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SIMULATION STUDY OF DESIGN VARIATIONS FOR AN ENGINE MOUNT OF A PASSENGER VEHICLE

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Abstract: The purpose of this project is to gain a deep understanding of the concept of engine mounts, their working properties, design considerations and the factors that affect its performance. The initial step of this project was to learn and understand the functions and components of an engine mount, it's desirable characteristics, types of engine mounts, it's design considerations, commonly used materials, and causes of damage and failure.

A rubber engine mount of a typical standard drive vehicle is selected for this study, the reason being that the simulation study is purposed to be simple. The selected engine mount is modeled in Solidworks, and the model is analyzed in ANSYS for static stress, and Modal analyses, which provides the physical, and vibrational properties of the engine mount model like stress distribution, strain rate and Deformation, and Natural frequencies. The obtained results (particularly deformation and region(s) of failure) are then compared to its real-life counterparts and the level of the simulations' accuracy is determined.

The engine mount model is then taken up for design changes, where the primary motives are to reduce strain rate and deformation, tuning it's natural frequency, and improve it's fatigue life, stiffness, and damping. The variations in design are based on the ideas to have good vibration damping and dissipation.

The models of the design variants are subjected to the same simulation processes that the standard model. The resulting successful model is determined based on the model that has better endurance and damping characteristics.

Keywords: Engine mount, Vibration, design, analysis

1. INTRODUCTION

Engine mounts are an integral part of every vehicle solely for its primary function of dampening and absorbing the vibrations of the engine. In four wheelers, there are usually four engine mounts (six in exceptional cases). Given its importance in a vehicle, it is still prone to failures that limits its durability, usually due to the high weight of the engine that exerts compressive the rubber over time, and the instances of hard acceleration and deceleration of the vehicle that creates additional pressure for the engine mount that can cause early failure. It also fulfills the purpose of securing the engine to the vehicle frame and preventing it from getting displaced due to external or its own forces. The engine mount is a type of anti-vibrational mount, the concept of which is an important aspect of a field in Automobile engineering called NVH (Noise Vibration and Harshness), which deals with the damping and isolation of unnecessary vibrations created by the powertrain of the vehicle, which can cause a lot of discomfort for the occupants and even cause long term damage to the vehicle parts. There are several types of engine mounts, which includes rubber types, hydraulic types, electronic types, and polyurethane types. This simulation study is conducted using a solid rubber engine mount, the primary components of which are a centre screw, a rubber support, the mount housing, including the metal brackets for bolting the mount to the vehicle frame as well as the engine. The performance of the engine mount can be evaluated by subjecting the engine mount model to various simulations, which include static stress, deformation, and modal analysis.

2. EXPERIMENTAL METHODS OR METHODOLOGY

This section discusses the procedures that was followed for the simulation study, from design and modelling to the comparison of the performance parameters among the alternate mounts and the standard mount models. The first step was the selection of the selection of engine mount model, the model selected for this study is a typical solid rubber mount

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that is widely used in most of the standard drive vehicles. Then the mount model specifications are referred and from multiple sources on the internet as well as from automobile experts for cross verification and to take note of critical dimensions. The next step was creating the CAD model of the complete engine mount. After the modelling and specifying the material properties, the mount model is tested for static stress loading conditions, constraining the centre screw and the sides covered by the cylindrical mount housing, along with static stress, deformation simulation is also performed. The mount model is also subjected to modal analysis to understand it's natural frequency characteristics. Based on the results obtained from the above, design variants of the engine mount rubber support are devised and modelled.

Fig. 1. CAD Model of standard model rubber support

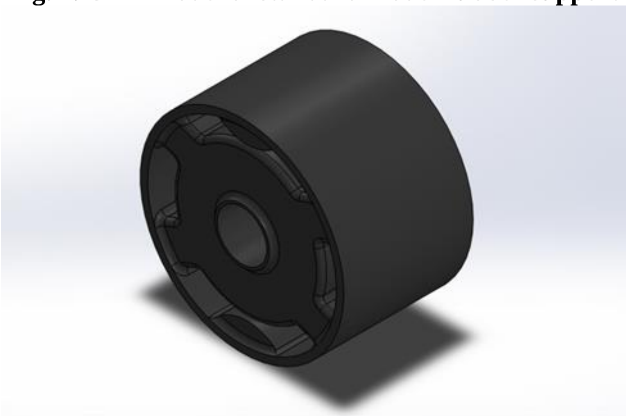

Fig. 2. CAD Model of alternate model B rubber support

Fig. 3. CAD model of alternate model C rubber support

These alternate models are put in the same simulation and analysis processes as the standard model, and based on the results, the properties and the performance parameters of the alternate models and the standard model are compared. The

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mount that successfully fulfils the load and vibration isolation and damping requirements is determined as the successful model.

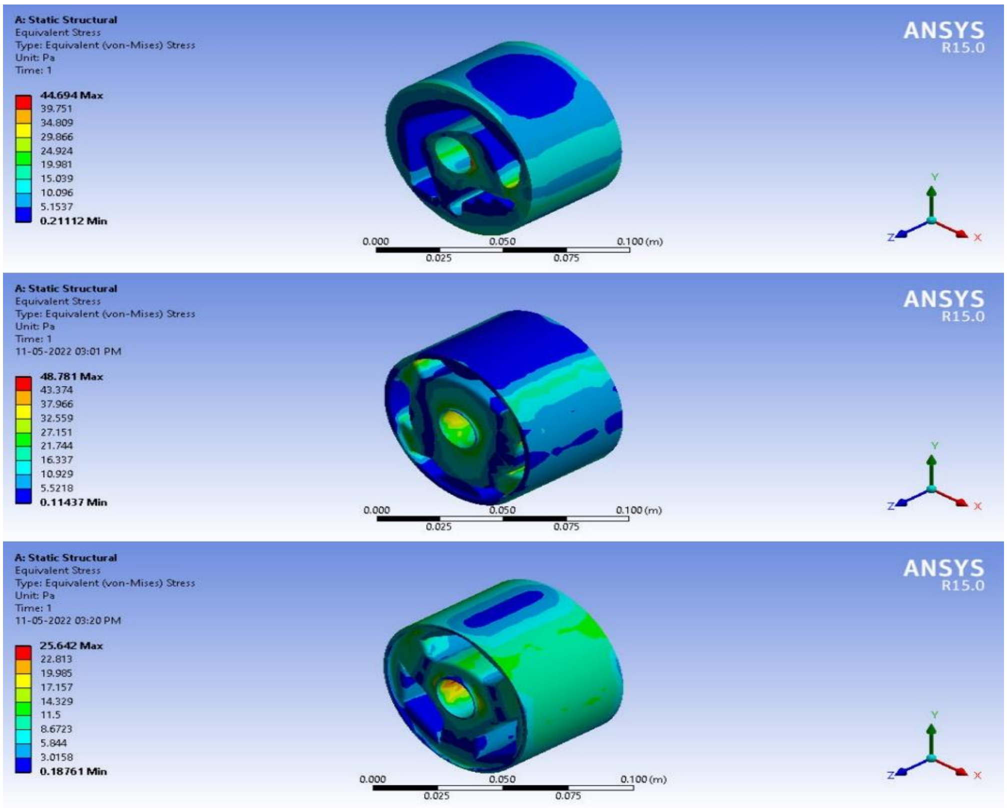

Fig. 4. Equivalent Stress Von-Mises results of Mount A, B, C (Static Structural)

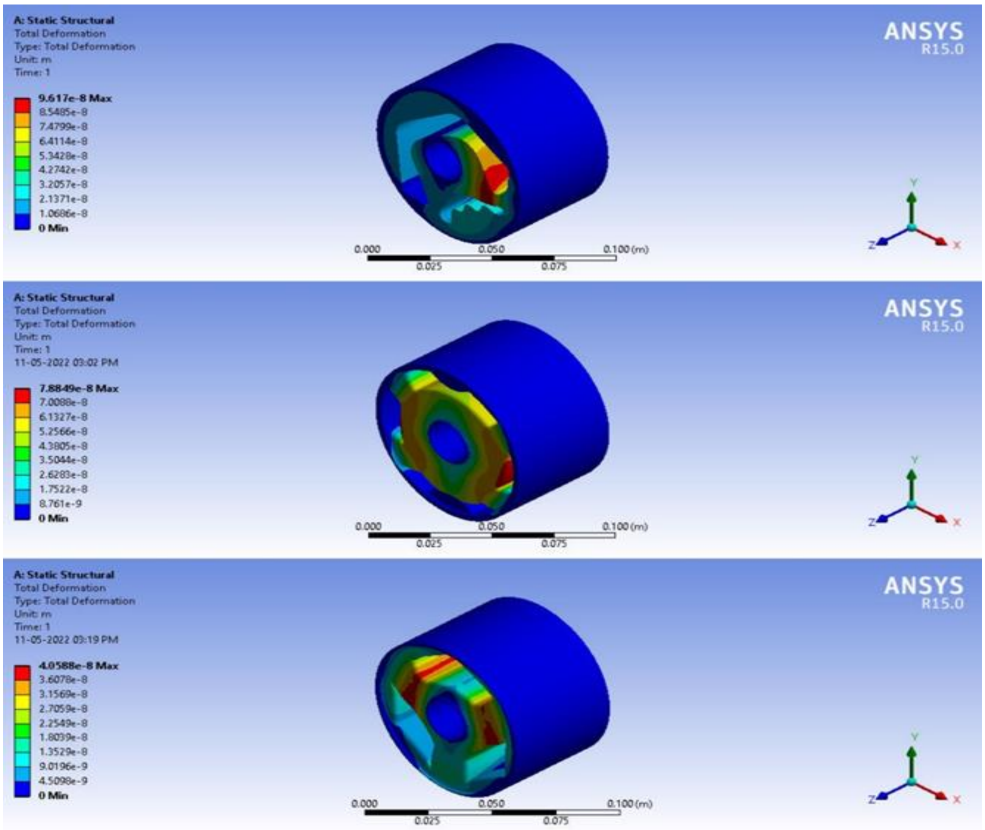

Fig. 5. Total Deformation Mount A, B, C (Static Structural)

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3. RESULTS AND DISCUSSION

3.1 Static stress

The static stress that acts on the engine mount is the engine's weight, as it is specified that the engine mounting system configuration consists of three mounts, the resolution of the engine weight acting on the selected mount for this study is determined. The stress distribution upon the engine weight acting for the standard and the alternate models are shown. Model C exhibits the lowest limit of equivalent stress of 25.642 Pa, compared to 44.694 Pa and 48.781 Pa in Models A and B, respectively. This implies that Model C will experience the greatest effect even from half of the static load of the engine than Standard model A and alternate model B.

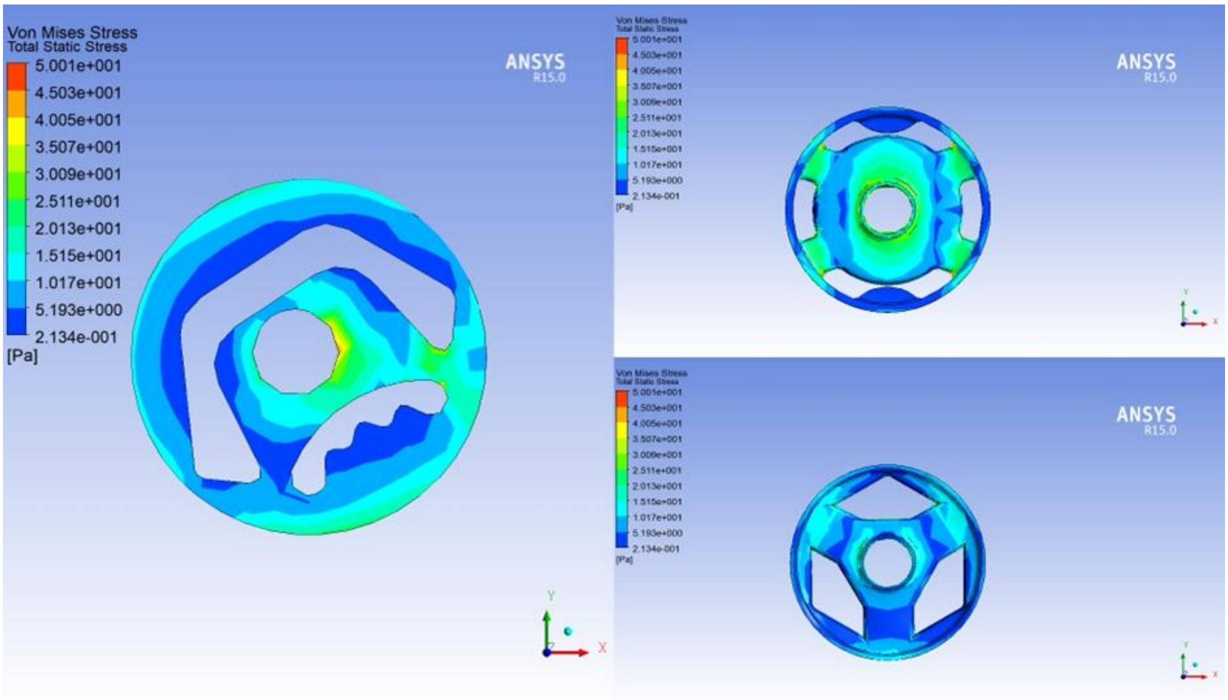

Fig. 6. Comparison Stress distributions for standard model A and alternate model B and C

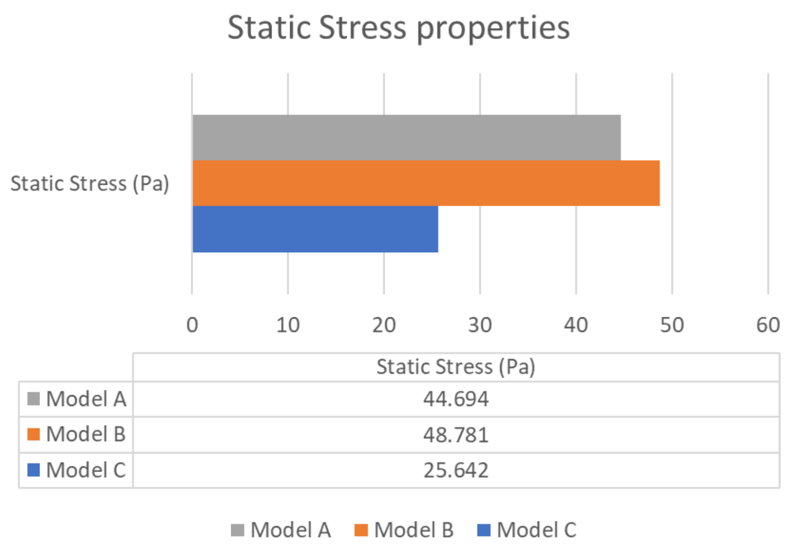

Fig. 7. Graph of static stress properties

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3.2 Deformation

The deformation indicates the regions more likely to experience eventual failure under the static load of the engine. It also indicates the damping capacity of the rubber support of the engine mount. The standard model exhibits regions where deformation can be damaging to it's form, leading to it's eventual failure with respect to it's maximum load. While the alternate model B has the deformation regions well within the permissible range with respect to it's maximum load. Alternate model C shows very less support for damping with the least deformation it experiences. Model B and C's deformations are 7.8849 x 10-8 m and 4.088 x 10-8 m respectively, and the deformation for model A is 9.617 x 10-8 m, this shows that Model C has the greatest stiffness since it deforms the lowest, it also implies that Model C structure is such that it couldn't support vibration isolation in the vertical direction (y- axis), which model A and B are capable of.

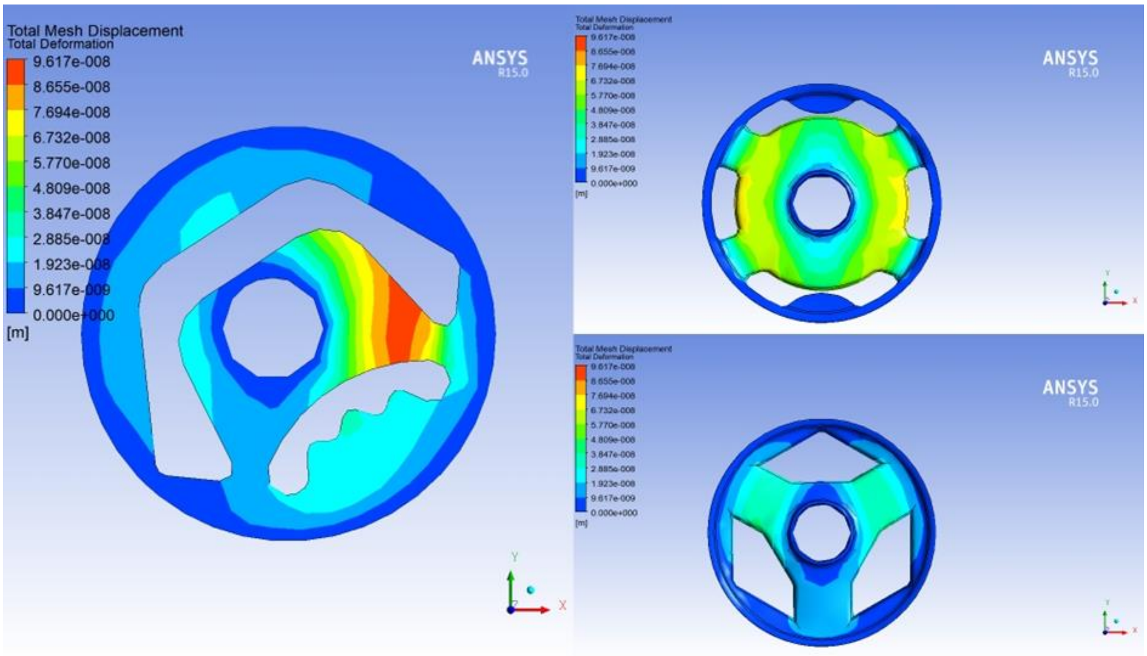

Fig. 8. Total Mesh Displacement of Mount A, B, C

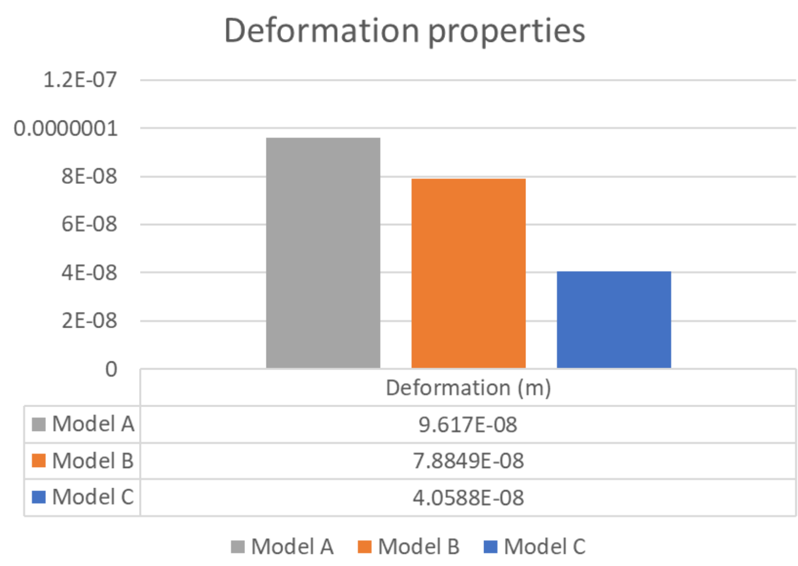

Fig. 9. Graph of deformation properties

3.3 Modal analysis

The modal analysis was done to determine the engine mounts natural frequency. The natural frequency of the engine mount is to be greater than that of the engine's disturbance frequency. It was found that the standard model of the engine

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mount is already designed in a way that it's natural frequency is well within the required range and the design variations of the rubber support did not have any significant effect on the natural frequency of the engine mount.

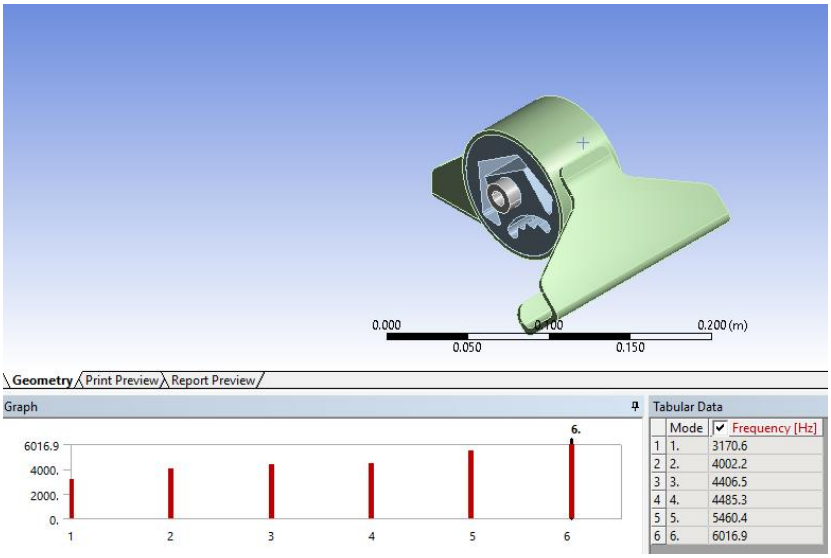

Fig. 10. Modal analysis of the engine mount complete model

CONCLUSION

The design variants exhibit considerable improvements in aspects like lesser strain rate and deformation, a well-tuned natural frequency that enables the mount to effectively damp the excess vibrations of the engine and withstand it's weight under static and cyclic load conditions. It is inferred that the alternate Model B exhibits better functional properties compared to that of alternate Model C and Standard Model A by considering the given results.

- Model B withstands 9.144% greater load than Model A, while C can only withstand 57.37% of the same load.
- Model B undergoes 81.989% of Model A's deformation.

Thus, it is inferred that the alternate Model B by far has slightly preferable functional properties compared to the other two models in terms of damping and stiffness, making it the successful model of this simulation study.

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