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VIBRATIONAL POWER TRANSMISSION MEASUREMENTS ON A SEMI-PRACTICAL MOTOR-ISOLATOR-SEATING ARRANGEMENT

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INTRODUCTION

An experiment is described which was designed to test some simple theoretical predictions of vibrational power transmission through vibration isolators, and also to test two experimental techniques for measuring vibrational power transmission.

The test rig consisted of a 1.5 Hp D.C. electric motor, (shown schematically in Figure 1) mounted by four vibration isolators upon a heavily damped beam stiffened plate. The motor was excited by (i) external excitation by an electrodynamic exciter applied at a point on the casing; (ii) internal excitation of the free running motor.

A comparison of the results measured using the two alternative methods displayed the effects of multi-point coupling and the significant contribution of acoustic excitation of the seating due to motor sound radiation.

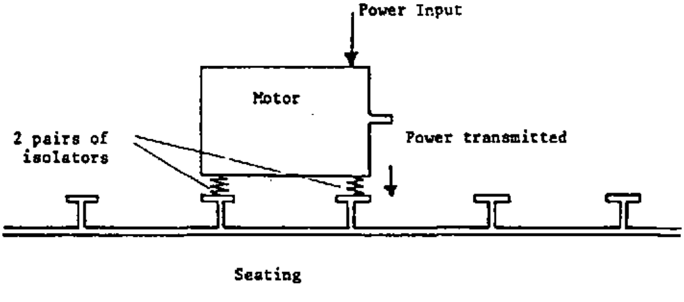

FIGURE 1

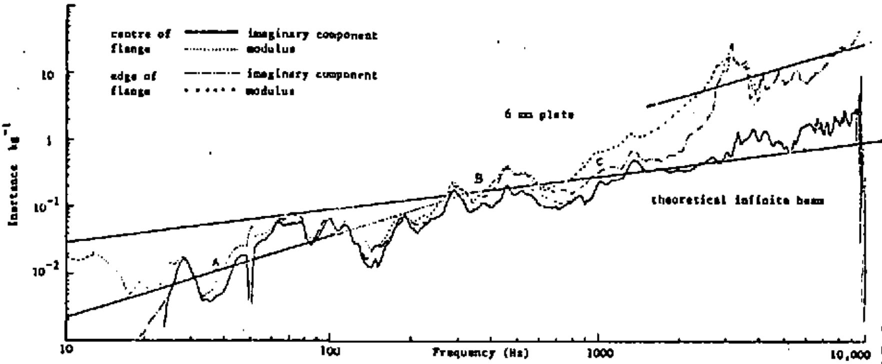

FIGURE 2: Measured inertance at the centre and edge of the beam top flange

DESCRIPTION OF THE COMPONENTS

The seating structure was a 6mm x 2.4m x 1.2m steel plate stiffened by five T section beams, along the length; each beam 6mm thick, 5.1cm high, and spaced 17.8cm. The plate was supported over the whole area by plastic foam and the perimeter embedded in dry sand. The point inertances of the plate, measured on the centre and edge of the centre beam top flange are shown in Figure 2.

The motor weighed 32.7Kg and the casing was mainly a 6mm thick casting. The point inertance of the front right motor foot is given in Figure 3.

Each vibration isolator was a 3cm x 3cm x 1cm slab of natural rubber bonded between two 3cm x 3cm x 5mm aluminium tablets. The transfer apparent mass of each isolator $\bar{A}_{12}$ was measured between 10Hz and 6kHz. It was assumed that for these isolators only compression of the isolator was significant.

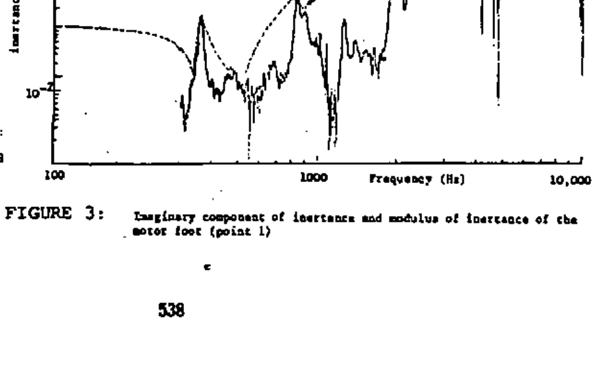

FIGURE 3: Imaginary component of inertance and modulus of inertance of the motor foot (point 1)

THE MEASUREMENT METHODS

Vibrational power was to be measured with two alternative methods. The first uses the cross spectral density of the acceleration above and below each isolator $\overline{G}_{12}$ and the isolator transfer apparent mass $\overline{A}_{12}$ in the expression [1]

$$P/Hz = (^1/\omega) . \operatorname{Im} \{\overline{G}_{12} . \overline{A}_{12}\} \qquad (1)$$

where Im { } denotes the imaginary component and ω the angular frequency. The second method for measuring vibrational power just uses the acceleration spectral density of the foot of each isolator G_2 and the imaginary component of the point apparent mass of the seating $\overline{A}_s$ at the connecting point (on the flange of the centre of the middle beam and adjacent beam). The power is given as [1].

$$P/Hz = (^1/\omega)\ G_2\ \operatorname{Im} \{A_s\} \qquad (2)$$

THE POWER TRANSMISSION FROM THE VIBRATING MOTOR TO THE SEATING

For the first test the inactive motor, supported by four isolators upon two adjacent beams of the stiffened plate, was excited externally by a rapid swept sine wave between 10 Hz - 1kHz. The input force was applied vertically at one end of the motor casing (see Figure 1). The power input to the motor was measured using Equation (2), and the power transmitted to the seating via the four isolators was measured using Equation (1), these results are shown in Figure 4.

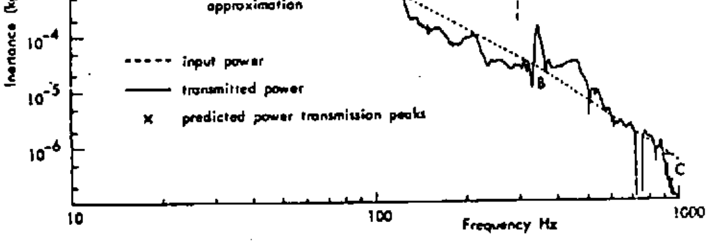

FIGURE 4: ω x POWER INPUT TO THE MOTOR AND TOTAL ω x POWER TRANSMITTED BY THE FOUR ISOLATORS.

In this figure there are three points of interest (i) vibrational power is input and transmitted mainly by the vertical translational mode and the rocking mode of the rigid motor, at about 35 Hz and 50 Hz respectively: (ii) above these two resonances, the rigid body motion (see dotted line), is responsible for most of the vibrational power transmission up to 1 kHz. This includes the region above 300 Hz where, although the motor resonates in its whole body modes of vibration, there is not much increase in power transmission over that which can be accounted for by rigid body motion: (iii) negative power transmission was measured through the rear two isolators.

In a high frequency test 1kHz - 8 kHz the vibrational power transmitted were measured using Equations (1) and (2). Method 2 overestimates the true value until there is half a wavelength between motor feet above this frequency, equation (2) gives a good estimate of the true vibrational power transmission.

In a final test the motor was supported upon one isolator and the power transmission was measured using Equations (1) and (2). For this test the motor was run at 40 cycles per second and no external excitation applied. It was found that Equation (2) consistently produced larger values for power than equation (1) between 100 Hz and 2 kHz. This was shown to be because the sound radiation from the motor, was responsible for most of the seating excitation in this frequency region. Equation (2) is insensitive to the source of the seating vibration, whether acoustic or by another input to the structure while Equation (1) only measures the power transmitted by the isolator.

REFERENCES

1. R.J. Pinnington and R.G. White. "Power Flow through machine isolators to resonant and non-resonant beams". Journal of Sound and Vibration, 75, 1981, pp179-197.

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