Comparison of Magnesium, Aluminium and Cast Iron to obtain Optimum Frequency for Engine Bracket using Finite Element Analysis

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ABSTRACT

The incorporation of light weight materials in the automotive structures is playing vital role to increase fuel economy and to decrease the emissions. The strategy of increasing use of light alloy content in vehicle has proven to be successful method of achieving fuel economy and environmental concepts. The strong emphasis on cost demanded the component manufacturers to improve the performance of their materials and to find better method to reduce cost. This paper focuses on Finite Element Analysis of Engine mount bracket for optimizing Natural frequency by use of different lightweight materials.

Keywords **– Engine bracket, FEA, modal analysis, static structural, magnesium, aluminium**

I. INTRODUCTION

The automobile engine-chassis-body system may undergo undesirable vibrations due to disturbances from the road and the engine. The vibrations induced by the road or the engine at idle are typically at the frequencies below 30Hz. In order to control the idle shake and the road-induced vibrations, the engine mount bracket should be stiff and highly damped. On the other hand, for a small amplitude excitation over the higher frequency range (30-250Hz) from the engine, a compliant and lightly damped mount bracket is required for vibration isolation and acoustic comfort. So, the engine mount bracket must satisfy these two essential criteria [1]. This difference between isolation characteristics and control characteristics has greatly changed the way in which the automobile industry approaches mount design. A conventional rubber mount cannot satisfy the conflicting requirements simultaneously as the lumped stiffness and the viscous damping are nearly invariant with excitation amplitudes and frequencies over the concerned excitation range (1-250Hz) the present study is based on comparison of lightweight materials for optimizing natural frequency of engine mount bracket by Finite Element software.

The transmission mount assembly includes a support member arranged to be attached to a vehicle frame component, a pair of elastomeric transmission isolators positioned relative to each other on the support member, and a pair of transmission mounting brackets arranged to be positioned on the isolators and attached to a transmission component, wherein the transmission isolators are arranged to maintain the transmission mounting brackets in spaced related to the support member thereby dampening powertrain vibration and controlling powertrain movement relative to the vehicle [2].

The transmission mount in a powertrain mounting system is often a primary path for noise. The vehicle’s structure at the mounting location is crucial in regard to noise transmission, durability and crash worthiness. The upper bracket attaches to the transmission by use of two horizontal fasteners. A limited vertical space is available for both the rubber mount and bracket. With limited rubber volume it is not possible to allow the rubber to be as soft as it is desired for maximum isolation of vibration. Therefore the bracket must be designed to be as stiff as possible. Through the use of Computer Aided Engineering, an optimized bracket design for stiffness, strength and mass is obtained while still supporting a shortened development cycle [3].

Today’s interest in magnesium alloys for automotive applications is based on the combination of high strength properties and low density. For this reason magnesium alloys are very attractive as structural materials in all applications where weight savings are of great concern. In automotive applications weight reduction will improve the performance of a vehicle by reducing the rolling resistance and energy of acceleration, thus reducing the fuel consumption.

Magnesium with its good strength to weight ratio is one of the candidate materials to realise light weight construction, but it has to compete with various other materials. Material selection is thereby determined by economical issues as much as by its component characteristics or properties. However magnesium shows high potential to substitute conventional materials. Magnesium alloys should be used in applications where low mass and high specific properties are required.

In an average General Motors (GM) vehicle, the consumption of aluminium is 123 kg against 4 kg magnesium. The average weight of magnesium in European cars is about 2.5 kg Powertrain applications are so far restricted to lower temperature applications. GM uses magnesium transfer cases in their GMT800-based trucks and sport utility vehicles; VW uses manual transmission cases in the Passat and the Chinese Santana model and Audi in the A4/A6 model. Cam covers are made from magnesium on vehicles ranging from the Dodge Viper to the new Ford F-150, utilising the good sound dampening characteristics Audi has some more magnesium applications in the power train, such as the air intake module on its W12 engine, cylinder head covers on its V8 and the company's multitronic CVT and five speeds manual transmissions both have magnesium housings. BMW uses magnesium using for the fully variable intake manifold featured on BMW's 8-cylinder power units 43 and also VW's W12 engine for the Phaeton has a magnesium inlet manifold 44. Engine blocks (after the end of VW's beetle air cooled engine) are just used in racing cars [4].

Kim [5] used parametric approach to obtain an automatically designed shape of engine mount, an optimum shape design process of engine mounting rubber. They developed optimization code to determine the shape to meet the stiffness requirements of engine mounts, coupled with a commercial nonlinear finite element program. A bush type engine mount used in a passenger car is chosen for an application model. The shape from the result of the parameter optimization is determined as a final model with some modifications. The shape and stiffness of each optimization stage are shown and the stiffness of the optimized model along the principal direction is compared with the design specification of the current model. Finally, an overview of the current status and future works for the engine mount design are discussed. A bush type engine mount has been designed using a parameter optimization method. A well-defined parametric approach is successful in the design of a conceptual shape. The shape obtained from the parameter optimization is determined as a final mode1 with some modifications. This approach can be used in the design of any type of engine mount

Yu [6] investigated that the ideal engine mount system should isolate engine vibration caused by engine disturbance force in engine speed range and prevents engine bounce from shock excitation. That is the dynamic stiffness and damping of the engine mount should be frequency and amplitude dependent. The development of engine mounting systems is concentrating on improvement of frequency and amplitude dependent properties

II. PROPOSED METHODOLOGY

At first the theoretical study of bracket is done. The overall purpose of engine bracket is to support the Engine and powertrain and sustain the vibrations caused by engine as well as bumps from tires due to uneven road surfaces. The key areas for modification are identified. The main task in this study is to tune the natural frequency of bracket by optimizing it for various material combinations. The 3-Dimensional model is prepared for Bracket and Plate assembly. Different types of materials are assigned and analysis is carried out using finite element analysis software named Ansys Inc. Best material combination is selected by comparing various combinations for bracket body and supporting plate. The results are compared with practical results

III. SCOPE OF WORK

This paper explains the process of optimization of natural frequency of engine mount bracket. The problem of engine vibration is considered for noise reduction by optimization of natural frequency. Further scope is to use different lightweight materials, which further reduces weight.

IV. OBJECTIVE

To do static structural and modal analysis of engine mounting bracket for three different materials viz. aluminum (Al), Magnesium (Mg) and Cast Iron (CI) and suggest best material for the bracket.

V. ANALYSIS OF ENGINE MOUNT BRACKET

Figure 1 below shows the computer aided drafting model of the engine mount bracket and figure 2 shows mesh model for the bracket. This Bracket has been assigned various materials according to the Material combinations given in the Table 1. According to the conditions described the finite element Analysis (FEA) is carried out by using Ansys software

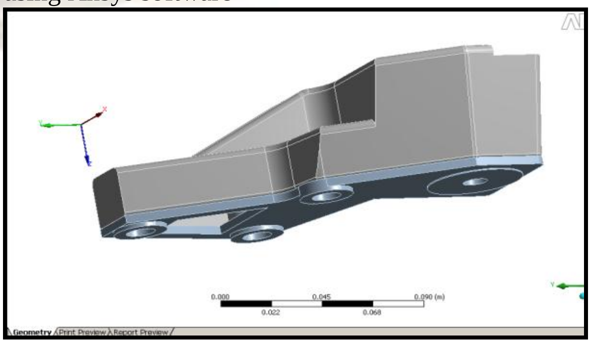

Fig. 1 CAD model of engine mount bracket

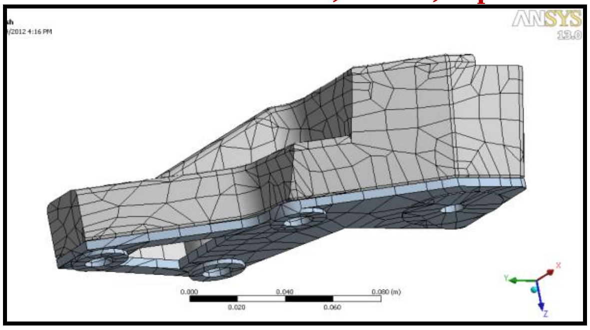

Fig. 2: mesh model of engine mount bracket

Table 1: Different Material combinations

	Bracket Body		
Plate	Magnesium (Mg)	Aluminium (Al)	Cast Iron (CI)
Mg	Mg-Mg	Al-Mg	CI-Mg
Al	Mg-Al	Al-Al	CI-Al
CI	Mg-CI	Al-CI	CI-CI

VI. FINITE ELEMENT ANALYSIS

Finite element analysis (FEA) is a powerful engineering tool that can solve many kinds of engineering problems to as high degree of precision as necessary. In essence, the finite element is a mathematical method for solving ordinary & partial differential equations.

FEM is a computational technique used to obtain approximate solutions of boundary value problems in Engineering. This involves deciding what parts are important and what unnecessary detail can be omitted i.e. disregard any small geometric irregularities; consider load as concentrated, homogenized composite material properties. Then we choose the theory which best describes the behavior of the model such as the behavior best described by beam theory, plate-bending theory, plane elasticity, plane strain or plane stress formulations. When modeling something in FEA attention must be paid to what you are actually trying to achieve.

In this analysis, a complex region defining a continuum is discretized into simple geometric shapes called finite elements. The material properties and the governing relationships are considered over the elements and expressed in terms of unknown values at element corners called as nodes.

Figure 3 describes the boundary conditions of bracket for the analysis. One out of four holes is fixed and load is applied at other three holes. And FE analysis is carried out. The resultant von-mises stress in the analysis is shown in figure 4 and maximum deformation in Figure 5 for Mg-Mg (magnesium –magnesium) combination for the bracket body and plate. The modal analysis of bracket gives natural frequency which is shown in the Figure 6.

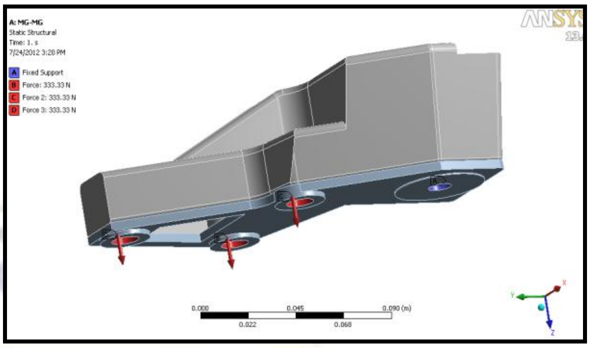

Fig.3: Boundary conditions applied to the Engine Mount bracket

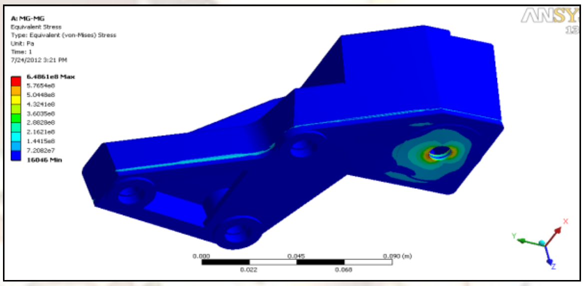

Fig.4: Maximum stress (von mises) for Mg-Mg combination

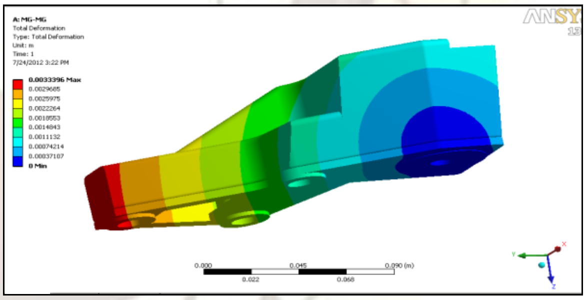

Fig. 5: Maximum deformation (Total) for Mg-Mg combination and 2 mm mesh size

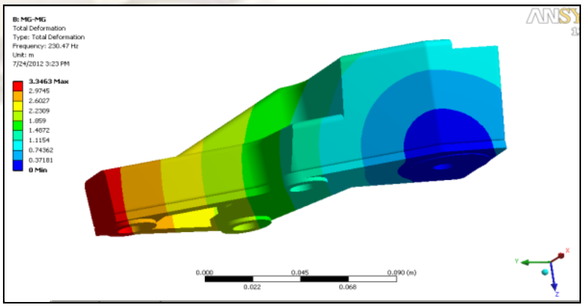

Fig. 6: Mode 1 for Mg-Mg combination and 2 mm mesh size

VII. RESULTS AND DISCUSSION

The graph of stress verses Natural frequency and stress verses deformations are plotted from the FEA.

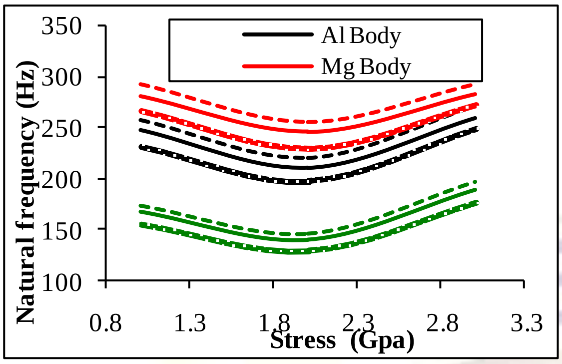

Fig. 7: Natural frequency (Hz) VS stress (GPa)– comparison between Mg, Al and CI body

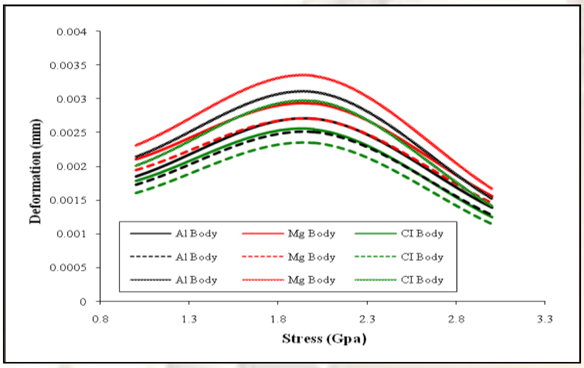

Fig. 8: Deformation (mm) VS stress (GPa) – comparison between Mg , Al and CI body

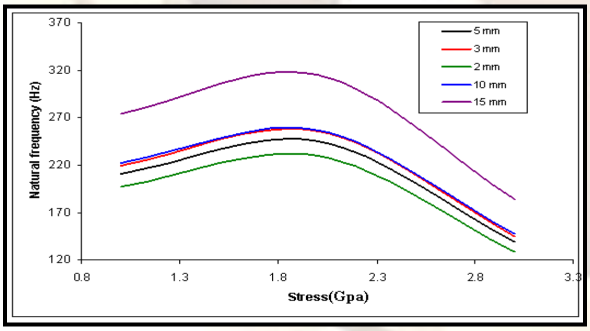

Fig. 9 Natural frequency (Hz) VS stress (Gpa) comparison for 2, 3, 5, 10 and 15mm mesh sizes

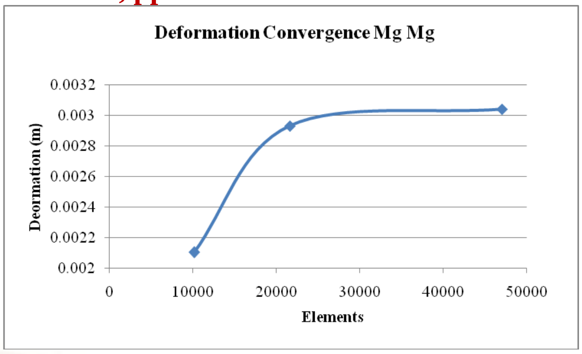

Fig. 10: Deformation convergence for Mg-Mg

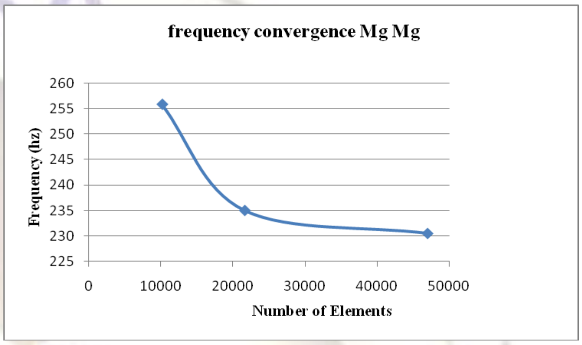

Fig. 11: Frequency convergence for Mg-Mg

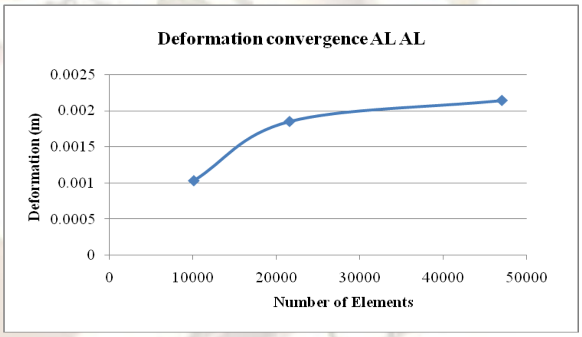

Fig. 12: Deformation convergence for Al-Al combination

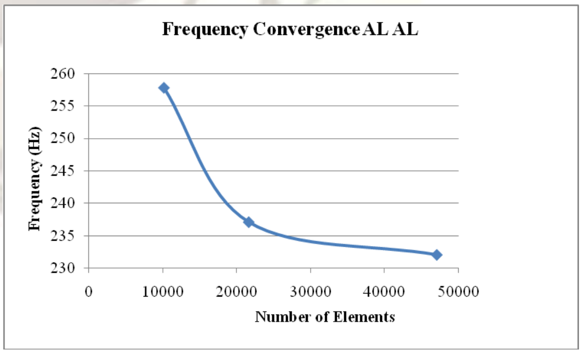

Fig. 13: Frequency convergence for Al-Al

VIII. EXPERIMENTAL TEST MATRIX

The Bracket was tested on shaker table. The vibration signal is sampled by Eddy current sensor and DAQ (data acquisition system). Two excitation methods are used to measure natural frequency of the system. Traditional impulse method, that gives the system single impulse and periodic impulse method realized by electro-magnetically excited impulse. Average natural frequency values (Hz) for AL, CI, and MG are 258.2 Hz, 200.3 Hz and 257.9 Hz respectively.

IX. CONCLUSION

Evaluation of proposed Model of Engine Mount bracket assembly was performed using FEA and modal analysis techniques.

Figure 7, 8 & 9 conclude that natural frequency verses stress and stress verses deformation for different materials with various mesh sizes follow the same trend but at Mg alloy bracket has highest natural frequency followed by Al alloy. CI gives less frequency so it is rejected. Figure 10 & 11 gives the deformation & frequency convergence graph for Mg-Mg combination. From figure 12 and 13 it is clear that the deformation and frequency values converge so the results are correct.

So, performing the analyses, for All possible combinations of three materials Mg, CI, and Al for different mesh sizes of 2mm,3mm,5mm,10mm,and 15mm has been done to Optimize the Natural frequency of Bracket. The results are compared with experimental results and it was found that the bracket manufactured with Mg alloy gives optimized frequency. In addition, Al can be used in few applications but CI alloy gives minimum frequency. Mg and Al are preferred.

X. ACKNOWLEDGEMENTS

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