Comparative study between Mild Steel and Composite Materials for Torsion Bar

Anurag Dubey[1], Pooja Tiwari[2]

[1,2] *Department of Mechanical Engineering, Shri Ram Institute of Technology, Jabalpur MP, India*

***Abstract*- Torsion bar suspension is used on tracked vehicles like armored tanks; artillery guns etc., but there are some four wheelers like luxury sedans, pickup trucks etc. which are using this type of suspension. The torsion bar is just a length of metal rod fixed at one end to the vehicle body and the other end to the suspension lower link of wheel hub .The working of suspension is simple, when the wheel of the vehicle hits a bump in the road the control arm which is connected to the wheel hub rotates which in turn twists the torsion bar which is fixed at one end with the vehicle body. The torsion bar is gripped by the control arm through numbers of splines on the control arm which only translates the vertical movement of the control arm to the rotational or torsional force. There is some amount of load which is permanently applied to the bar for maintaining the car's ride height. This research work is carried out to make a brief comparison between traditionally used mild steel for torsion bar with the composite materials like Carbon fiber and E-Glass fibers and find out which are best in every perspective. The Research is carried by using FEA software with CAD modelling of the torsion bar.**

Index Terms- Torsion Bar, Epoxy\E-Glass; Carbon fiber; Strain Energy; Von-Misses Stress; Deformation.

I. INTRODUCTION

Suspension is the basic system of tires, air in the tire, springs/bars, shock absorbers and linkages which are used to connect a vehicle to its wheels and allows relative motion between the two.

A torsion bar is a very simple device: A metal rod that can be loaded by twisting it, and then twists back when released. By securely anchoring one end, and fitting a lever to the other, it can be used in a suspension system to handle the vertical motions of a wheel. It's a similar to energy-storage principle to the wind-up elastic band found on common toy planes and the like ones. The stiffness of the spring is directed by both the resistance of the torsion bar to twisting, and the length of the suspension arm it is attached with. The torsion bar's resistance to twisting is directed by its thickness and length. If two torsion bars are of the same diameter, then whichever is longer will have the least resistance to twisting - and if they're the same length, either one has the lower diameter will be easier to twist.

II. MATERIAL SELECTION

- Conventional material
- Composite Material

A. Conventional material: Conventionally mild steel is used for manufacturing of Torsion bar suspension system.

Density	7850 kg/m^3
Young modulus (E)	2 x 10^5 MPa
Poisson Ratio (v)	0.3
Bulk Modulus (K)	166670 MPa
Shear Modulus (G)	76923 MPa

Table 1: - Properties of Mild Steel

B. Composite material: Generally common composite materials are used for this experiment which are E-glass and Carbon fiber. These two materials are very popular in composite as they are scientifically outperforming mild steel as well as they have high strength to weight ratio.

Density	2000 kg/m^3	
Young modulus (E)	X-Direction	45000 MPa
	Y-Direction	10000 MPa
	Z-Direction	10000 MPa
Poisson Ratio (v)	XY-plane	0.3
	YZ-plane	0.4
	XZ-plane	0.3
Shear Modulus (G)	XY-plane	5000 MPa
	YZ-plane	3846.2 MPa
	XZ-plane	5000 MPa

(a)

Density	1490 kg/m^3	
Young modulus (E)	X-Direction	1.21 x 10^5 MPa
	Y-Direction	8600 MPa
	Z-Direction	8600 MPa
Poisson Ratio (v)	XY-plane	0.27
	YZ-plane	0.4
	XZ-plane	0.27
Shear Modulus (G)	XY-plane	4700 MPa
	YZ-plane	3100 MPa
	XZ-plane	4700 MPa

(b)

Table 2: - Properties of (a) E-Glass\Epoxy & (b) Epoxy Carbon UD

III. DIMENSIONS & BOUNDARY CONDITIONS

DIMENSIONS

Dimensional considerations are done on the basis of literature review and are selected as follows

Diameter of bar	16 mm
Length of bar	100 mm

Table 3:- Data used for mild steel

Outer diameter	25 mm
Inner diameter	9 mm
Length of bar	100 mm

Table 4:- Data used for Composite materials

BOUNDARY CONDITIONS

- Moment of 150 N-mm on one end
- Other end is kept fixed
- Meshing: Automatically Generated
- Meshing Relevance center : Medium
- Contact meshing with size of : 1mm element

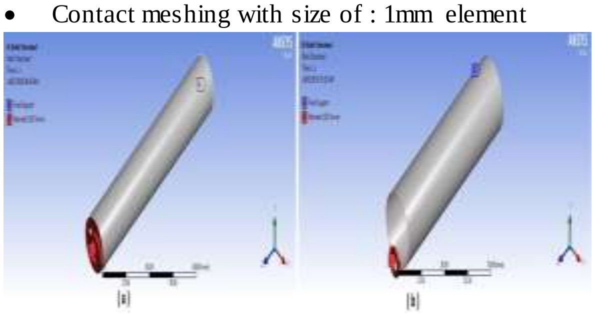

Fig 1: - Boundary Conditions (a) Mild Steel & (b) Composite Bar

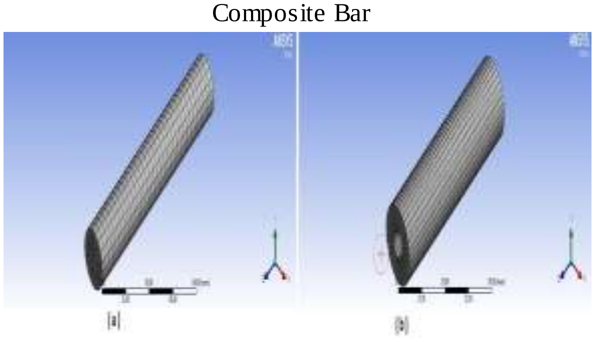

Fig 2: - Meshing of (a) Mild Steel & (b) Composite Bar

IV. MASS CALCULATION

Formula of Mass: - Mass (m) = Density (ρ) x Volume (V)

Given:-

Density of Mild steel = 7850 kg/m^3; Density of Carbon Fiber = 1490 kg/m^3; Density of E-Glass/Epoxy = 2000 kg/m^3

Diameter of steel Bar = 16 mm; Length of steel bar = 100 mm

Outer diameter of composite bar = 25 mm; Inner Diameter of composite bar = 9 mm; Length of composite bar = 100 mm

Volume of solid bar = $\pi \times (8)^2 \times 100 = 20106.19\ mm^3$

$= 2.0106 \times 10^{-5}\ m^3$ -------------- (i)

Volume of Hollow composite bar = $\pi \times 100 \times ((12.5)^2 - (4.5)^2) = 42725.66\ mm^3$

$= 4.2725 \times 10^{-5}\ m^3$------ (ii)

Mass of solid bar = $7850 \times 2.0106 \times 10^{-5} = 0.1578$ kg -- (iii)

Mass of Hollow composite bar of carbon fiber = $1490 \times 4.2725 \times 10^{-5} = 0.0636$ kg -------------- (iv)

Mass of Hollow composite bar of carbon fiber = $2000 \times 4.2725 \times 10^{-5} = 0.0854$ kg -------------- (v)

V. ANALYSIS RESULTS

Equivalent stress

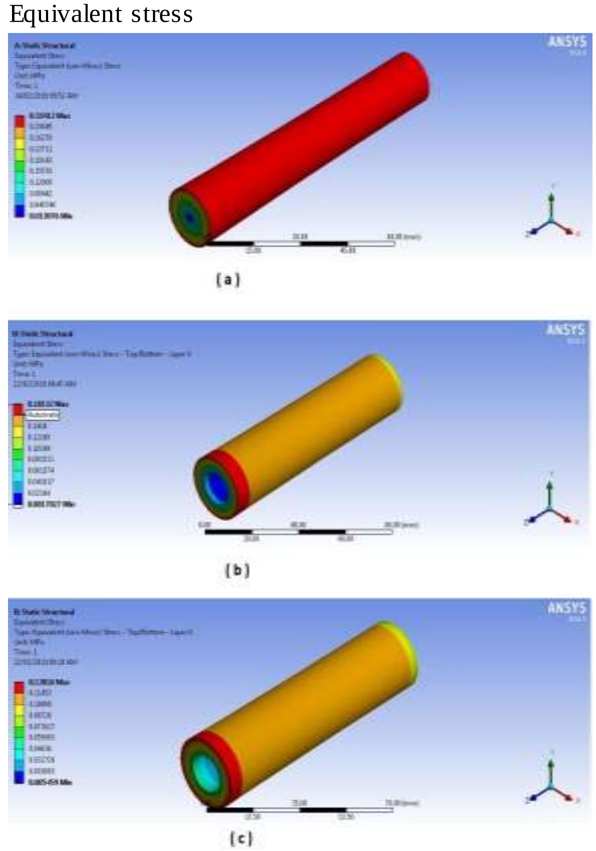

Figure 3: (a) Mild Steel, (b) Epoxy\E-Glass & (c) Epoxy Carbon UD

Total Deformation

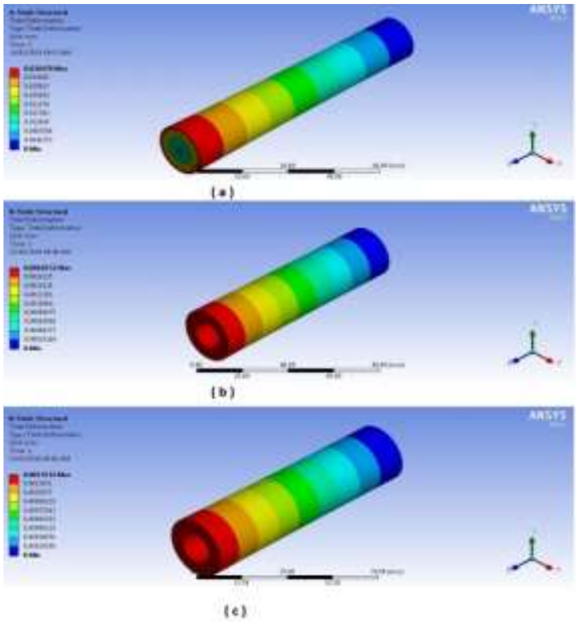

Figure 4: (a) Mild Steel, (b) Epoxy\E-Glass, & (c) Epoxy Carbon UD

Total Strain Energy

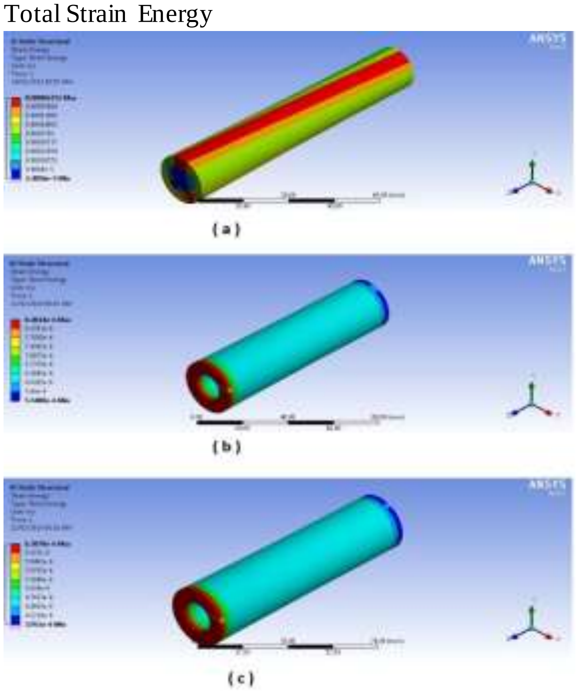

Figure 5: (a) Mild Steel, (b) Epoxy\E-Glass, & (c) Epoxy Carbon UD

Analysis Results

The results are represented in graphs and the detailed result is presented in tabular form. Results are obtained by brief analysis of different ply orientation of fibers in both E-Glass and Carbon Fiber and it comes out to be 90^{O} is the best orientation for both.

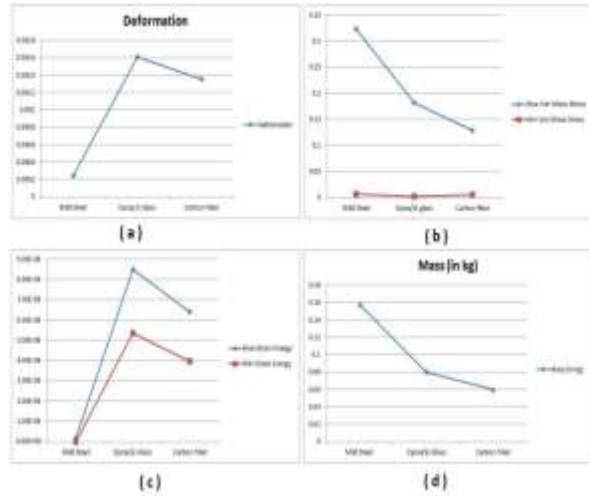

Figure 6: (a) Total Deformation, (b) Equivalent Stresses, (c) Strain Energy & (d) Mass

Table 5: Detailed results of overall analysis

Material	Shaft Dimensions		Deformation (in mm)	Equivalent stress (in MPa)		Strain Energy (in mJ)		Mass (in kg)
	Dia (in mm)	Length (in mm)		Max	Min	Max	Min	
Mild Steel	16	100	0.000243	0.32368	0.0057179	1.82×10^{-7}	8.77×10^{-12}	0.1578
E Glass Fiber	25	100	0.00162	0.18132	0.0017027	8.484×10^{-6}	5.341×10^{-9}	0.0854
Carbon Fiber	25	100	0.00135	0.12816	0.005459	6.387×10^{-6}	3.951×10^{-9}	0.0636

VI. CONCLUSION

In the above analysis the results are very effective and competitive. Our main aim is to find the feasibility of the composite material against the conventional Mild Steel as Torsion bar in suspension system in the vehicles.

The parameters which we set for our standards are:-

1. *Total deformation*: - For the same applied torque of 150 N-mm the bar which shows least deformation is best for torsion bar because if the bar deform too much in little force it will deform a lot on actual load conditions and thus cause in failure of suspension system. In this we found that deformation of mild steel and Carbon Fiber is almost close values rather than that of Epoxy E-Glass Fiber. Thus it proves Carbon Fiber as Alternate material for torsion bar.

2. *Von-Mises Stress (Equivalent stress):-* For the same applied torque of 150 N-mm the bar which shows least value of Von-Mises Stress generated due to the applied shows that the bar has less probability of failure due to actual loads. In this context Carbon Fiber shows less generation of Von-Mises stress in the body and thus best suited for torsion bar.

3. *Strain Energy*: - Strain energy is the parameter use to define the energy absorption capacity of the material. If a torsion bar absorb more strain energy it means it will absorb all the energy of jerk in suspension system and gives less spring back effect thus make the ride comfortable .Strain energy of glass fiber material is more therefore torsion bar with Glass Fiber Reinforced material has more strength to weight ratio.

4. *Weight:* - The main objective in automobile industry is to increase the power to weight ratio of the vehicle thus increase the efficiency of the vehicle. In this context our main aim is to optimize the weight of the vehicle so the torsion bar with less weight is more recommended for the application. In the above analysis it is found out that the Carbon Fiber bar is of less weight as compared to other thus it is most suitable for suspension system.

REFERENCES

[1] Rajashekhar Sardagi1, Dr. Kallurkar Shrikant Panditrao2,Design and Optimization of Passenger Car Torsion Bar, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X ,PP 15-18– 2014.

[2] Vaibhav P. Vinchure1, S.B.Kumbhar2, Analysis of Glass Fiber reinforced composite Torsion Bar, International journal of advance research in science and technology, volume no. 7, special issue no.3, April 2018.

[3] M. Manikandan1, K. Raja2, V.S. Chandrasekar3, Experimental investigation on torsion bar suspension system using E- Glass fiber reinforced composite material, IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308, Volume: 03 Special Issue: 11 | NCAMESHE - 2014 | Jun-2014.

[4] M.Prakash1, R.Sureshkumar2, Analysis of Hollow Torsion Bar Made of E- Glass Fiber Reinforced Composite Material IJRSI (International Journal of Research and Scientific Innovation) ISSN 2321 – 2705, Volume III, Issue V, May 2016.

[5] V.S. Chandrasekar a, Dr.K.Raja b, Material selection for automobile torsion bar using fuzzy topsis tool, International Journal of Advanced Engineering Technology E-ISSN 0976-3945, Vol. VII/Issue II/April-June,2016/343-349.

[6] Gerald R. Kress, Paolo A. Ermanni, CFRP torsion bar: load introduction problem, 16TH International conference on composite materials, Kyoto, Japan-2007.

[7] T.Rangaswamy, S. Vijayarangan, R.A. Chandrashekar, T.K. Venkatesh and K.Anantharaman, Optimal design and analysis of automotive composite drive shaft, International Symposium of Research Students on Materials Science and Engineering; December 2002-04 Chennai, India; Department of Metallurgical and Materials Engineering Indian Institute of Technology Madras .

[8] M.A.K. Chowdhuri 1, R.A. Hossain 2, Design Analysis of an Automotive Composite Drive Shaft, International Journal of Engineering and Technology Vol.2(2), 2010, 45-48.

[9] A.Sridhar1, Dr. R. Mohan2, R.Vinoth Kumar3, Design and analysis of composite drive shaft, International Journal of Scientific & Engineering Research, Volume 7, Issue 5, May-2016; ISSN 2229-5518.

[10] D.Dinesh*, F.Anand Raju**; Optimum Design And Analysis Of A Composite Drive Shaft For An Automobile By Using Genetic Algorithm And Ansys; (IJERA) ISSN: 2248-9622 Vol. 2, Issue4, July-August 2012, Pp.1874-1880.