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Review Article

A Review on Anti-Roll Bar used in Locomotives and Vehicles

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Abstract

An anti-roll bar is part of an automobile suspension system which limits body roll angle. This U-shaped metal bar connects opposite wheels together through short lever arms and is clamped to the vehicle chassis with rubber bushes. Its function is to reduce the body roll while cornering, also while travelling on uneven road surface which enhances safety and comfort during driving. An anti-sway or anti-roll bar is intended to force each side of the vehicle to lower, or rise, to similar heights, to reduce the sideways tilting (roll) of the vehicle on curves, sharp corners, or large bumps. This paper includes the materials to be used for the manufacturing of anti-roll bar. The objective of this paper is a detailed review of functions and development of anti-roll bar.

Keywords: *The author can include 5-7 words like Anti roll bar, Design, camber angle, Development, Geometry.*

1. Introduction

Anti-roll bar, also referred to as stabilizer or sway bar, 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. Vehicle anti-roll bar is part of an automobile suspension system. The bar's torsional stiffness (resistance to twist) determines its ability to reduce body roll, and is named as “Roll Stiffness”. Most vehicles have front anti-roll bars. Anti-roll bars at both the front and the rear wheels can reduce roll further. Properly chosen (and installed), anti-roll bars will reduce body roll, which in turns leads to better handling and increased driver confidence. A spring rate increase in the front anti-roll bar will produce under steer effect while a spring rate increase in the rear bar will produce over steer effect. Thus, anti-roll bars are also used to improve directional control and improves traction by limiting the camber angle change caused by body roll. Anti-roll bars may have irregular shapes to get around chassis components, or may be much simpler depending on the car. Ride comfort requires insulating the vehicle and its occupants from vibrations and shocks caused by the road surface. An anti-roll bar improves the handling of a vehicle by increasing stability during cornering. Handling requires providing safety in maneuvers and in ease in steering. The anti-roll bar, as being a suspension component, is used to improve the vehicle performance with respect to these three aspects. The anti-roll bar is a rod or tube that connects the right and left suspension members. It can be used in front suspension, rear suspension or in both suspensions, no matter the suspensions are rigid axle type or independent type. (Kelvin Hubert, *et al*, 2005)

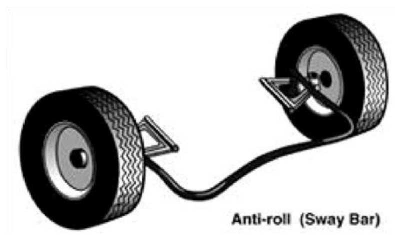

Figure 1 Anti Rolling Bar

2. Parts of Anti roll bar

Anti roll bar is equipped with the parts like mounting plates, bushes, brackets etc., as mentioned below

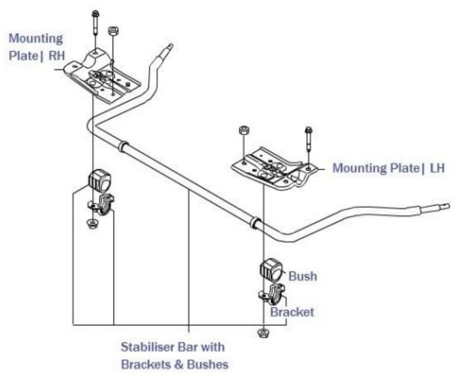

Figure 2 Parts of Anti Rolling Bar

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3. Principle of Anti roll bar

It is usually constructed out of a cylindrical steel bar, formed into a "U" shape, that connects to the body at two points, and at the left and right sides of the suspension. If the left and right wheels move together, the bar rotates about its mounting points. If the wheels move relative to each other, the bar is subjected to torsion and forced to twist. Each end of the bar is connected to an *end link* through a flexible joint. The sway bar end link connects in turn to a spot near a wheel or axle, transferring forces from a heavily-loaded axle to the opposite side (J. E. Shigley, *et al* , 1989),

Forces are therefore transferred:

1) from the heavily-loaded axle
2) to the connected end link via a bushing
3) to the anti-sway (torsion) bar via a flexible joint
4) to the connected end link on the opposite side of the vehicle
5) to the opposite axle.

4. Basic Properties of Anti-Roll Bars

4.1 Geometry

Packaging constraints imposed by chassis components define the path that the anti-roll bar follows across the suspension. Anti-roll bars may have irregular shapes to get around chassis components, or may be much simpler depending on the car. Two sample antiroll bar geometries are shown in Fig.2. Anti-roll bars basically have three types of cross sections: solid circular, hollow circular and solid tapered, in recent years use of hollow anti-roll bars became more widespread due to the fact that, mass of the hollow bar is lower than the solid bar.

Figure 3 Sample Anti-roll bar geometries

5. Material and Processing

Anti-roll bars are usually manufactured from SAE Class 550 and Class 700 Steels. The steels included in this class have SAE codes from G5160 to G6150 and G1065 to G1090, respectively. Operating stresses should exceed 700 MPa for the bars produced from these materials. Use of materials with high strength to density ratio, such as titanium alloys, is an increasing trend in recent years.

6. Connections

Anti-roll bars are connected to the other chassis components via four attachments. Two of these are the rubber bushings through which the anti-roll bar is attached to the main frame. And the other two attachments are the fixtures between the suspension members and the anti-roll bar ends, either through the use of short links or directly.

6.1 Bushings

There are two major types of anti-roll bar bushings classified according to the axial movement of the anti-roll bar in the bushing. In both types, the bar is free to rotate within the bushing. In the first bushing type, the bar is also free to move along bushing axis while the axial movement is prevented in the second type. The bushing material is also another important parameter. The materials of bushings are commonly rubber, nylon or polyurethane, but even metal bushings are used in some race cars (P. M. Bora , *et al* , 2014).

7. Studies on design of Anti Roll bar

The design of an anti-roll bar actually means to obtain the required anti-roll stiffness that improves the vehicles' the stability and handling performance without exceeding the mechanic limitations of the bar material. Since, it's a straightforward process to analyze the anti-roll bar, it's not possible find published studies in the literature. The standard design analyses are performed by manufacturer companies, and the results are not published. Rather, the studies focused on the bushing characteristics and fatigue life analysis of the anti-roll bars are available. Also, some design automation studies about anti-roll bars are present.

Society of Automotive Engineers (SAE), presents general information about torsion bars and their manufacturing processing in "Spring Design Manual"

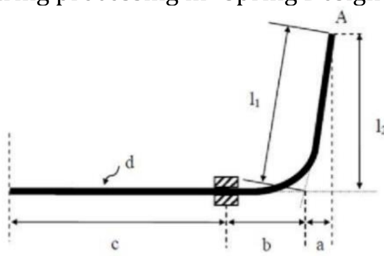

Figure 4 Anti-roll bar geometry used in SAE Spring Design

8. Functions of Anti- roll bar

Anti-roll bars provide two main functions.

1) The first function is the reduction of body lean. The reduction of body lean is dependent on the total roll stiffness of the vehicle. Increasing the total roll stiffness of a vehicle does not change the steady state total load (weight) transfer from the inside wheels to the outside wheels, it only reduces body lean. The total lateral load transfer is determined by the CG height and track width. The other

function of anti-roll bars is to tune the handling balance of the vehicle (Mohammad Durali, *et al*, 2005).

2) Understeer or oversteer behavior can be tuned out by changing the proportion of the total roll stiffness that comes from the front and rear axles. Increasing the proportion of roll stiffness at the front increases the proportion of the total load transfer that the front axle reacts to—and decreases the proportion that the rear axle reacts to. In general, this makes the outer front wheel run at a comparatively higher slip angle, and the outer rear wheel to run at a comparatively lower slip angle, which is an understeer effect. Increasing the proportion of roll stiffness at the rear axle has the opposite effect and decreases understeer (Darling J, *et al* , 1988)

9. Development of Anti-roll bar

The invention has the advantage that for installation of the anti-roll bar according to the invention, the modules and components that are already in use on motor vehicles for this purpose and have proven themselves in terms of vehicle safety technology can be left unchanged in terms of their essential characteristics, as provided, for one thing, by the configuration and shape, and for another, by the selection of the material of the anti-roll bar being presented. An anti-roll bar (stabilizer bar) is a part of many automobile suspensions that helps reduce the body roll of a vehicle during fast cornering or over road irregularities. It connects opposite (left/right) wheels together through short lever arms linked by a torsion spring.A sway bar increases the suspension's roll stiffness—its resistance to roll in turns, independent of its spring rate in the vertical direction. The first stabilizer bar patent was awarded to Canadian inventor Stephen Coleman of Fredericton, New Brunswick on April 22, 1919. The invention relates to an anti-roll bar for a motor vehicle, the anti-roll bar being one-piece or multi-piece and being composed of a torsion rod (12) and bent rotating legs (14) on both sides, the free ends (16) of which can each be connected to a wheel suspension of the motor vehicle by means of swivel joints, wherein the anti-roll bar (11) is formed from a resin-bonded main body. According to the invention, the main body consists of a cord (4), which achieves stiffness by curing the resin. The cord (4) is introduced into a closed tool as a preform and resin is injected into the tool. This has the advantage that, for the installation of the anti-roll bar according to the invention, the assemblies and elements that have already been used on motor vehicles for this purpose and have been tested with regard to driving safety can be left unchanged in the essential characteristics thereof, which is a result of the design and shape of the presented anti-roll bar and of the selection of the material of the presented anti-roll bar. Anti-roll bars were unusual on pre-war cars due to the generally much stiffer suspension and acceptance of body roll. From the 1950s, production cars were more commonly fitted with anti-roll bars, especially those with softer coil spring suspension. An automobile company is developing a hybrid carbon fibre-aluminium anti-roll bar for series production that saves weight and helps improve vehicle efficiency. The composite anti-roll bar is made using epoxy resin, and consists of a hollow composite tube mated to aluminium arms using press fit connection technology. Compared to a steel component is up to 35% lighter. Many firms are developing composite materials so they can be used in more areas of passenger vehicles, from it's anti-roll bar to steering columns and springs.Wider use will help reduce weight, but more complex manufacturing processes, joining challenges and cost remain key hurdles for engineers.

10. Literature Survey

Kelvin Hubert Spartan chassis et.al studied and explained.anti-roll bars are usually manufactured from SAE Class 550 and Class 700 Steels. The steels included in this class have SAE codes from G5160 to G6150 and G1065 to G1090, respectively. Operating stresses should exceed 700 MPa for the bars produced from these materials. The bars are heated, formed (die forged or upset), quenched and tempered. The high stress regions should be shot peened and then coated in order to improve the fatigue life of the bar.

Mohammad Durali and Ali Reza Kassaiezadeh studied & proposed the main goal of using anti-roll bar is to reduce the body roll. Body roll occurs when a vehicle deviates from straight-line motion. The line connecting the roll centers of front and rear suspensions forms the roll axis roll axis of a vehicle. Center of gravity of a vehicle is normally above this roll axis. Thus, while cornering the centrifugal force creates a roll moment about the roll axis, which is equal to the product of centrifugal force with the distance between the roll axis and the center of gravity. (Danesin D, *et al* ,2003).

J. E. Shigley, C.R. Mischke explained that the moment causes the inner suspension to extend and the outer suspension to compress, thus the body roll occurs Actually, body roll is an unwanted motion. First reason for this is the fact that, too much roll disturbs the driver and gives a feeling of roll-over risk, even in safe cornering. Second reason is its effect on the camber angle of the tires. The purpose of camber angle is to align the wheel load with the point of contact of the tire on the road surface. When camber angle is changed due to body roll, this alignment is lost and also the tire contact patch gets smaller.

Conclusion

1) Anti-roll bars are tunable vehicle components which have direct effect on the vehicle’s performances.
2) Locating the bushings closer to the centre of the bar increases the stresses at the bushing locations

which results in roll stiffness of the bar decreases and the max Von-mises stresses increases

3) By changing the parameters of the bar, bar properties can be improved.

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