Review of Design Optimisation and Analysis of Anti Roll Bar in Automotive Vehicle

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Abstract- *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. The ends of the anti-roll bar are connected to the suspension links while the center of the bar is connected to the frame of the car such that it is free to rotate. The ends of the arms are attached to the suspension as close to the wheels as possible. Body roll is an unwanted motion. First reason for this is the fact that, too much roll disturbs the driver and give feeling of roll over risk, even in safe cornering. Thus, driver cannot drive the vehicle with confidence. To reduce this body roll of vehicle anti roll bar is used in suspension system. Optimization of anti-roll bar is to analyze the main geometric parameter which affect rolling stiffness of anti-roll bar. By optimization of geometric parameters, we can increase the rolling stiffness and reduce mass of bar. Changes in design of anti-roll bar are quite common at various steps of vehicle production and a design analysis must be perform for each change. To calculate rolling stiffness mass von-mises stresses ANSYS parametric design languages (APDL) is used. The effect of anti-roll bar design parameters on final anti roll bar properties are also evaluated by performing sample analysis with FEA program developed in this paper.*

Keywords- Anti-Roll Bar, APDL, FEA, Rigid axle, Rolling Stiffness

I. INTRODUCTION

Ride comfort, handling and road holding are the three aspects that a vehicle suspension system has to provide compromise solutions. Ride comfort requires insulating the vehicle and its occupants from vibrations and shocks caused by the road surface. Handling requires providing safety in maneuvers and in ease in steering. For good road holding, the tires must be kept in contact with the road surface in order to ensure directional control and stability with adequate traction and braking capabilities. 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. A typical anti-roll bar is shown in Figure 1. The ends of the anti-roll bar are connected to the suspension links while the center of the bar is connected to the frame of the car such that it is free to rotate. The ends of the arms are attached to the suspension as close to the wheels as possible.

A. Suspension System

Suspension is the system of tires, tire air, springs, shock absorbers and linkages that connects a vehicle to its wheels and allows relative motion between the two. Suspension systems serve a dual purpose contributing to the vehicle's handling and braking for good active safety and driving pleasure, and keeping vehicle occupants comfortable and a ride quality reasonably well isolated from road noise, bumps, vibrations etc. These goals are generally at odds, so the tuning of suspensions involves finding the right compromise. It is important for the suspension to keep the road wheel in contact with the road surface as much as possible, because all the road or ground forces acting on the vehicle do so through the contact patches of the tires. The suspension also protects the vehicle itself and any cargo or luggage from damage and wear. The design of front and rear suspension of a car may be different.

B. Body Roll

When a vehicle is fitted with a suspension there is compliance between the mass of the vehicle and the vehicle's contact with the ground. Body roll is the noticeable (either perceived or measurable) deflection produced when load transfer acts on the compliant elements of the suspension. Anti-roll bars directly impact body roll but their design intent is actually to act as a tool to adjust roll couple percentage or roll moment distribution.

C. Anti-Roll Bar

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. The bar's torsional stiffness (resistance to twist) determines its ability to reduce body roll, and is named as “Roll Stiffness”. An anti-roll bar improves the handling of a vehicle by increasing stability during cornering. Most vehicles have front anti-roll bars. Anti-roll bars at both the front and the rear wheels can reduce roll further. Anti-roll bars will reduce body roll, which in turns leads to better handling and increased driver confidence Thus, anti-roll bars are also used to improve directional control and stability. One more benefit of anti-roll bar is that, it 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.

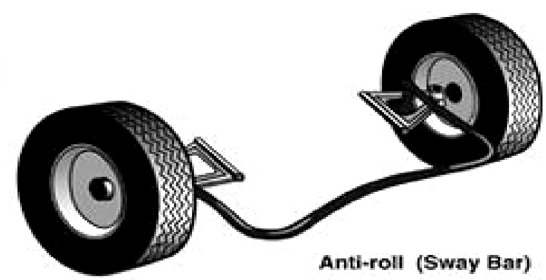

Figure 2.1 - A typical anti-roll bar

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. A typical anti-roll bar is shown in Figure 2.1. The ends of the anti-roll bar are connected to the suspension links while the center of the bar is connected to the frame of the car such that it is free to rotate. The ends of the arms are attached to the suspension as close to the wheels as possible. If the both ends of the bar move equally, the bar rotates in its bushing and provides no torsional resistance.

II. LITERATURE REVIEW

The literature review of the present study is as follows:

A.F. Naud_e and J.A. Snyman [1] were studied the two-dimensional vehicle simulation programme Vehsim2dhas been developed. The leap-frog optimisation algorithm for constrained problems (LFOPC) has been linked to the multi-body dynamics simulation code (Vehsim2d) to enable the computationally economic optimisation of certain vehicle and suspension design variables. This paper describes the simulation programme, the qualification of the programme, and gives an example of the application of the Vehsim2d/LFOPC system. In particular it is used to optimise the damper characteristics of an existing 22 ton three axle vehicle, over a typical terrain and at a representative speed. By using this system the optimised damper characteristics with respect to ride comfort for the vehicle are computed. The optimum damper characteristics give a 28.5% improvement in the ride comfort of the vehicle over the specified terrain and prescribed speed. Further optimisation runs were performed considering other terrain and different speed values. From these results final damper characteristics for the vehicle are proposed. Using the proposed characteristics, simulations were performed with the more advanced and proven DADS programme. The results show that the damper suggested by the optimization study is indeed likely to improve the suspension of the vehicle. This study proves that the Vehsim2d/ LFOPC vehicle modelling and optimisation system is indeed a valuable tool for a vehicle design team.

P.S. Els, et al [2] were investigated the evaluation of the feasibility of using gradient-based approximation methods for the optimization of the spring and damper characteristics of an off-road vehicle, for both ride comfort and handling. The Sequential Quadratic Programming algorithm and the relatively new Dynamic-Q method are the two successive approximation methods used for the optimisation. The determination of the objective function value is performed using computationally expensive numerical simulations that exhibit severe inherent numerical noise. The use of forward finite differences and central finite differences for the determination of the gradients of the objective function within Dynamic-Q is also investigated. This is done in investigating methods for overcoming the difficulties associated with the optimisation of noisy objective functions. A recreational off-road vehicle is modelled in ADAMS, and coupled to MATLAB for the execution of the optimisation process. The full vehicle ADAMS model includes suspension kinematics, a load-dependent tyre model, as well as non-linear springs and dampers. Up to four design variables are considered in modelling the suspension characteristics. It is found that both algorithms perform well in optimising handling. However, difficulties are encountered in obtaining improvements in the design process when ride comfort is considered. Nevertheless, meaningful design configurations are still achievable through the proposed optimisation process, at a relatively low cost in terms of the number of simulations that have to be performed.

M.J. Thoresson, et al [3] were studied methodology which is proposed for the efficient determination of gradient information, when performing gradient based optimisation of an off-road vehicle's suspension system. The methodology is applied to a computationally expensive, non-linear vehicle model that exhibits severe numerical noise. A recreational off-road vehicle is modelled in MSC.ADAMS, and coupled to MATLAB for the execution of the optimisation. The successive approximation method, Dynamic-Q, is used for the optimisation of the spring and damper characteristics. Optimisation is performed for both ride comfort and handling. The determination of the objective function value is performed using computationally expensive numerical simulations. This paper proposes a non-linear pitch-plane model, to be used for the gradient information, when optimising ride comfort. When optimising for handling, a non-linear four wheel model, that includes roll, is used. The gradients of the objective function and constraint functions are obtained through the use of central finite differences, within Dynamic-Q, via numerical simulation using the proposed simplified models. The importance of correctly scaling these simplified models is emphasized. The models are validated against experimental results. The simplified vehicle models exhibit significantly less numerical noise than the full vehicle simulation model, and solve in significantly less computational time.

Guangqiang Wu, et al [4] were investigated two different whole vehicle multibody models, including rigid and rigid-flexible coupling multibody vehicle models. The former is all composed by rigid bodies while in the later model, the flexible rear suspension is built based on the finite element method (FEM) and mode superposition method, in which the deformations of the components are considered. The ride simulations with different speeds are carried out on a 3D digitalized road and the weighted root mean square (RMS) of accelerations on the seat surface, backrest and at the feet are calculated. The comparison between the responses of the rigid and rigid-flexible coupling multibody models shows that the flexibility of the vehicle parts significantly affects the accelerations at each position, and it is necessary to take the flexibility effects into account for the assessment of ride comfort.

Andreas Ueckermann, et al [5] were studied Pavements are 3D in their shape. They can be captured in three dimensions by modern road mapping equipment which allows for the assessment of pavement evenness in a more holistic way as opposed to current practice which divides into longitudinal and transversal evenness. It makes sense to use 3D vehicle models to simulate the effects of 3D surface data on certain functional criteria like pavement loading, cargo loading and driving comfort. In order to evaluate the three criteria mentioned two vehicle models have been created: a passenger car used to assess driving comfort and a truck-semitrailer sub model used to assess pavement and cargo loading. The vehicle models and their application to 3D surface data are presented. The results are well in line with existing single-track (planar) models. Their advantage over existing 1D/2D models is demonstrated by the example of driving comfort evaluation. Existing "geometric" limit values for the assessment of longitudinal evenness in terms of the power spectral density could be used to establish corresponding limit values for the dynamic response, i.e. driving comfort, pavement loading and cargo loading. The limit values are well in line with existing limit values based on planar vehicle models. They can be used as guidelines for the proposal of future limit values. The investigations show that the use of 3D vehicle models is an appropriate and meaningful way of assessing 3D evenness data gathered by modern road mapping systems.

III. CONCLUSION

The design of an anti-roll bar actually means to obtain the required anti-roll stiffness that improves the vehicles' 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 is 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", Anti-roll bars are dealt as a sub-group of torsion bars. Some useful formulas for calculating the roll stiffness of anti-roll bars and deflection at the end point of the bar under a given loading are provided in the manual. However, the formulations can only be applied to the bars with standard shapes (simple, torsion bar shaped anti-roll bars).

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