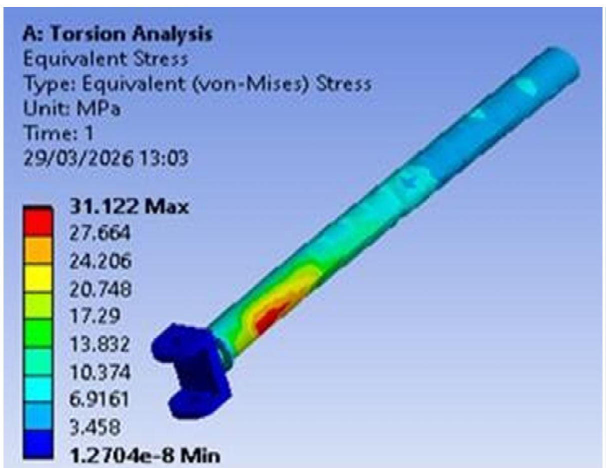

Fig. 7.1 Equivalent Stress after Torsional SMC45

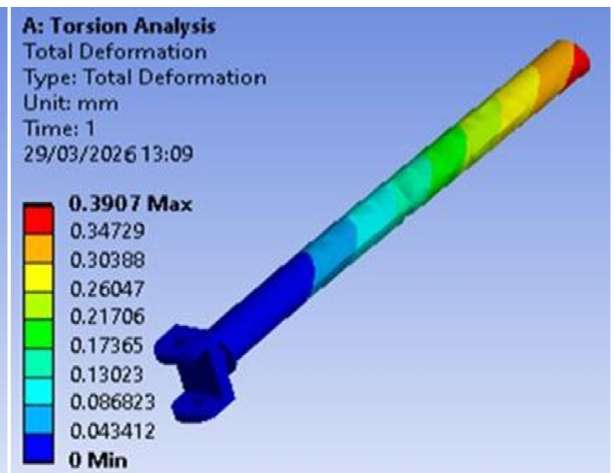

Fig. 7.2 Deformation Torsional SMC45

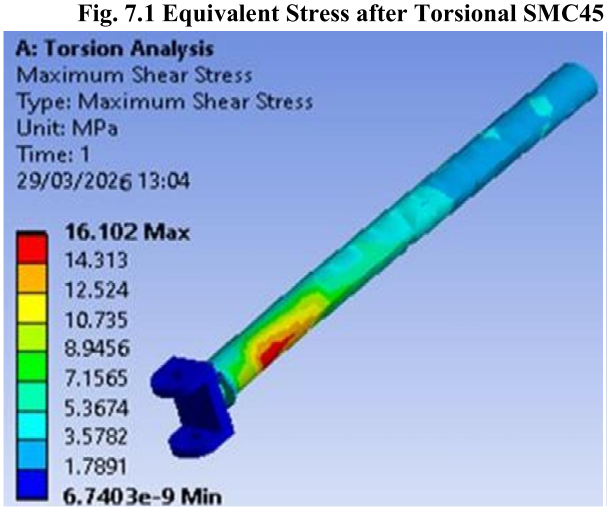

Fig. 7.3 Shear Stress After Torsional SM45C

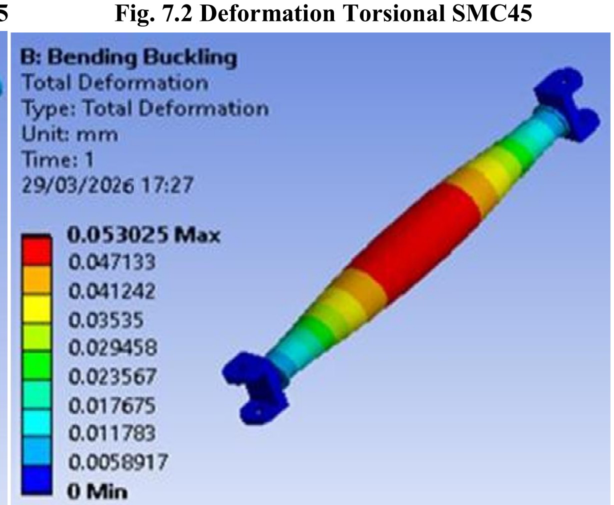

Fig. 7.4 Deformation after Buckling SMC45

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, May 2026
Impact Factor: 8.2

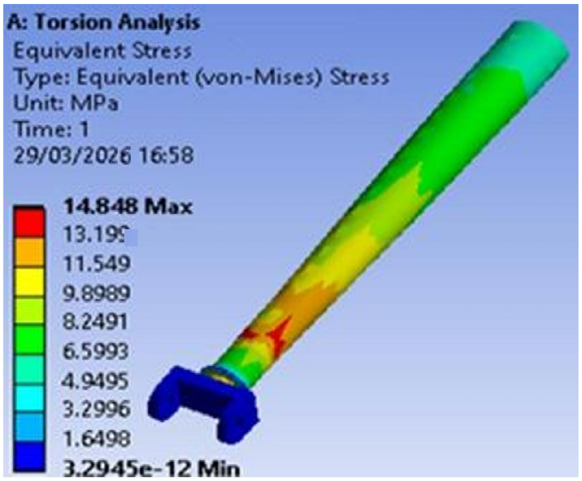

Fig. 7.5 Equivalent Stress after Torsional Al2024

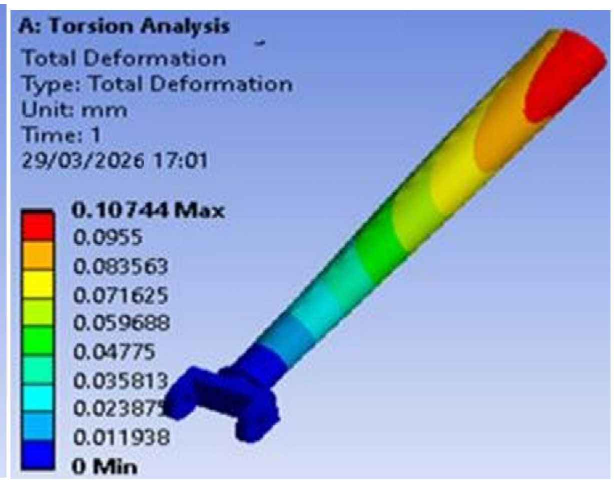

Fig. 7.6 Deformation after Torsional Al2024

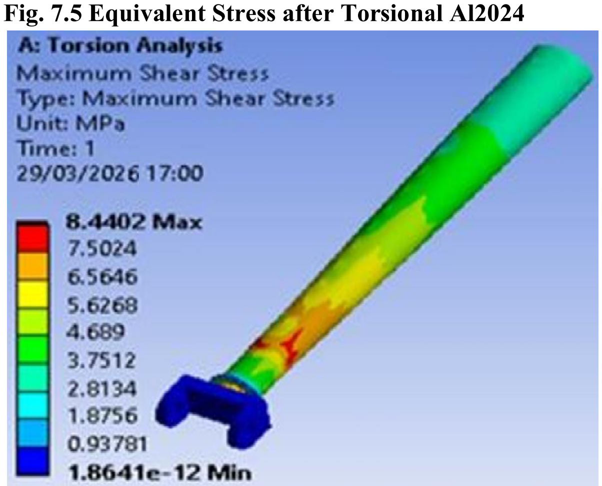

Fig. 7.7 Shear Stress after Torsional Al2024

Fig. 7.8 Equivalent Stress after Buckling Al2024

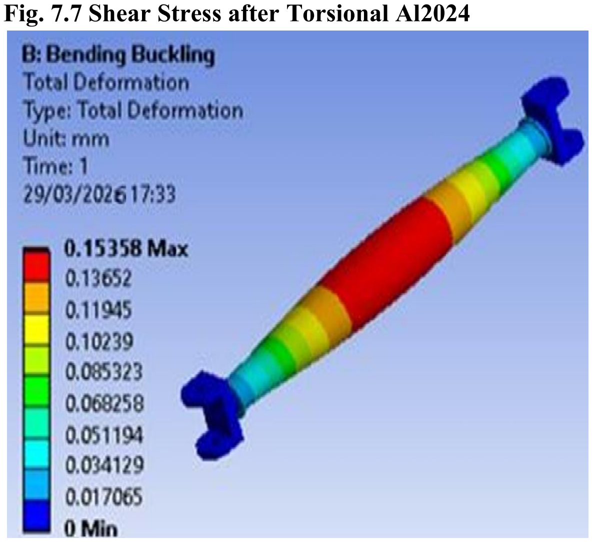

Fig. 7.9 Deformation after Buckling Al2024

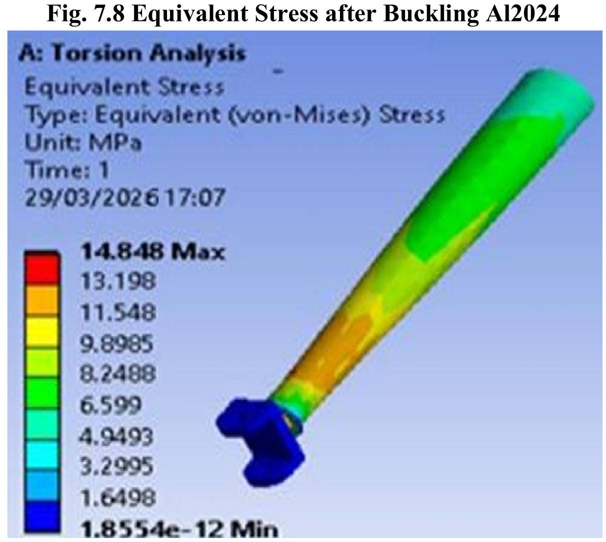

Fig. 7.10 Equivalent Stress after torsional carbon

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, May 2026
Impact Factor: 8.2

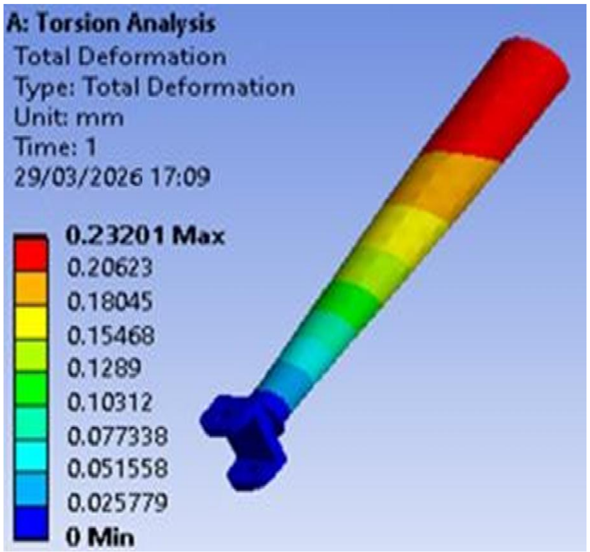

Fig. 7.11 Deformation After Torsional Carbon Fibre

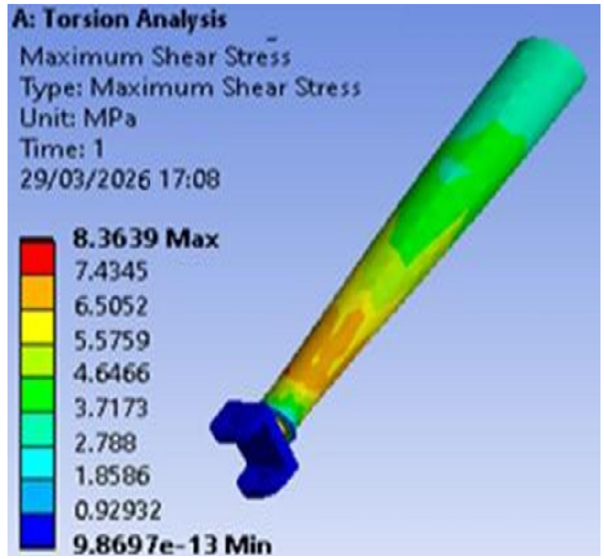

Fig. 7.12 Shear Stress after Torsional Carbon Fibre

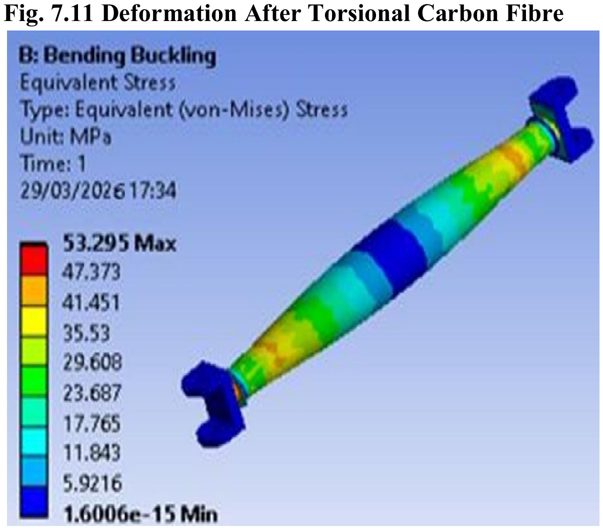

Fig. 7.13 Equivalent Stress after Buckling carbon Fibre

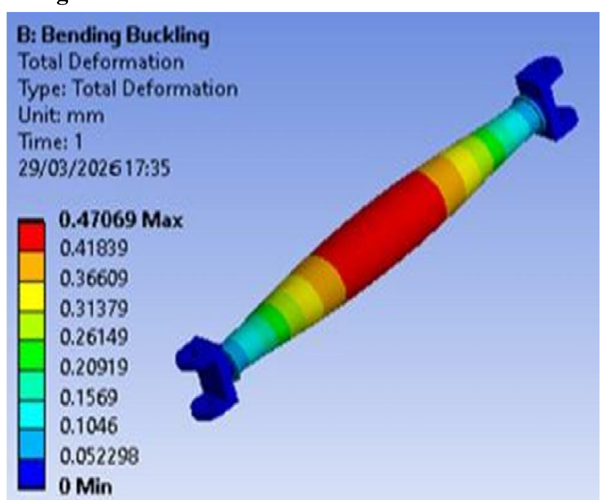

Fig. 7.14 Deformation after Buckling Carbon Fibre

VII. RESULTS AND DISCUSSIONS

With respect to the working hour's life, the life of carbon fibre and Al-2024 is more than that of steel. Hence use of matrix components will increase the life of shaft. Fatigue damage is the design life divided by available life of component. This result may be scoped. The default design life is set by control panel. For Fatigue, values greater than 1 indicates failure before designed life. Hence, according to damage criteria, all the three materials are safe. Biaxiality indication is said to be the principal stress smaller in magnitude divided by larger principal stress with the principal stress nearest to zero. Hence, with the more ratio the more effective material. Hence all the three materials are safe under working.

DOI: 10.48175/IJARSCT-34980

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, May 2026
Impact Factor: 8.2

VIII. CONCLUSION

In this paper, the material optimization of shaft made SMC45 Steel is done with the replacement of aluminium 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 Aluminium 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.

REFERENCES

[1] Zhao G, Zhang L, Wang B, Hao W, Ying L, HHT-based AE characteristics of 3D braiding composite shafts, Journal of Polymer Testing, Elsevier Publication, Volume 79, 2019; 106019.

[2] Zhao L, Xing Q, Wang J, Shen-long Li, Zheng S, Failure and root cause analysis of vehicle drive shaft, Journal of Engineering Failure Analysis, Elsevier Publication, Volume 99, 2019; 225-234.

[3] Godec M, Mandrino D, Jenko M, Investigation of the fracture of a car's drive shaft, Journal of Engineering Failure Analysis, Elsevier Publication, Volume 16, 2019; 1252-1261.

[4] Liu Y, Lian Z, Xia C, Qian L, Liu S, Fracture failure analysis and research on drive shaft of positive displacement motor, Journal of Engineering Failure Analysis, Elsevier Publication, Volume 106, 2019; 104145

[5] Hao W, Huang Z, Zhang L, Zhao G, Luo Y, Study on the torsional behavior of 3-D braided composite shafts, Journal of Composite Structure, Elsevier Publication, Volume 229, 2019; 111384.

[6] Shokrieh M, Hasani A, Lessard L, Shear buckling of a composite drive shaft under torsion, Journal of Composite Structure, Elsevier Publication, 2018; 63-69.

[7] Gong L, Gao X, Yang H, Liu Y, Yao X, Design on the driveshaft of 3D 4-Directional carbon fiber braided composites, Journal of Composite Structures, Elsevier Publication, Volume 203, 2018; 466-473.

[8] Nadeem S, Giridhara G, Rangavittal H, A Review on the design and analysis of composite drive shaft, Materials Today, Elsevier Publication, Volume 05, 2018; 2738-2741.

[9] Prasad A, Ramakrishna S, Madhavi M, Experimental Investigations on Static and Dynamic Parameters of Steel and Composite Propeller Shafts with an Integrated Metallic Joints, Materials Today, Elsevier Publication, Volume 05, 2018; 26925-26933.

[10] Elanchezian C, Ramnath B, Raghavendra K, Murlidharan M, Rekha G Design and Comparison of Strength and Efficiency of Drive Shaft made of Steel and Composite Material, Materials Today, Elsevier Publication, 2018; 1000 1007