Abstract

In simple terms, a rubber-to-metal component is a vulcanized rubber block bonded to metal (or plastic), used to join components or structures that must be isolated from noise and vibration. In practice, reaching an effective compromise between durability, safety and comfort when designing each RTM component to suit a specific vehicle model and purpose involves many complex considerations. This leads to unique rubber/additive recipes and product designs to tune dynamic properties while also meeting requirements such as high fatigue strength, resistance to ageing, temperature resistance and recyclability. In addition, vehicle safety systems such as anti-lock braking and traction control can only function perfectly if all suspension components are in faultless condition. Wear in the strut mounts may lead to increased vibration, longer braking distances, or stiff/non-self-centering steering, symptoms that usually develop gradually and go unnoticed by the vehicle owner until a knocking noise prompts investigation [10]. Where possible without dismantling, visual inspection may reveal folds or cracks in the surface of the rubber (see pic, below) or the rubber detaching from the metal. They also create higher loads on new shock absorbers and other suspension components such as drop links, which then wear more rapidly. Therefore motivation for this research is to increase fatigue life of rubber isolator so that there is increase in the life of strut mount of Honda CRV SUV (model no: EX-L 4WD).
1. INTRODUCTION

MacPherson suspension system: It is true that the average member of the vehicle owning public is unaware of the range of duties performed by a vehicle suspension. Certainly many would recognize the importance of the suspension for ride, but fewer would identify its importance in the handling of a vehicle. In reality a vehicle suspension is required to perform effectively under a range of operating conditions including high levels of braking and accelerating, cornering at speed and traversing rough terrain – manoeuvres which are required to be done in comfort and with safety. It is very important to study the vehicle suspension system Design and its fatigue life. Suspension system consists of the different suspension components and there are also different suspension systems. MacPherson suspension is one of the most popular type of Independent suspension system MacPherson strut suspensions started appearing on cars back in the late 1970s as an alternative to the traditional short long arm suspension. When Dodge introduced the front-wheel drive minivan in 1984, it also was fitted with MacPherson struts up front.

![Figure 1: MacPherson suspension system](image)

2. THE ROLE OF A VEHICLE SUSPENSION

I. To provide good ride and handling performance – this requires the suspension to have vertical compliance providing chassis isolation and ensuring that the wheels follow the road profile with very little tyre load fluctuation;

II. To ensure that steering control is maintained during manoeuvring – this requires the wheels to be maintained in the proper positional attitude with respect to the road surface;

III. To ensure that the vehicle responds favourable to control forces produced by the tyres as a result of longitudinal braking and accelerating forces, lateral cornering forces and braking and accelerating torques – this requires the suspension geometry to be designed to resist squat, dive and roll of the vehicle body;

IV. To provide isolation from high frequency vibration arising from tyre excitation. This requires appropriate isolation in the suspension joints to prevent the transmission of Road noise’ to the vehicle body. It will be seen that these requirements are virtually impossible to achieve simultaneously, leading to design compromises with less than ideal performance.

3. RELEVANCE

A strut mount is one of the most important parts of our vehicle’s suspension system. The strut mount serves as the mounting point for the top of our vehicle’s strut assemblies to
connect to vehicle’s chassis. MacPherson strut suspensions started appearing on cars back in the late 1970s as an alternative to the traditional short long arm suspension. Struts were first used on import cars, followed by small domestic front-wheel drive cars like the Ford Escort, Dodge Omni and GM X-cars. When Dodge introduced the front-wheel drive minivan in 1984, it also was fitted with MacPherson struts up front. Today, we will find struts used on a wide variety of vehicles, including passenger cars, crossover SUVs and even some full-size SUVs and pickup trucks. The strut was invented by Earl MacPherson (thus the name given to the component). Replacing the upper control arm, ball joint, shock absorber and coil spring with a strut assembly simplifies the front suspension. The shock damping elements inside the strut housing provide the ride control function of an oversized shock absorber. A strut mount is like sandwich. One side bolts to the vehicle and the other side is to strut and in the middle there is rubber like insulating material called as rubber isolator its function is to dampen suspension noise and vibration. This leads to product designs to tune dynamic properties while also meeting requirements such as high fatigue strength, resistance to ageing, temperature resistance and recyclability. Worn top mounts impair ride comfort, generating noise and transmitting vibrations into the vehicle interior. They also create higher loads on new shock absorbers and other suspension components then wear more rapidly. Faulty components create symptoms like increased vibration, longer braking distances, or stiff/non-self-centring steering. The failure of rubber isolator shows folds or cracks in the surface of the rubber (see pic, below) or the rubber detaching from the metal. So, main objective of this research is to enhance the fatigue life of the rubber isolator of strut mount of Honda CRV with the help of material optimization.

4. LITERATURE REVIEW

i.) J.R Cho et al.(2015),[1] In this domain the fatigue life of the fabric braided composite rubber hose in complicated large deformation cyclic motion is investigated. Because less fatigue life tends to the problems like micro cracks in braking hose which leads to oil leakage .This paper intend to introduce a numerical method for predicting fatigue life of braking hose in the lamination structure composed of pure rubber and fabric braided layer with three different models .The $\varepsilon$-$N$ curve of the inner and outer rubber were obtained by the curve fitting of the experimental data which were made by in house fatigue testing using rubber specimens The validity of proposed numerical method is illustrated numerically and comparison is done with different models.

ii.) J.-H. Kim, H.-Y. Jeong (2005),[2] In this paper the author has studied the effect of carbon enforcement in rubber on its fatigue life, hysteresis, fracture surface morphology and optical J value. Here N330, N650, N990 were investigated experimentally. Hysteresis was calculated by loading and unloading curves obtained during the fatigue testing. After the fatigue test, the obtained surface finish was investigated with the help of surface finish tester .The J value is also calculated experimentally by conducting the tensile test on the specimen From this research the
author come to know that all the four properties were ranked in the following order N330, N990, N650 and from this research it is also proved that logarithmic value of fatigue life is varies directly to square root of product of critical J values.

iii.) C.-S. Woo et al. (2009), [3] The fatigue life evaluation and prediction is one of the important tasks according to safety and reliability is concerned. In this paper the author has studied the effect of ambient temperature on the fatigue life of the vulcanised rubber. The finite element analysis is performed for the both ambient and 70 degree Celsius conditions. The green Lagrangian strains were determined at the critical locations. The model is tested experimentally with the help of dump bell shaped vulcanised rubber specimen and it is found that predicted fatigue lives of rubber components mates with experimental results with the factor of 2.

iv.) F. Rauscher (2013), [4] have done Fatigue analysis of the non-welded pressure vessels which made up of high strength steel is carried out. In case of welded connections stability of the pressure vessels greatly affected in case of moment loading and tend to buckle because of rigid nature. The sophisticated fatigue analysis and testing method is applied to meet the problem of cyclic fatigue. Because of using same wall thickness of high strength steel range the testing is done with standard hydraulic accumulator with the threaded end. This problem of fatigue failure was analysed by reducing the one side wall thickness and higher stress amplitude.

v.) D. Colombo et al. (2009), [5] In this domain the author investigated the cause of premature failure of the upper strut mount of the McPhersons suspension. Here both experimental and numerical analysis has been carried out to estimate the service life of the component. The defect tolerance analysis has been carried out to find out whether there are chances of failure of components. The analysis shows that there are non-propagating cracks present in the components, So there is no danger of fatigue failure of components. The main cause of failure is impulsive load that can be justified by the static and dynamic loads acting on the components.

4. OBJECTIVES:

- Study the suspension system
- Study the material properties and Load and boundary condition applied to the suspension mount strut
- FE modeling of the assembly using Pre-processor
- Explicit analysis for the rubber component
- Result interpretation using Hyper View Interface
- Fatigue life prediction using Fatigue analysis software such as FEMFAT
- Re-analysis for the alternative rubber material
- Experimentation & Validation for the benchmark material

5. METHODOLOGY

5.1 Mathematical Calculation:
Forces acting on the assembly are calculated using mathematical imperial formulae.

- **Force Calculations:**
  Load due speed of the vehicle
  Consider Speed of the vehicle as 80 km/hr
  Kinetic Energy is calculated by,
  \[ KE = \frac{1}{2} MV^2 \]
  \[ KE = \frac{1}{2} \times 1875 \times 22.22^2 \]
  Work Done = Kinetic Energy = 462870.38 J
  Static friction between good tires and a good road surface \( \mu = 0.8 \)
  Stopping distance –
  \[ d = \frac{V^2}{2 \times \mu \times g} \]
  \[ d = \frac{22.22^2}{2 \times 0.8 \times 9.81} \]
  \[ d = 31.46 \text{ m} \]
  \[ W = F_b \times d \]
  \[ 462870.38 = F_b \times 31.46 \]
  \[ F_b = 14712.98 \text{ N} \]
  Load shared by each wheel
  \[ F_b = 3678.25 \text{ N} \]

**5.2 Analytical Method**
Following steps will be used for the execution of the present dissertation work.

- Study the Existing system
- Secure data over Loads, Boundary Conditions & Responses
- Employ Pre-Processor for FE Modelling
- Deploy Solver for Analyzing the Meshed Model
- Suggest Design Alternatives
- Iterate to Secure Results
- Validate using Benchmark Model for Checking Performance
- Recommend the Solution
6. EXPERIMENTATION & VALIDATION
The process of validation for this method is sought through the physical Experimentation. The results of Experimental work considering fatigue life cycle for the existing case study shall be compared for results with the numerical methodology. The concurrence of the results shall offer validation for this thesis work.

7. CONCLUSION
The strut mount job is to reduce noise, vibration that could transmit to vehicle and forces generated due to uneven road surface. There is frequent aging or wearing of the rubber like insulating material called rubber isolator which is sandwiched between two parts of the strut mount. The motivation for this research is needs to increase fatigue life of rubber isolator so that there is increase in the life of strut mount of Honda CRV.

8. REFERENCES
[10] www.pmmonline.co.uk
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