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Review on of Internal Combustion Engine mounting system

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ABSTRACT:
Internal combustion engine (ICE) vibrations not only affect noise but also affect the ride comfort of the engine. An overview and development of various engine mounts from traditional rubber mounts to semi-active or active mounts of ICE is analyzed in this study.In addition,dynamic models of ICE mounts are presented. The results of the overall analysis have shown that the hydraulic mounts of ICE have better vibration reduction ability than traditional rubber mounts of ICE under low excitation frequency conditions. Especially, the ride comfort performance of semi-active hydraulic mounts or active mounts of have better vibration reduction ability than traditional hydraulic mounts of ICE.

KEYWORDS: *ICE, rubber mount, semi – active mount, active mount*

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I. INTRODUCTION

Various types of internal combustion engine vibration isolation mounts, ranging from rubber to hydraulic and from passive to semi-active and active types, have been developed to improve vibration isolation performance and enhance ride comfort. D.A. Swanson [1] proposed several active isolation system designs, along with various actuator technologies, sensor options, and control systems. Additionally, an effectiveness analysis of the mounts demonstrates the performance improvements of active isolation systems compared to passive rubber-hydraulic mounts.A separator mount design has been introduced to enhance the controllability of the separator without significantly affecting the stability of the mechanism, while improving response time. Additionally, Christopherson et al [2] proposed integrating the separator mechanism into a smaller, lighter hydraulic mount design, which was more adjustable and therefore more efficient.Nguyen Huy Truong et al [3]proposed a new multi-objective optimization method, "Hybrid NSGA-III," based on a full-vehicle vibration model under road surface excitation. Hoang Anh Tan et al [4]proposed a method to enhance ride comfort by using additional damping coefficient values for the rubber mounting system of an internal combustion engine (ICE). They analyzed the impact of adding these damping values to the rubber mount system on ride comfort using a full-vehicle vibration model with 10 degrees of freedom. The research results indicated that the optimal parameters of the passive engine vibration isolation system achieve better vibration reduction than the original vibration isolation system. This method was applied to develop a control structure based on experimental results.Ta Tuan Hung et al [5] proposed a full-vehicle dynamic model under the combined excitation of an internal combustion engine and road surface inputs to evaluate ride comfort performance between hydraulic engine mount (HEM) and rubber engine mount (REM) systems. Timpner, F. [6] presented an early design for a rubber mount connecting the engine to the vehicle frame. The research results achieved a reduction in vibrations and noise transmitted from the engine to the vehicle body and vice versa.Wang M A et al [5] proposed a study analyzing the characteristics of semi-active engine mounts anda mathematical model and controller were applied to examine the properties of semi-active engine mounts. The main objective of this paper is to provide an overview analysis of characteristics ofmounting system of ICE.

II. DEVELOPMENT DIAGRAM OF ICE MOUNTING SYSTEM

To enhance ride comfortable and reduce vibrations transmitted from the engine and road surface to the vehicle body and engine frame, the engine vibration isolation system plays a crucial role in blocking vibration sources from reaching both the engine itself and the vehicle body. This is particularly important for vibration sources with large amplitudes and low excitation frequencies ranging from f = 0 Hz to 25 Hz. Today, the design of ICE mounting systems continues to be improved and refined from metal and rubber mounting systems to electromagnetic mounting systems.The development diagram of the internal combustion engine mount system is shown in Fig.1.The study about the ideal engine mounting system which would isolate the vibration excitations from the engine and shown the concentration requirement of improvement of frequency and amplitude dependent properties. They explored how the rubber mounts trade-off the static deflection and provides the vibration isolation and what way the hydraulic mounts provided the better performance than the rubber mounts. At the final they reviewed about the different methods of optimization of engine mounting systems and suggested that active mounting systems would be considered for future trend [8].

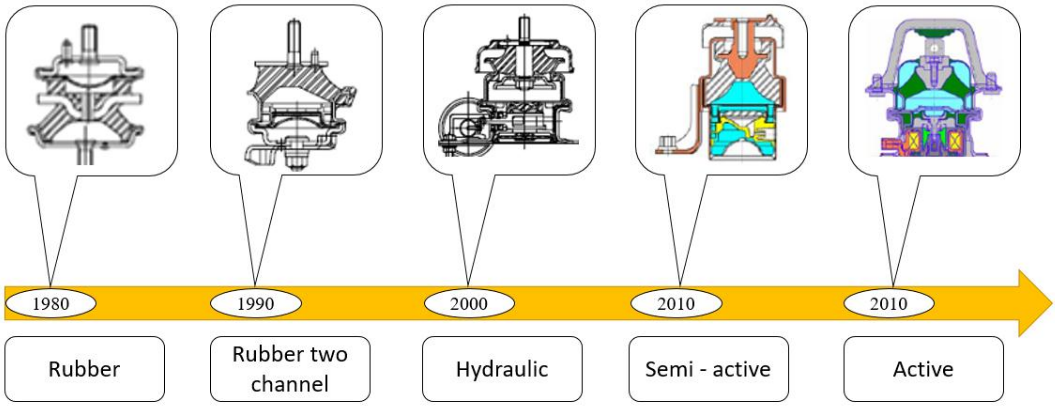

Fig 1. Development diagram of the internal combustion engine mount system

Bo-Ha Lee and Chong-Won Lee[9] studied and developed a new type of active control engine mount (ACM), feed forward control based electromagnetic engine mount that illustrates both the active and passive characteristics of ACM such that the model includes the vibration isolation estimation algorithm, current shaping controller and an enhanced model for ACM. The results obtained from the prototype were depicted that the ACM behavior at the dynamic conditions at the desired range of frequency were found to be accuracy. They also showed that the vibration estimation algorithm efficiently explored the anti-vibration signals for the vibration isolation and the proto type ACM effectively isolated the vibration forces from the engine. J.S.Lee and S.C Kim[10] focused on the performance enhancement of engine mount rubber(EMR) by adopting a form a design optimization approach. The optimal design was arrived by considering the material stiffness and fatigue strength of a rubber. The objective of the optimal design was made to minimize both the weight and the maximum stress of the EMR and to maximize the fatigue life cycle subjected to constraints on static stiffness of rubber. A micro-genetic algorithm was adopted as global optimizer in order to consider the inherent non linearity analysis of the model.

Jun-Hwa Lee and Kwang-Joon Kim[11], developed viscous damping model for hydraulic engine mount and represented the model in terms of design variables. The design variables are geometry of inertia track, resultant stiffness and damping characteristics. The parametric studies were presented the relation between the equivalent viscous damping coefficient and the design variables. The authors discussed the lumped parameter and dynamic performance characteristics of the mounts. Based on these two combinations the efficient design technique for the hydraulic mount was made. The authors state that relation between the design variables and the dynamic characteristics will be helpful in design modification and initial design of hydraulic mounts so that the desirable performance of the mount will be obtained. Li-Rong Wang et.al [12]developed a non-linear parameter model to determine the dynamic characteristics of hydraulically damped mount (HDM). The results of dynamic characteristics obtained from the mathematical model with fixed-decoupler were compared with the experimental values of the typical HDM and verifies the effectiveness of the modeling. The HDM's working methodology was clarified by super positioning the performance with the rubber mount, inertia track and. The authors also made a analysis of parametric effect to bring out the influence of structural design parameters on the vibration isolation performance of the HDM. The authors identified the following: modeling technology of rubber viscoelasticity, fluid-structure interaction between rubber parts and fluid in chambers and frequency and amplitude dependent characteristics of volumetric stiffness of upper chamber for future study.

Currently, in the trend of developing and improving internal combustion engine vibration isolation systems, active isolation is the clearest example. With this type of isolation, both stiffness and damping coefficients are intelligently controlled according to a program, adapting to all engine operating modes. This significantly enhances the smoothness and vibration reduction efficiency. Ahn et al [13] developed an MR fluid-based mount to be used for supporting electronic equipment (e.g., CD players) inside automobiles. The results presented by the authors indicate that the MR fluid addition to the mount reduces the peak transmissibility about three times, in addition to shifting the peak in transmissibility by about 4 Hz toward higher frequencies.

III. DYNAMIC MODELS OF ICEMOUNTS

Through analyzing the types of vibration isolation systems of internal combustion engines of passenger cars, we see that there are some dynamic models of engine vibration isolation as follows:

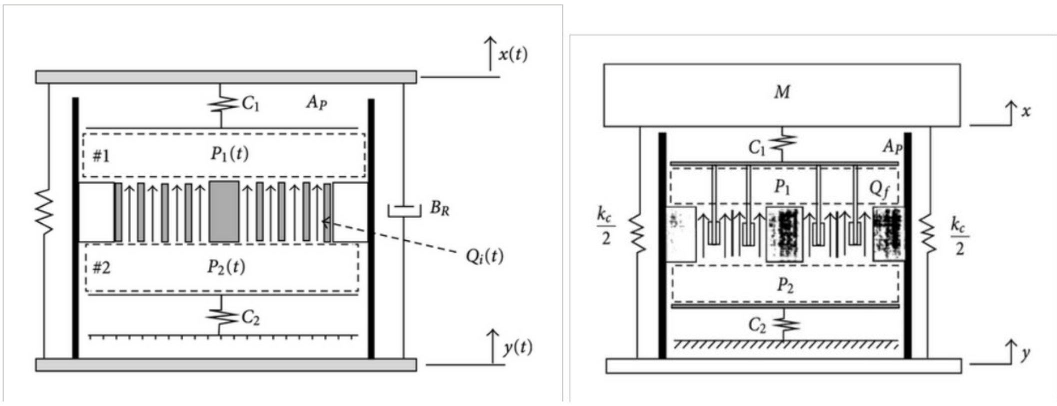

Fig 2. Dynamic models of engine mounting (ER) [14-15].

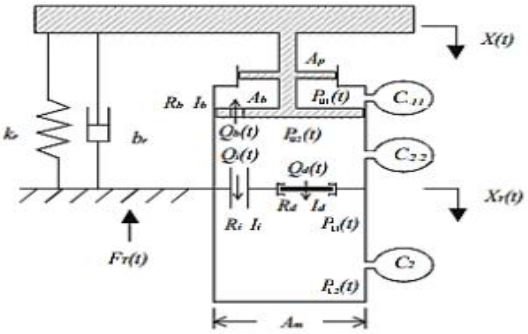

Fig 3. Dynamic models of engine mounting [1]

Linear models for a typical hydraulic mount are developed using the bond graph method, with parameters and variables grouped and assigned to physical characteristics to define the linear system equations.

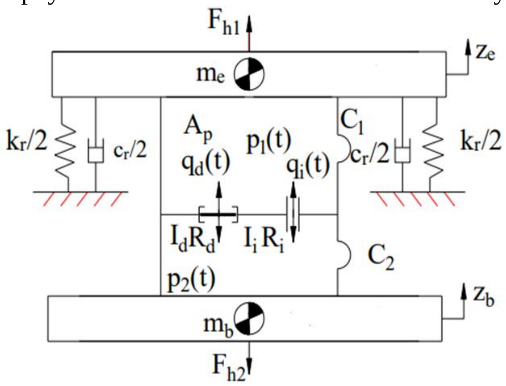

Fig 4. Physical models of a semi-active engine mount [5]

IV. CONCLUSION

In this study, firstthe overview and development of various engine mounts from traditional rubber mount to semi-active mount of ICE was analyzed, and then dynamic models of ICE mounts were presented. Some conclusions drawn from the following overview research results: (i)The hydraulic mounts of ICE have better vibration reduction ability than traditional rubber mounts of ICEunder low excitation frequency conditions; (ii) Semi-active and active techniques are used to improve performance of hydraulic mounts of ICE by making them more tunable; (iii)Active mounts of ICE could be very stiff at low frequency and be tuned to be very soft at the higher frequency range to isolate the vibration. The results of the study are the theoretical basis for selecting semi-active mounts of ICE for further research.

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