IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified

Vol. 3, Issue 8, August 2016

# An Overview of Analysis of Torsion Bar of Light Motor Vehicle Car with Nonlinear Parameter

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**Abstract:** Torsion bar is a suspension component used at the front, rear, or at both ends of a car such as it keep tires in contact with the surface of the road, support the weight of a vehicle and absorb the forces generated by the movement and motion of the vehicle. Most real-world phenomena exhibit nonlinear behavior. In these paper overviews of various works are done. This paper tries to give an idea about the previous researches & their finding about study of Torsion Bar (Torsion Spring Suspension or Torsion Beam Suspension), Static analysis of Torsion bar, finding out torsional stiffness, study related to vibration absorber and its application & comparison results of linear & nonlinear with its parameter.

**Keywords:** Torsion bar (Torsion Spring Suspension or Torsion Beam Supension), FEA, Nonlinear Behavior.

## I. INTRODUCTION

All suspension systems have a common goal, which is to improve the ride in terms of comfort, handling, and safety. Torsion bar suspension is commonly used on tracked vehicles, although there are some wheel driven vehicles using this type of suspension. The suspension works by having one end of the bar fixed in position on the vehicle chassis to prevent rotation, whilst the other end is connected to a control arm and wheel hub. The control arm is fixed to the chassis using rubber bushings which allow only vertical movement about the mounting points. The torsion bar is connected to the control arm through a number of splines which translate the vertical movement of the control arm into a rotational or torsional force. The difference between torsion bar and anti-roll bar is that , torsion bar is type of suspension system that uses a circular torsion rod which act as a spring and anti-roll bar is circular torsion rods that are connected between the two struts of either the front or rear axle. In torsion bar, when the wheel is subjected to a bump there will be disturbance in the control arm, thus causing the torsion bar to twist. This is when it behaves as a spring and produces the suspension effect.

The working principle of torsion bar is a shaft under torsion stresses. In earlier researches linear parameter of torsion bar were considered but in practice torsion bar behaves with nonlinear parameter. So it is important to consider the nonlinearities of torsion bar. When the structural response (deformation, stress & strain) is not linearly proportional to the magnitude of the load (force, pressure, moment, torque, temp. etc) then the analysis of such a structure is nonlinear analysis. A nonlinear structure response may arise due to geometric and material nonlinearities, as well as change in the boundary conditions and structural integrity.

In geometric nonlinearities may be related to large deformation, large strain, large rotation. It takes into account that as a result of large deformation. Material nonlinearities occur when the stress-strain or force-displacement law is not linear, or when material properties change with the applied loads. In material nonlinearities, it takes into account that entire range of environmental condition such as loading, temperature and rate of deformation for analysis. In boundary or contact nonlinearities, it takes into account that boundary condition in FE model for analysis and contact pair is complicated phenomenon due to nonlinearity, comparing results of theoretical and experimental of linear and nonlinear with its parameter.

## II. THE EFFECTS ON TORSION BAR

G.Brabie:-"The effects of torsion on the initial geometry of bars having non-circular cross-sections." In this paper they have studying "The effects of torsion on the initial geometry of bars having non-circular cross-sections". In that they are important aspects such as aspects concerning the changes in length and aspects concerning the changes of the initial shape, when effect of torsion on bars twisted with large angles of twist. They have taken two geometry shape such as square cross- sectional shapes and rectangular cross- sectional shapes.

Aspects concerning the changes in length: The variation of the changes in length depending upon the twist angle for a square cross- sectional shapes and rectangular cross-sectional shapes. In the analysis we get the graph result of

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both shapes of cross- sectional. The increase of the contraction size is determined by the increase of the twist angle; for angles of twist between 0° and 1440°, the contractions vary between 0 and 4% in the case of square and between 0 and 8% in the case of the rectangular cross-section. Its results will be twist angle and cross sectional area influence the size of contraction in length.

Aspects concerning of the initial shape: In this aspects, they are two cases such as 1) both cross-sectional shapes, the longitudinal at faces 2) both cross-sectional shapes, the transverse direction. In the first case we have examining that longitudinal sections cut along the axis of twisted bars, it can get remarked that the edge of the sections are composed of convex and concave curved lines on the bar. In the second case, experimental results can obtained in different twisting stages, it will be the outline of the square and rectangular cross-sectional of straight lines pass into curved lines after twisting and also the curvature of these lines increasing with increases of the twist angle.
In the axial direction, there is contraction in length, helical orientation of the longitudinal geometrical forms and inclination and warping of the cross sections. In the transverse direction there is change of the initial cross-sectional shape, curving of the straight sides and inclination of the axes of symmetry. This is most important in the effects of torsion on the initial geometry of bars having non-circular cross-sections for square and rectangular cross-sectional of bars.

Mr. Rajkumar D. Patil1, Prof. P. N. Gore:-"The Effect of Specimen Geometry on Torsion Test Results". In this paper they have studying the effect of specimen geometry on torsion bar and also done by experimental by using Nadai method. In this method to determine the true shear stress-strain curve without measurement of radial and hoop strains. This method taken into accounts for change length in free-end torsion. This paper is comparing between solid and tabular (hollow) specimen but its results shows that tabular specimen is more reliable than solid specimen for torsion bar .When force is applied in axial direction then axial displacement is maintained constant, torque is increased, the axial load carrying capacity of specimen decreases. A rapidly drop in the axial load carrying capacity when the angle of twist is maintained constant and axial load is increases.

## III. FATIGUE IMPACT AND FATIGUE CRACK GROWTH ON TORSION BAR

Ion Dumitru, Liviu Marsavina et al:-"Experimental study of torsional impact fatigue of shafts". In this paper we are studied the fatigue strength of shafts under repeated impacts. In this paper repeated impacts was designed for torsion tests of shafts when loading conditions are same. The stress concentration effect occur due to a fillet radius between square and circular cross section. They have selected for five groups of shafts with radius between 0.5 and 3.2mm from a number of 100 shafts with different notch radius. It will be taken two different numbers of cycles, analysis will be done by energy reduction factor β due to a notch the variation of the notch sensitivity factor. It was observed that for a high number of cycles (N= $2x10^6$cycles) impacts, the behavior is similar to that of traditional fatigue tests. For lower number of cycles (N= $7x10^4$cycles) the particular aspect of the notch sensitivity is highlighted in the limited durability domain. The crack propagation direction at the surface of the specimen was almost constant with an angle approximately 48.61° under torsional impact fatigue.

D. Chandra, J. Purbolaksono, et **al:-**"Fatigue crack growth of a corner crack in a square prismatic bar under combined cyclic torsion–tension loading". In this paper we have evaluating the stress intensity factors (SIFs) and fatigue crack growth (FCG) of a corner crack in a prismatic bar under combined cyclic torsion–tension loads. They have taken three of mode name such as Mode I, Mode II & Mode III & also considering as a aspect ratio(a/c) i.e a/c= 0.66 (4/6), a/c= 1(4/4), a/c= 1.5(6/4). It was crack growth behavior under non-proportional combined Cyclic Mode I & Static Mode II, Cyclic Mode II & Static Mode I. They revealed that Static Mode I load (tensile mode) raised significantly crack growth rate under Cyclic Mode II (shear mode) due to reduction of crack surface contact, whereas the introduction of a Static Mode II component on Cyclic Mode I loading led to a decreasing crack growth rate. But the larger Mode III SIFs and the shorter fatigue life were found at the model with the crack aspect ratio a/c ≠1 and having a larger torsional loading.

## IV. DESIGN AND OPTIMIZATION OF TORSION BAR

Rajashekhar Sardagi, Dr. Kallurkar Shrikant Panditrao:-" Design and Optimization of Passenger Car Torsion Bar". In this paper they have designed and optimization of passenger car torsion bar. In this paper they have taken Nylon considered as alternative material and also its compared with mild steel properties. Reducing the un-sprung weight which effect on fuel consumption. Maximum of shear stress and torsional rigidity of Nylon material is grater than mild steel material by using ANSYS software so that Nylon material is more reliable than the mild steel. Nylon material can be used as alternative material because of properties of Nylon is excellent of abrasion resistance, elasticity, resilience, high strength to weight ratio.

## V. ALTERNATIVE MATERIAL OF TORSION BAR

Gerald R. Kress, Paolo A. Ermanni:-"CFRP Torsion Bar: Load Introduction Problem". In this paper we have studied about CFRP Torsion Bar, CFRP (Carbon Fiber Reinforced Plastics) is used as alternative material than steel. CFRP is more efficient and effectively used than steel. This paper they have investigations of load introduction problem and solved it by, a proposed design and manufacturing principle. Composite material is combination of Toolox44 and T-1000 Epoxy; pure composite material can store

IARJSET
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International Advanced Research Journal in Science, Engineering and Technology
ISO 3297:2007 Certified
Vol. 3, Issue 8, August 2016

more deformation energy than one of the steel. Composite spring wound on steel mandrel. The CFRP torsion bar is fiber wound by using a mandrel with enhanced functionality and its diameter increases at the ends so that it holds the fiber strands in place at the fiber path turns. Fiber spike annulus there is a region which can be serrated for connecting other parts with the torsion bar, the diameter increases reduces the stresses holding equilibrium to the applied torque. Various types of considerations is used for designing and analysis model. Types of models for designing areas such as geometry model, fiber winding simulations model and analysis model. In the geometry model, the numbers indicate the following measures and figure:

1) Active length of torsion bar
2) Length of load introduction zone
3) Width of side disk
4) Width of groove toothing
5) Base mandrel radius
6) Active spring radius.

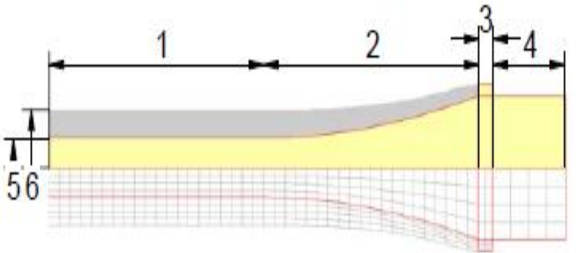


Figure 1:- Geometry Model of Torsion Bar

Load transfer mechanism: - The upper half of visualizes the distribution of the circumferential displacement in µ when darker shades of grey correspond with higher displacement values. Increasing distance from both the center cross-section and the axis of rotation and reaching maximum values at the side disk edge. Load transfer mechanism when torque applied it as shown as following:

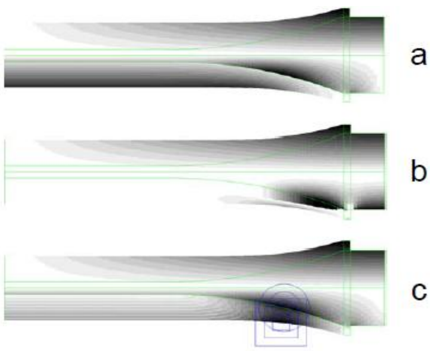


Figure 2:- Load Transfer Mechanism of Torsion Bar

Its concluded that, the shape transition from active spring to the load introduction zones has been optimized by using a parameterized geometry model and a mathematical programming technique. The geometry model takes, via fiber winding simulation into account the dependence between mandrel and CFRP body shapes. The FEM analysis model utilizes rotational symmetry but calculates a fully three-dimensional stress state.

## VI. ANALYSIS OF TORSION BAR BY THE FINITE ELEMENT TECHNIQUE

Mr. H. J. Nadaf, Prof. A. M. Naniwadekar: - "Analysis of Anti-Roll Bar of Passenger Car for its Nonlinear Behavior with Help of CAE". In this paper they have done of analysis of Anti-Roll bar of passenger car for its nonlinear behavior by using Ansys Software and comparing results nonlinear with linear. Stress distribution of an Anti-Roll Bar has been investigated by using FE method when various load is applied. In the Anti-roll bar, linear and nonlinear results indicating that shear stress concentrating on bushing location and reduction in shear stress is realized by bushing provided, also increases 37% in torsional stiffness.

Filiz ÇIVGIN:- "Analysis Of Composite Bars In Torsion". In this paper they have investigations about the torsional deflections and stress analysis of composite bar in torsion. Here we have taken three test piece such as Test Specimen 1(L=200mm, D0=75mm,Di=25mm), Test Specimen 2 (L=150mm, Do=75mm,Di=25mm), Test Specimen 3(L=200mm, Do=70mm, Di=25mm). In this experimental results of three test pieces of torque and deflection are as following as:

Table 1:- Experimental Results of Torsion Bar

| Test Piece | Length (L) mm | Outer Dia meter (Do) mm | Inner Dia meter (Di) mm | Torque Nm | Defle - ction ° |
|---|---|---|---|---|---|
| Specimen 1 | 200 | 75 | 25 | 3200 | 9° |
| Specimen 2 | 150 | 75 | 25 | 3000 | 10° |
| Specimen 3 | 200 | 70 | 25 | 2900 | 16° |

Experiment results with the computerized data are as follows as:

Table No. 2:- Experimental Results with Computerized data of Torsion Bar

| Test Piece | Lengt h(L) mm | Outer Diam eter (Do) mm | Inner Diam eter (Di) mm | Torqu e Nm | Defle ction ° |
|---|---|---|---|---|---|
| Specimen 1 | 200 | 75 | 25 | 2800 | 7° |
| Specimen 2 | 150 | 75 | 25 | 2400 | 4° |
| Specimen 3 | 200 | 70 | 25 | 2400 | 5° |

The experimental results are close to the expected theoretical results for the all specimens. There is an exception in the specimen1, which occurred due to early failure in the connection but this can be disregarded when 75% of the viable area is concerned.

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified

Vol. 3, Issue 8, August 2016

## VII. CONCLUSION

By the literature review it is clear that its importance of nonlinear analysis and different types of method of static analysis of torsion bar. In previous research paper in that they are considered as linear parameter of torsion bar but actually it behaves non-linear characteristic. In designing we are consider non-linearity in an torsion bar.

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