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A NEW CONCEPT FOR ENGINE MOUNTING - THE SELECTIVE ACTIVE MOUNT

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INTRODUCTION

The concept of selective control, devised at Essex University in 1975, [Refs. 1 & 2] is a novel self-adaptive method for synthesising the appropriate waveform to cancel noise and vibration of a repetitive nature. An important feature of the system is that the cancellation waveform is synthesised in synchronism with the prime mover responsible for the offending vibration. The synchronous process eliminates the need for conventional signal processing, with its inherent sensing and time delay problems. Furthermore, the system confers a new property, namely selectivity, enabling radically new vibrational characteristics to be achieved.

SELECTIVE CANCELLATION OF VIBRATION

It is suggested that the selective cancellation of vibration has a significance to the design of dynamic structures far exceeding that of simply eliminating vibration. Not only can it eliminate much currently intractable vibration, but it provides the designer with an entirely new dimension in the design of dynamic structures.

An example of the conceptual changes made possible is illustrated in Figures 1&2 which compare the typical response of a conventional elastomeric anti-vibration machine mount with the properties conferred by the selective active mount. The well known response of the conventional elastomeric mount (Figure 1) includes a resonant frequency, typical of a damped mass/spring resonator system in which the mass is the supported engine and the elasticity and damping are provided by the mount. In this conventional approach, the designer attempts to place the system resonance below the lowest frequency at which vibration is significant. The limit to this current procedure is set by the fact that the resulting increase of the compliance of the mounts reduces their stiffness to the motional forces experienced in a "vehicle", such as a ship in a seaway, and results in excessive displacement of the engine. Furthermore, a similar, and even more undesirable, displacement results from the static torque reaction transmitted by an engine to its mounts.

The selective response of the Essex mount, shown in Figure 2, however, avoids completely both the unwanted resonance and the compliance to motional forces and to static torque reaction forces. Instead of the normal continuous response, there exists a series of discrete harmonic lines. At all of the engine harmonic frequencies the new mount offers virtually total isolation, but between these discrete frequencies, the mount is quite rigid.

Furthermore, the structural designer should be helped by the fact that the exceptionally high degree of isolation is independent of the characteristics of the supporting structure, or bedplate, unlike the passive situation.

VERIFICATION OF THE NEW MOUNT

The problem in implementing this "ideal" engine mount is not in its selective control, since this is an inherent property of the Essex system, but in the provision of a suitable actuator to respond to the required cancellation signal.

The control system has been fully verified on a laboratory rig [Ref.2] consisting of a compressor, bolted to a raft,which in turn was attached to a bedplate by four vertical active mounts. Moving coil actuators were used in the laboratory demonstration, but because they are not capable of supporting the full static weight, elastomeric mounts had to be installed in parallel. The problem with this arrangement is that the elastomers are able to transmit transverse vibration, with a consequent reduction in the cancellation attainable. Even so, a vibration reduction of over 30dB was achieved when the control system was switched on.

The ideal actuator would be capable of supporting the entire vertical static weight, whilst not transmitting horizontal forces.

IMPLEMENTATION OF SELECTIVE MOUNT

Calculations made from vibration measurements on a large number of engines, both land-based and ship-borne, have confirmed that a completely unconstrained engine has a surprisingly small vibrational displacement at its mounting points - varying from about 1mm for a car engine to as little as 10 microns for a 3,000 SHP ship's diesel engine. Based on this information, the specification for the required actuator is as follows:

Displacement	-	up to 1mm
Frequency response	-	0-200Hz
Static force	-	up to 2,000Kg depending on application
Isolation in shear	-	40dB min.

THE FUTURE

The potential benefits of selective cancellation and the implication to the structural designer go far beyond the elimination of vibration, since the penalty of compliance to motional forces and static torque reaction forces no longer obtains. We therefore have the intriguing situation of an engine which appears to be rigidly mounted, but does not transmit vibration. Two examples of the important side benefits are as follows. In ships, there is the possibility of dispensing with the cardan shaft, enabling the engine to be moved further aft to provide more cargo space. In cars the elimination of rotational displacement in response to engine torque should simplify pipework and remove the sluggish response associated with compliantly-mounted front wheel drive engines. Such significant side effects will progressively appear as the application to different industries is investigated, and they are likely to have far-reaching economic implications.

REFERENCES

[1] Chaplin, G.B.B. and Smith R.A. UK Patent 19717/76, Active Methods of Cancelling Repetitive Vibrations.

[2] M.O.D. Contract, 'Adaptive Methods in Active Vibration Control Systems' 1979-82.

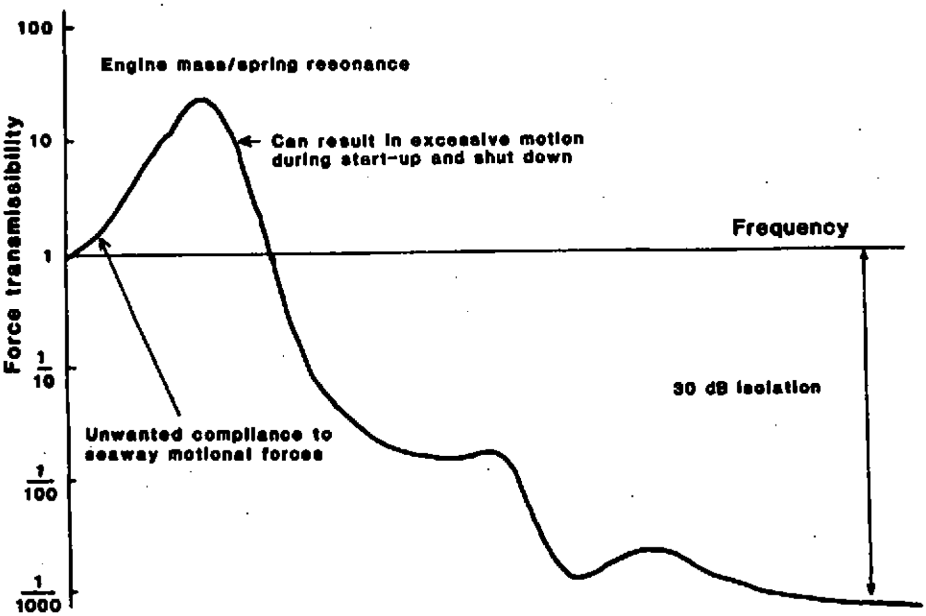

Fig.1 PASSIVE MOUNT

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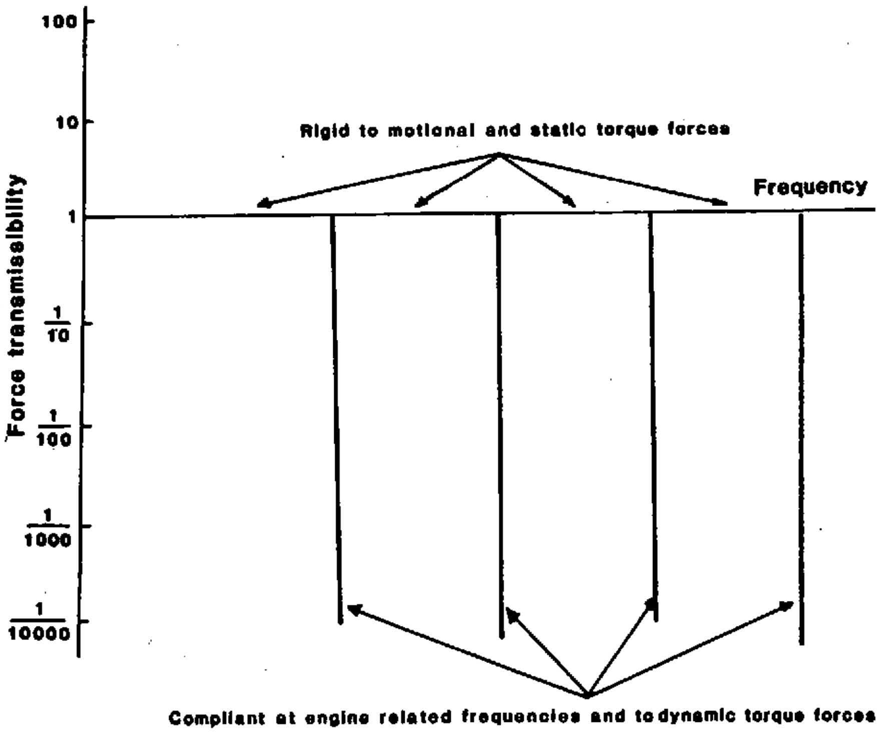

Fig. 2 ESSEX ACTIVE MOUNT