ISSN 2395-1621

Effect of Composite Materials on The Stiffness of The Torsion Bar

[#1]Mr.Kumbar R. B.,[#2]Dr.Sonawane C. R

[1]rvkumbar@yahoo.com
[2]rcsonawane@gmail.com

[#1]ME – Design Dept. of Mechanical, SavitribaiPhule Pune University, Pune.
[#2] Professor Dept.of Mechanical, SavitribaiPhule Pune University, Pune.

ABSTRACT

This paper presents the study of the effect of composite materials on the stiffness of the torsion bar used in suspension system of the automobiles. One end of the bar is fixed while free end is attached to the suspension system. This causes the stabilization of the suspension system. Counteracting the torque is the fact that the torsion bar naturally wants to resist the twisting effect and return to its normal state. This resistance is the key principle behind a torsion bar suspension system.

It was observed that stiffness of the bar plays important role in the performance of the system. Use of composite materials like glass fiber or carbon fiber shows increase in the stiffness of the system. For torsion bar with high stiffness will cause the bumpy ride and even catastrophic failure of the bar. Low stiffness will cause high deformation and fracture. Generally stiffness depends on various parameters like material properties, cross sectional area, load applied. Using advanced numerical technique like finite element analysis one can easily simulate the complex physics problems. In this paper we did the finite element analysis for a regular available torsion bar. The stiffness was calculated using analytical approach and results from finite element analysis were validated. The layer of composite material was considered to be glued on the surface of torsion bar and using finite element analysis the stiffness was calculated. It was observed that the stiffness increases. The optimum thickness of the composite material was found after iterations

Keywords— **Torsion bar, Composite materials**

ARTICLE INFO

Article History

Received :18th November 2015

Received in revised form :

19th November 2015

Accepted : 21st November , 2015

Published online :

22nd November 2015

I. INTRODUCTION

All suspension systems have a common goal, which is to improve the ride in terms of comfort, handling, and safety. This is accomplished by influencing the motions affected by road irregularities to the wheels and axles while minimizing their affect on the vehicle body and frame. A successful design would therefore incorporate (a) a high Sprung-To-Unsprung-Mass-Ratio, (b) A Mass-Spring-Damper System between the vehicle body and the wheels, and (c) An anti-roll bar. Consequently, the wheels and axles endure the most of the motions caused by road irregularities while their affect is minimized on the vehicle body as desired.

Torsion bar suspension, also known as a torsion spring suspension or torsion beam suspension, is a general term for any vehicle suspension that uses a torsion bar as its main weight bearing spring. One end of a long metal bar is attached firmly to the vehicle chassis; the opposite end terminates in a lever, the torsion key, and mounted perpendicular to the bar that is attached to a suspension arm, a spindle, or the axle. Vertical motion of the wheel causes the bar to twist around its axis and is resisted by the bar's torsion resistance. The effective spring rate of the bar is determined by its length, cross section, shape, material, and manufacturing process.

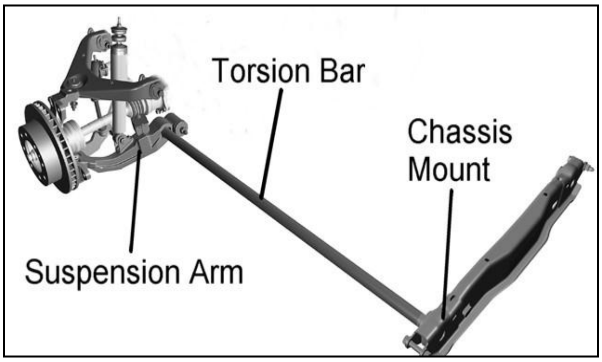

Fig.1 Torsion bar arrangement

Torsion bar suspensions are used on combat vehicles or tanks like the T-72, Leopard 1, Leopard 2, M18 Hellcat, and Abrams (many tanks from late in World War II used this suspension), and on trucks and SUVs from Ford, Chrysler, GM, Mitsubishi, Mazda, Nissan, Isuzu and Toyota. Manufacturers change the torsion bar or key to adjust the ride height, usually to compensate for heavier or lighter engines. While the ride height may be adjusted by turning the adjuster bolts on the stock torsion key, rotating the stock key too far can bend the adjusting bolt and (more importantly) place the shock piston outside its standard travel. Over-rotating the torsion bars can also cause the suspension to hit the bump-stop prematurely, causing a harsh ride. Aftermarket forged-metal torsion key kits use relocked adjuster keys to prevent over-rotation, and shock brackets to keep the piston travel in the stock range.

Anti-roll bar is used in suspension system to limiting body roll angle. They are useful to improve the handling characteristics of the vehicle. Design changes of anti-roll bars are quite common at various steps of vehicle production, and a design analysis must be performed for each change. Anti-roll bar, also referred to as stabilizer is a rod or tube, usually made of steel, that connects the right and left suspension members together to resist roll or swaying of the vehicle which occurs during cornering or due to road irregularities. The bar's torsional stiffness determines its ability to reduce body roll. An anti-roll bar improves the handling of a vehicle by increasing stability during cornering.

II. LITERATURE REVIEW

Many of researchers have contributed in development of peristaltic pump. In this chapter the relevant research work reported is reviewed.

1. Design and Optimization of Passenger Car Torsion Bar.

RajashekharSardagi and Dr. KallurkarShrikantPanditrao are designed torsion bar for passenger car. Torsion bar is generally made of mild steel but they use Nylon is alternative material for torsion bar. Test could conduct on nylon material. It is also compared with mild steel properties. The modeling and failure analysis is done using CATIA and ANSYS. In this work they conduct torsion test on mild steel specimen and nylon specimen. For comparing testing data they use ANSYS software for analysis. The ANSYS result of the torsion bar shows favorable results to select Nylon as alternative material for torsion bar. For comparing the nylon and mild steel the specimen is subjected for torsion test. The mild steel specimen diameter is 16 mm. The MS is used due to cost and easy machinability. The results show the nylon can be one of the alternative materials for torsion bar. [1]

2. Reduction of Stress Concentration at the Corner Bends of the Anti-Roll Bar by using Parametric Optimization.

M. Murat Topac et al are studied to reduction of stress concentration at the corner bends of the anti-roll bar by using parametric optimization. For study, stress concentration at the corner bends of an anti-roll bar use passenger bus anti-roll bar. Stress concentration at the corner bends of an anti-roll bar that is designed for an intercity passenger bus is reduced by optimizing the shape of the critical regions. Stress concentrations in the component are reduced by changing geometry parameter at stress concentration area. The effect of these parameters on stress concentration is evaluated by using Design of Experiments (DoE) approach. Possible design options and their corresponding mass and maximum equivalent stress values are obtained by using finite element analysis. For this study ANSYS Workbench V11.0 commercial finite element software was utilized. FE analyses showed that it is possible to decrease the maximum stress σmax at the critical regions ca. 11% with a mass increase of 3.5%.

The results and research method in this paper can be reference for the optimization of anti-roll bar of passenger car. [2]

3. Parametric Optimization to Reduce Stress Concentration at Corner Bends of Solid and Hollow Stabilizer Bar.

PreetamShinde and M.M.M. Patnaik studied stress concentration at corner bends of anti-roll bar of front axle suspension system for parametric optimization. They use solid and hollow anti-roll bar for this study. This project looks into the performance of stabilizer bar with respect to their stress variations at corner bends and weight optimization. In order to do this, parameters which constitute the geometry of the stress concentrated regions are determined. Design of Experiments (DOE) approach and parametric correlations are used for evaluating effect of these parameters on stress concentration. For the limited deformation of the bushings, behavior of the material was assumed as linear isotropic. Therefore, application of the Parametric Optimization Process to minimize the stress concentration at these regions of the anti-roll bar that is subjected to dynamic loading during the service life of the vehicle is very much essential. To minimize the stress concentration at the corner bends the transition length and the transition radius that constitute the geometry of the critical regions are studied for solid as well as hollow stabilizer bar. FE analyses showed that it is possible to decrease the maximum equivalent stress at the critical regions [3]

4. Investigation into Effect of Rubber Bushing on Stress Distribution and Fatigue Behavior of Anti-Roll Bar.

M. Cerit et al are investigation into effect of rubber bushing on stress distribution and fatigue behavior of anti-roll bar. In this study, stress distribution of an anti-roll bar has been investigated by using FE method for various polyurethane rubber material type and wall thickness under 7o rotational loading. Structural analyses and experimental results indicated that the inner surface of the corner bend is critical from point of fatigue failure.. It was found that both soft rubber and thick wall thickness tend to reduce stress in the critical region. Based on FE analyses results of anti-roll bars with specific bushing were planned. It was concluded that the reduction of equivalent stress in anti-roll bar accomplished by modifying the bushing provided a significant improvement in the fatigue life. Approximately nine percent improvement in the fatigue life with respect to base bushing could be obtained by selecting relatively soft rubber materials. [4]

5. Analysis of Torsion Bar by the Finite Element Technique.

Yogesh Sharma analyzes torsion bar by the finite element technique. For this study, full vehicle simulations were done in ANSYS to predict the response of the proposed solutions. A Maruti Alto 800 was used as the test vehicle to verify the results of the simulations. In this paper he analyzes, liner analysis of antiroll bar is carried out. A stress analysis is also carried out by the finite element technique for the determination of highly stressed regions on the bar. The factor of safety of theoretical calculations is more than two; whereas for the FE simulations the stress developed are within yield strength of the material, so again the factor of safety in this case is more than two. Considerable factor of safety (FOS) or design factors is applied to the anti roll bar design to minimize the risk of failure & possible resulting injury. [5]

6. Application of Finite Element Method in the Study of Variables that Influence the Stiffness of the Anti-Roll Bar and the Body Roll.

Ribeiro, S. and Silveira, M published a paper in SAE Technical Paper 2013. The objective of this work is to analyze the main geometric variables that alter the stiffness of the anti-roll bar, which consequently influence the charge transfer between the wheels of the axle, while in a curve, and the body roll. To calculate stiffness FEM software was use. It was verified the change in stiffness caused by varying the position of the bushings that are used to hold the bar, profile cross-section. The ratio between stiffness and weight served as a comparison for the bars, and revealed for what configuration studied was achieved the best effect in reducing rollover and with minor addition of weight to the vehicle. [6]

7. Design and Software Base Modeling of Anti-Roll System.

Durali, M. and Kassaiezadeh are published paper in SAE Technical Paper 2002.This paper focuses on design and modeling of anti-roll system for a subcompact passenger car. In this paper two software are linked and a complete model is made for study and controller design. Simulink. The system consists of hydraulic assisted torsion bars on car suspensions, a hydraulic power unit, and controls. This paper introduces the method as a useful tool for vehicle dynamics studies and discusses the problems and advantages of the method. [7]

8. Light Truck Stabilizer Bar Attachment Non-linear Fatigue Analysis.

Zhao, Y., Lee et al are published paper in SAE Technical Paper 1998. The stabilizer bar attachments problem cannot be simply analyzed by using linear FEA methodology. In this paper they use nonlinear analysis for anti-roll bar. Here considering contact nonlinearity like large deformation in the bushing, the elastic-plastic material property in the bushing retainer bracket, and the contact between different parts. It was found that using strains to estimate the fatigue life was more accurate and reliable than using stress. Many modeling techniques used in this analysis were able to improve analysis efficiency. [8]

9. Non-Linear Analysis of Tunable Compression Bushing for Stabilizer Bars.

Fan, X et al published paper in SAE Technical Paper 2004.In this paper, nonlinear CAE tools are used to evaluate compressively loaded bushing system. To prevent the axial movement of the stabilizer bar within the bushing, several new systems have been developed. The new systems introduce permanent compressive force between the bar and the bushing thereby preventing the relative movement of the bar within the bushing. Effects of the compression parameters such as compression length and the compression depth on bushing rates are discussed. [9]

III. Literature Summary

By the literature review it is seen that importance of nonlinear analysis and various methods of static analysis of anti-roll bar. In earlier researches linear parameters of torsion bar were considered but in practice it behaves with nonlinear characteristic. So it is important to consider the nonlinearities in system while designing the torsion bar. As development in material science, the use of composite materials has increased. In this competitive world industries are always seeking for optimization and it can be achieved by using advanced techniques.

IV. Problem Identification

The torsion bars are used in cars for stabilizing the suspension system and adjust the height of the vehicle. Torsion bars are generally subjected to torsional shear stresses. Researchers have carried a lot of work on the various design concepts. But the use different composite materials have not yet been observed in the literature reviewed yet. In this dissertation a torsion bar made of steel will be tested for different loading conditions and the material will replaced by different. Also various parameters affecting the performance of the torsion bar will be studied.

Analytical Calculations:

	C	Mn	P	S	Si	Cr	Mo
AIAI 4140	0.38	0.75	0.035	0.04	0.15	0.80	0.15
AISI 4340	0.43	0.80	0.035	0.04	0.30	1.65	0.3

Design of torsion bar

According to maximum shear stress theory

$$\tau all = \frac{0.5\ Syt}{N}$$

Where,

τ= allowable shear stress

Sty= tensile yield strength

N= factor of safety = 2

According to shear stress theory

$$\frac{T}{\theta} = \frac{GJ}{l}$$

Where,

= Torque in N.mm

= Angle of twist in rad

G= Modulus of rigidity (N/ mm2)

J= Polar Moment of Inertia (N/mm2)

$$J = \frac{\pi}{32} * d^3$$

Tensile yield strength of material used for torsion bar is 450 N/mm2

Hence,

$$\tau all = \frac{0.5\ Syt}{N}$$

Basic shaft equation

$$T = \frac{\pi}{16} * \tau * d^3$$

Here we have allowable shear stress for torsion bar from that we can calculate maximum torque that can be transmitted by torsion bar.

$$T = \frac{\pi}{16} * \tau all * d^3$$

And hence we can find maximum allowable angle of twist of torsion bar is given by

$$\frac{T}{\theta} = \frac{GJ}{l}$$

$$\theta = \frac{T * l}{G * J}$$

$$\theta = 183.51^{o}$$

Angular displacement (rad)=Tangential deformation/radius*(pi/180)

Torsional stiffness = applied torque/ angular displacement

(N-m/rad)

V. CAD AND CAE MODEL

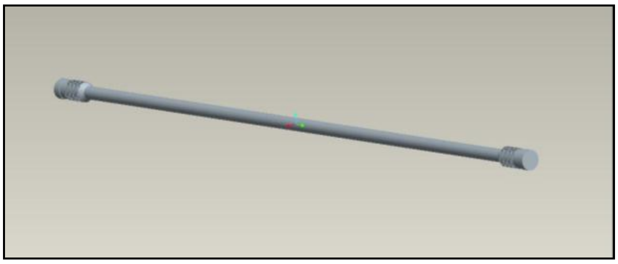

Fig.2 CAD model of a torsion bar

The results calculated from analytical method are necessary to be validated using numerical approach. Use commercial finite element program was done to find the deformation and maximum shear stresses developed. From finite element analysis it deformation in tangential direction was found.

The CAD model was developed using CAD software. The boundary conditions were applied and torque was applied on free end.

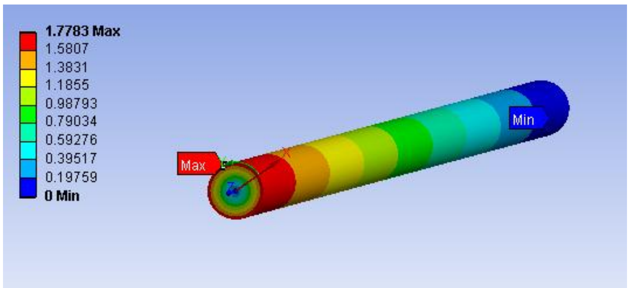

Fig.3 Tangential Deformation in bar using ANSYS

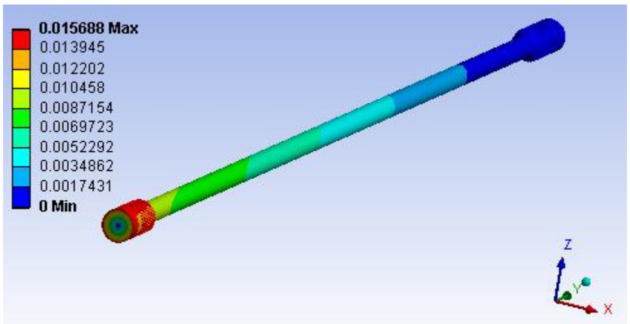

Fig. 4 Deformation of a torsion bar

The CAD model of the torsion bar is created. Using Finite element analysis the torsion bar is tested for the torque. The maximum shear stress is also calculated. It is necessary to validate these results. Use of analytical method cannot be done to find the exact values due to the shape of torsion bar. In stage two of this dissertation the experimental analysis will be done to find the stiffness of the torsion bar and validate results derived from finite element analysis.

VI. RESULTS

	Results from Analytical method	Results from Finite Element Analysis
Tangential deformation (degree)	183.51	182.34
Max. Stress (MPa)	450	438.6

VII. CONCLUSION

It was observed that the results from analytical approach and finite element analysis were within the error limit. It can be concluded that use of numerical analysis can be used for solving the problem but needed to be validated using experimental analysis. The finite element analysis is can be used for deriving the results for composite materials.

ACKNOWLEDGMENT

Thanks to Dr.Sonawane C. R. for his valuable contribution for this paper.

REFERENCES

.

[1] Filiz ÇIVGIN "Analysis Of Composite Bars In Torsion", DokuzEylul University

[2] Graduate School Of Natural And Applied Sciences, September, 2005, iZMiR

[3] Kemal Çalişkan "Automated Design Analysis Of Anti-Roll Bars", September 2003

[4] RajashekharSardagi, Dr. KallurkarShrikantPanditrao, "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

[5] VinkoMočilnik, NenadGubeljak, JožefPredan, "Model For Fatigue Lifetime Prediction Of Torsion Bars Subjected To Plastic Presetting", ISSN 1330-3651 UDC/UDK 620.172/.176:669.14-272.

[6] Jinho Woo1 and Won-Bae Na1 "Effect of Cutout Orientation on Stress Concentration of Perforated Plates with Various Cutouts and Bluntness", International Journal of Ocean System Engineering 1(2) (2011) 95-101 DOI 10.5574/IJOSE.2011.1.2.095

[7] N.T. Younis, "Assembly stress for the reduction of stress concentration", Mechanics Research Communications 33 (2006) 837–845.

