A Survey of Engine Mountings

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Abstract— Vehicles operate in a very dynamic and complex environment. To reduce vibration levels, rubber-to-metal bonded springs are utilised as primary and secondary suspensions, as well as engine installations. Vehicle safety, vibration while working, rough roads, vibration oscillation, and force during acceleration-deceleration of speed all have a significant impact on the structure of a vehicle and the safety of its occupants. This paper is attempting to locate contemporary work on engine mounting and type, as well as analytically engineering the material utilised for weight reduction and frequency vibration and noise reduction.

Keywords: Engine Mounting, Vibration, Frequency

I. INTRODUCTION

Automobiles are becoming a more common mode of transportation and a part of everyday life. Transportation ride comfort is becoming an increasingly significant factor in passenger cars as they become a vital component of everyday life. New passenger car technology, on the other hand, is heading toward higher speeds, large power-intensive engines, and lightweight automobile body designs in order to attain reduced fuel consumption.

Furthermore, losing weight has a negative impact on a car's NVH (noise, vibration, and harshness) characteristics. This movement for lighter car bodies generates passenger displeasure due to the increasing magnitude of vibration. Vibration is caused by two unpleasant elements. Vibration comes from two places.

First, high-frequency vibration of around 20 to 150 Hz is mostly caused by the drive, due to the obvious reversal mechanism of the column in the car. The engines of these two vibration groups provide the majority of the vibration that humans experience. The latter is produced by street imperfections. To deal with this type of vibration, many studies have generated various models of active suspension systems. The assembling mechanism must also be devised in order to safely isolate the engine vibrations.

A. Engine Mountings

The part of a car that keeps the engine in place is known as the engine mounting mechanism. One of the primary functions of an engine mounting system is to minimize engine vibration in the interior of the vehicle. To reduce the amount of friction energy transferred to the driver from the engine and the road surface, the engine mounting structure must be rigid enough to support the engine's load as well as displacement in the front, back, horizontal, and vertical directions. As a result, rubber is used to fill engine mounting systems to avoid direct metal-to-metal interaction between the engine and the car body. As a result, the amplitude of the emitted vibrations is reduced in the configuration of an engine mounting system. As a result, engine mounting systems are designed to reduce the amplitude of transmitting vibrations, avoid fatigue loss, and reduce passenger distress by partly isolating the engine vibration.

The fundamental premise is to find a balance between the amounts of energy absorbed and the degree of movement possible (sway space). To keep everything in place, a piece of machinery may have anywhere from 3 to 8 mounting points, some for the transmissions and others for the engine.

Engine mounts also serve as vibration dampeners, collecting energy from the system and producing heat in the process. Rubber is frequently the material of choice for engine mount construction since it has great dampening and heat dissipation properties as well as a high degree of design flexibility. A vibration mount's principal purpose is to provide a rubber barrier between two mating systems (engine and chassis). When compared to metal or solid engine mounts, rubber and elastomers absorb vibration and noise better than nearly any other material.

There are several factors to consider while constructing rubber engine mounts, including materials, cost, and function. Because there are so many various types and sizes of engine mounts, choosing the proper one may be a difficult task. The engine mount, on the other hand, may be customized and analyzed to fulfil specific requirements and improve the system's performance. It's crucial to consider the correct mounting technique when building an engine mount. Here are some data points to get you started:

- Weights of components
- Engine type
- Mount positions
- Component location
- Idle and running speeds
- Moments of inertia of mass
- Maximum output torque

II. TYPES OF ENGINE MOUNT

A. Simple Mounts:

Simple mounts are made up of two separate metal plates connected together by a solid rubber lump. They are commonly shaped like blocks, although they can also be shaped like discs. The plates are welded using studs, but these studs do not penetrate the rubber. One plate links to the sub frame and the other to the support bracket that attaches to the engine block, as is typical of engine mounts; soft mounts isolate more vibration while allowing more engine movement, as is typical of engine mounts. Engine mounts should be frequency sensitive, to get technical. Firmer mounts limit movement more, but they also convey a lot more vibrations.

To put it another way, engine mounts should be able to tolerate two sorts of unpleasant sensations: vibration and bouncing. The mount should be rigid enough to avoid bouncing but soft enough to isolate and absorb vibrations. As

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a result, the rigidity of an engine mount should ideally vary with frequency. Low frequency rigidity, softening at a high frequency.

Fig. 1: Sandwich mount

B. Elastomeric Mounts:

In engine mounting systems, simple elastomeric mounts are extensively employed. This is meant to sustain the load and to offer required rigidity in all directions for the isolation of the vibration (Richards and Singh 2001). These assemblies are often designed as a parallel combination of a linear or nonlinear spring with damping element. In view of their small form, cheaper costs and minimal maintenance, such mounts provide benefits. The elastic mounting has nonlinear stiffness characteristics with an arousal frequency, statistical load and deflection. The dynamic rigidity of an elastomeric mount is often greater at higher frequencies than its rigidity at lower frequencies(Swanson 1993). The design of a mounted system that meets all design criteria under a wide variety of operating situations is tough with such feature. A very rigid or damping elastomeric mount can provide a low shaker level at low frequencies, but its high frequency performance could be inadequate. Low rigidity and minimal damp mounts, on the other hand, produce low noise, but inducing a large amount of shock (Yu et al. 2001). Although performance limits are inherent in these mounts, because of their compact design, low costing and extended lifetime these mounts have been successively utilized for engine mounts for many decades. Figures 2 illustrate several common elastomeric mounts. Current trends towards light weight, front wheel drives and smaller engines at low idle speeds can lead the chassis to vibrate less frequently, closer to the occupant's convenience and perception. There are therefore elastomeric mounts that are capable of isolating lower frequency vibrations. In addition, nonlinear force-deflection qualities might result in natural frequency fluctuations with speed changes. Many approaches for the characterization of elastomeric mounts have also developed. Although most research are characterizing mounts by static deflection, much research have studied the rate dependent rigidity properties. The experimental procedures described.(Richards and Singh 2001) include single and multi-level designs and various forms of excitement. Static rigidity tests are performed to assess time invariant load distortion curves and rubber durometer affects. The engine mounting technique used for optimizing parameters was devised by (J. J. Kim and Kim 1997) . A commercial non-linear software of finite elements is used to determine the design that meets the rigidity of the mounted engines.

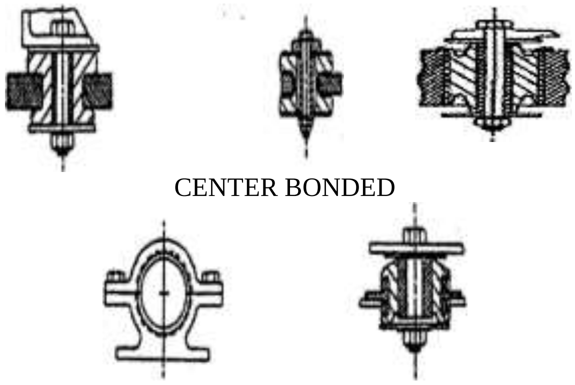

Fig. 2: Typical elastomeric mounts [3]

1) Benefits of Using Rubber Engine Mounts:

Rubber engine mounts are advised for a number of reasons. Consider the following advantages of using rubber engine mounts:

- It has excellent damping and energy absorption properties.
- Superior heat dissipation and noise and vibration dampening.
- At the appropriate hardness, it provides stability.
- A diverse elastomer range for a variety of applications.
- Long lifespan even when subjected to constant pressure, oscillation, or vibration.
- Resistant to oil, water, ozone, and other harmful substances.

All of these advantages are largely dependent on the type of rubber used for the mount. For most applications, natural rubber or oil-resistant neoprene are the most commonly used materials because they provide all of the benefits listed above. Rubber engine mounts are a safer alternative to solid engine mounts that are guaranteed to last a long time.

Fig. 3: Industrial design view of mount

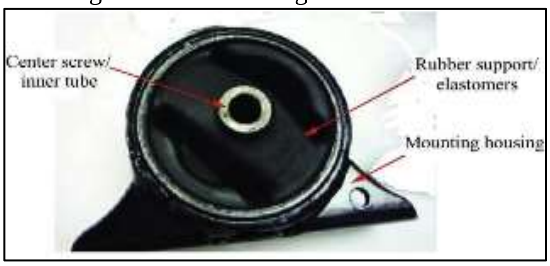

Fig. 4: Centre screw mountings

C. Hydraulic Engine Mount:

HEMs are passive nonlinear devices that provide a dependence on damping amplitude. A basic hydraulic mount, as illustrated in Figure 5, consists of two chambers filled with fluids, joined by a disconnector and an inertia system. The

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fluid inside the mount is usually a combination of ethylene glycol and water, even if different fluids can be employed. The primary rubber compliance structure on top of the upper chamber and a steel spreader plate on the lower part containing the inertia track and disengagement. The upper compliance is static by the engine and the liquid pumping action happens in the event of excitations, pushing fluid between two chambers. Under the circumstances in operation the bottom chamber a sturdy framework is attached to the base of the mount between both the chambers.

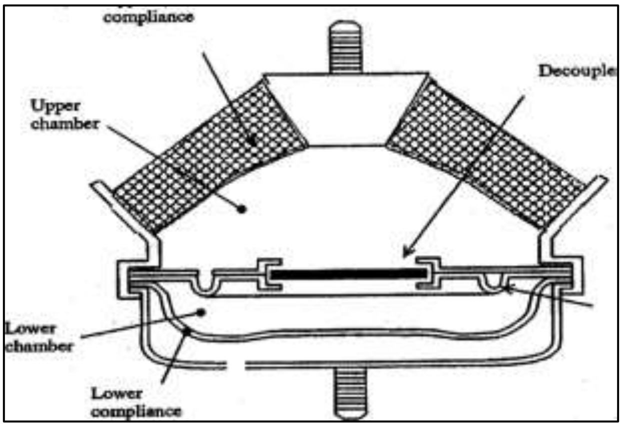

Fig. 5: Sketch view of hydraulic engine mount

The lower chamber is confined by a low-conformity rubber flow, which expands and contracts with fluid passing through the inertia and decoupler system. The decoupler board has a long distance from the cage. The fluid is then driven into the inertia path when the plate falls out of the cage. The inertia track provides a lengthy column of fluid between the two chambers, so limiting the amount of fluid which may flow between high amplitude excitations from the top and bottom chambers. The inertia track hence offers greater damping, a desired quality for isolation of vibrations in low frequency high amplitude situations.(Marzbani, Jazar, and Fard 2014)

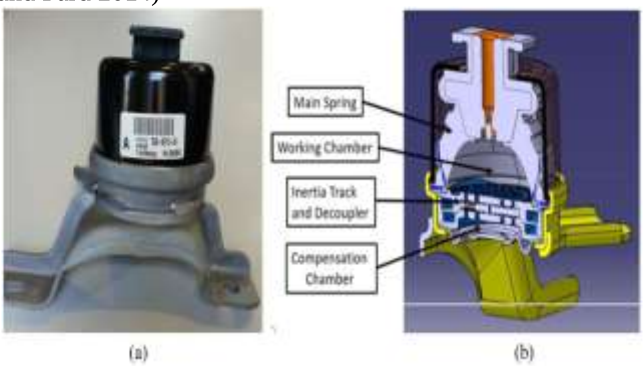

Fig. 6: The hydraulic engine mounting components are shown

D. Voice Coil Actuated (VCA) Engine Mount:

The VCA mounting role is to isolate and lower the vibration provided by the motor. The VCA mount needs quick reaction, a wide range of frequencies and a strong excitation power to minimize the vibration efficiently. Two kinds of VCA mounting are available. One is the built-in type and a distinct type. Due to its rapid reaction and broad frequency range, the separated type is better suited as the VCA mount. The VCA engine mount is shown in Figure 1. It comprises two yokes, a permanent magnet (PM), a spindle, a coil and two springs. The yoke was made of steel 1010, the PM was made of neodymium, and the coil housing was made of aluminum. The PM may be found in the yoke. Figure 1 depicts the magnetized direction of permanent magnets. Both the top and bottom of the yoke have plate springs. For actuator operation, there are two sorts of approaches. The moving coil approach and the moving magnet approach are both viable options. The moving magnet approach is used in this study. When the yoke and PM move, the coil and coil housing remain stationary. While the coil is stationary, the yoke and PM are one stiff body that moves up and down due to both stored spring energy and magnetic force. To move the actuator, the Lorentz Force, which is the connection between the PM and the current delivered to the coil, is employed. The direction of the current flow in the coil determines the direction of its motion. The PM and the yoke reciprocate at a high rate with regular strokes throughout this procedure. The yoke and PM are designed to have a maximum displacement of 4.5 mm. The spring force is determined by the yoke and PM displacement.(S. Kim, Park, and Kim 2020)

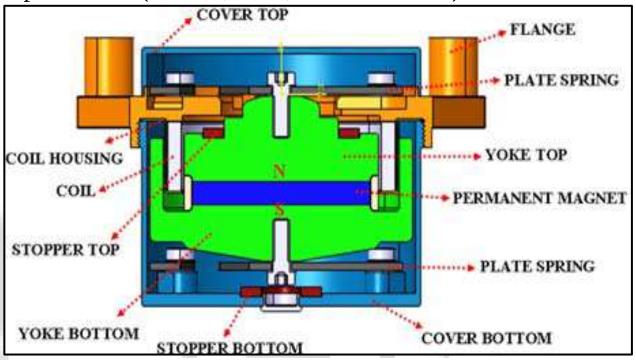

Fig. 5: Voice coil actuated engine mount

III. Elastomer Mount Material Selection:

Engine mounts, like other components can be built of a variety of materials. The rubber portion and the substrate to which it is attached are the two main components. One of the most essential parts of engine mount design is the rubber piece. Vibration, harshness, and stability may all be affected by the rubber we choose. Some of the most prominent rubber materials used in engine mounts are:

1) Natural rubber: Natural rubber has high vibration absorption, fatigue resistance, and resilience. It is by far the best material for vibration mounts since it has the highest resilience rate (ability to return back to original form). Natural rubber, on the other hand, is not as resistant to heat and chemicals as other polymers. Because this rubber is one of the most cost-effective polymers, it's a good option for engine mounts.

   Typical temperature range: -50°C to +100°C (-58°F to +212°F). Can be used with some dilute inorganic chemicals and polar organics.
2) Neoprene rubber: Neoprene has a high tensile strength and is resistant to abrasion. When there is a stable supply of oil for fuel exposure, this is the best option. While our basic natural rubber mounts can withstand the occasional oil spray and drips seen in engine bays. Constant contact will eventually deteriorate the elastomer, which is where Neoprene shines.

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3) EPDM rubber: EPDM is sometimes utilised, but only in very specific circumstances, because EPDM components have a low flame and tear resistance. EPDM is best suited to situations including UV rays or direct sunshine. EPDM may be made with a wide range of tensile strength/rigidity, which is useful in some applications.
4) Typical temperature range: -45°C to +150°C (-49°F to +302°F), up to +180°C (+356°F) in steam. Mineral oil/grease lubricants should not be used to aid assembly.
5) Silicone rubber: Silicone rubber is a reasonably appropriate material in some applications, although it is prone to tears and abrasion.

Natural rubber, Neoprene, EPDM, and silicone are some of the finest for rubber engine mounts in general.

ASTM designation	Chemical composition
Natural rubber (NR)	*cis*-Polyisoprene
Neoprene rubber (CR)	Poly chloroprene
EPDM	Poly(ethylene-propylene-diene)
Silicone rubber (VMQ)	Poly (methylphenyl-siloxane)

A. *Static Physical Properties:*

Rubber has unique characteristics that set it apart from other engineering materials. As a result, it has its own physical testing methods. Rubber has characteristics that are both elastic and viscous. The predominance of one of these traits is usually dependent on the testing conditions.

ASTM designation	Natural rubber (NR)	Neoprene rubber (CR)	EPDM	Silicone rubber (VMQ)
Durometer range (Hardness Number)	30–90	30-95	40–90	30-90
Tensile max	4500	4000	2500	1500
Elongation max.	650	600	600	900
Compression set	A	B	B-A	B-A
Creep	A	B	C-B	C-A
Resilience	High	High	Med.	High-Low
Abrasion resistance	A	A	B	B
Tear resistance	A	B	C	C-B
Heat aging at 212°F	C-B	B	B-A	A
Tg, °C	-73	-43	−65	-127, -86
Weather resistance	D-B	B	A	A
Oxidation resistance	B	A	A	A
Ozone resistance	NR-C	A	A	A
Solvent resistance	A	B	A	A
Water				
Ketones	B	C	B-A	B-C
Chloro-hydro-carbons	NR	D	NR	NR
Kerosene	NR	B	NR	D-C
Benzol	NR	C-D	NR	NR
Alcohols	B-A	A	B-A	C-B
Water glycol	B-A	B	B-A	A
Lubricating oils	NR	B-C	NR	B-C

Where A = excellent, B = good, C = fair, D = use with caution, NR = not recommended

Table 1: a Static physical property

IV. LOCATION OF ENGINE MOUNTS:

Every connection has a damper of some sort. There are just four points on this automobile where the drive train is linked to the body: two rubber engine mounts and two rubber differential mounts. The exhaust is likewise shielded from the bodywork by a rubber exhaust hanger, as it is fastened directly to the engine. Not only does this isolation make life more pleasant and easy since some vibration energy is minimized rather of simply shaking itself to bits. Engine mounts or motor mounts are used to attach engines to the body or the subframe. The mounts for this engine are as straightforward as they get. A normal rear-wheel-drive automobile will have mounts on both sides of the engine, as well as a third one that supports the transmission farther back, however this is not always the case.

In front-wheel drive automobiles, the engine is usually mounted in a triangle arrangement with three mounts. Engine mounts and transmission mounts are the same thing. An upper mount, which is a more sophisticated form of the bonnet that used to be used in muscle cars, keeps the engine from shaking by connecting it to the bodywork inside the engine compartment. Upper mounts are usually tie bars with rubber bushings to isolate vibration from the body. A bushing, by the means, is a cylinder of rubber that works as a vibration absorber between two bolted-together elements.

Fig. 6: location of engine mount

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A. Comparison of Different Types of Mounts:

	Simple Mounts	Elastomeric Mounts	Hydraulic Engine Mount	Voice Coil Actuated (VCA) Engine Mount
location of mount	on transmission	left or right of engine	below	below
force dissipation capacity	low	medium	high	high
sensitivity (spring effect)	low	medium	high	high
deflection	5%	10-20%	25%	30%
composition	metal, rubber	metal and rubber	metal, rubber and fluid	metal spring, rubber and magnets
vibrational efficiency	5%	10%	10-15%	15-20%
cost	cheap	moderate	high	very high

Table 2: Comparison of Different Types of Mounts

V. Conclusion

According to the findings, Vibration plays a critical role in Engine components. The following characteristics and parameters may be used and studied to enhance the design and material of mounts.

- Different forces on mounts
- Optimization methods
- Optimum location of the mount
- Geometrical dimensions and mechanical construction parametric techniques
- Finite element analysis of different shapes
- Linear and Nonlinear characteristics of mounts
- Vibration isolation study of mounts
- Weight reduction and ageing factor.
- These are the parameters which can be optimized for getting better results of structural performance enhancement.

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