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# PRACTICAL CONSIDERATIONS TOWARDS THE OPTIMUM DESIGN OF VIBRATION ISOLATORS

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## ABSTRACT

The paper presents practical experiences in the field of optimum design of vibration isolators. The effect of type, size, shape and orientation of the isolators were throughly high lighted. Practical recommendations for the optimum design of the isolators are then given.

## KEYWORDS

Vibration, isolation, transmissibility, size, shape, spectrum.

## INTRODUCTION

Vibrations, like some deseases, are "epidemic". They are vastly transferable from machine to another through their respective foundations. During this process of transfer, vibration may increase in amplitude causing the "reciever" to be greately endangered, especially when it may happen to be a vibration sensitive machine. The process of protecting the machines and/or foundations from the transfer of vibrations is called (vibration isolation), Technically, (vibration isolation) is a process of storing the energy caused by a vibrating system within resilient mounts, specially designed and put in the vibration path, between the machine and its foundation, in such a way as to prevent the export of this energy (active isolation) or its import to a sensitive machine (passive isolation). It lies within the capacity and methodology of the good design of the resielient mounts to achieve the BEST protection effeciency in the relevant case of isolation.

However, the process is not a straight forward one, complications are neumerous. Investigations (1 - 3) are mainly oriented towards streamlining the design process to optimize the isolation effeciency. A quick look at the accumulated literature, with an experts eye, reveals that the investigations are mainly running into two streams : The theoretical approach, which endevour to obtain a mathematical modelfor the problem and to introduce the best solution for this model, HSIAO et al (1,4) represents an example of this approach. Investigators representing the other stream are trying to put, through practical experimentations, rules for the optimal design to be applied in the different cases of isolation, RIVIN (2) is a good example for this stream.

This paper represents a step forward in the secondstream, where a trial is made to investigate, expermintally, the effect of the different factors, associated with the choice of the resilient mounts, on the performance of the isolator, with an ultimate goal to give practical design recommendations that may help the designer in the dilemma called "vibration isolation".

## THE EXPERIMENTAL SET-UP

Fig. 1. shows a schematic diagram of the set-up used for the experimentations necessary for this investigation. It was suggested to use as simple model as possible, to reduce the number of variables to a minimum. Excitation is made through the variable speed excentric weight exciter, especiallydesigned so as to have minimum errors in its mechanical parts. The excited base is clamped at the four corners with bolts grouted to the concerte foundation. Through these bolts different isolation mounts are clamped between the base and the foundations.

Measurements of the vertical vibration mode and the horizontal rocking mode both on the base and on the concerte foundation are made at different excitation frequencies to calculate the transmissibility for each mode. Curves depicted on Figs (2-8) represent the out come of the results.

## DISCUSSION OF RESULTS

Natural rubber mounts are chosen through out the experiments, size, height and shape of the mount are varied to study their effects.

Rubber in shear and rubber in compression are investigated, beside the use of double compression mounts in the case of double isolators.

### Effect of mount size

Fig. 2. represent the transmissibility spectra for two different sizes of a square-cross-sectional mount. From the Fig. it appears that the size of the mount has a great effect both on the value and mode of transmissibility. For smaller sizes (36 mm side) the transmissibility has a mode at about 55 Hz for which the value of transmissibility is as great as 50%. This is not the case with a larger size of mount (44 mm side) for which the transmissibility decreases gradually with frequency from 50% to about 5%. This can be attributed to the effect of size on the design stiffness of the rubber mount.

### Effect of the hight of the mount

Fig. 3. shows the transmissibility spectrum for the vertical mode for two cases of a square cross-section mount one with 48 mm in height and the other with 96 mm in hight (corresponding to dynamic stiffnesses of 53.1 and 26.3 kg/mm respectively). From the figure it is clear that for high hights of mounts (96 mm) the transmissibility in the vertical mode has a vibrating spectrum in the frequency range (20-40 Hz) with a minimum value of 4% and a maximum value of 25% (at 33 Hz, which is one of the natural frequencies of the base). The spectrum tends to settle at a value of 10% at high frequencies.
While the smaller mount hight (48 mm) gives an ever decreasing value of transmissibility with frequency which settles at about 5% at high frequency.

### Effect of mount shape

Fig. 4. illustrates the different transmissibility spectra for the vertical mode of vibration for rubber mounts of the same cross-sectional areas and same hights (48 mm) but different in shapes, the basic mount is of a square cross-section compared with rectangular and circular cross-sections.
From the figure it is clear that the square cross-section gives the lowest transmissibility at all frequencies, while the circular cross-sections comes second with a transmissibility 3 times higher

at some frequencies (35 Hz for the studied case) and the transmissibilities are approaching a common value of 5% at high frequencies. The rectangular cross-section gives the highst transmissibility for the whole range.

For the case of horizontal rocking mode of the same mounts (rubber in shear in this case), Fig . 5. represents the transmissibility spectra comparison of the three cross-sections mentioned above. From the figure, it is very clear that the performance of the three mounts is improved marginally. The circular cross-section gives almost a constant spectrum of the transmissibility for the range of frequencies up to 65 Hz (about 5%) and has a peak of 25% transmissibility at 75 Hz. The square cross-section mount gives higher transmissibility at the beginning (50%), then the transmissibility levels off at 5% for range of the frequencies considered. The rectangular cross-section mount begins with a transmissibility of 30% and it decreases to about 5% in the range of frequencies (30 - 40 Hz), then the transmissibility rises again and reaches as high as 35% at 65 Hz.

## USE OF DOUBLE ISOLATORS Fig. 6.

The last case of comparison is that with double isolator mounts as shown in Figs (7-8).

The figures show how the transmissibility is greately reduced in values and in modes when using double mounts as compared to the single one both in the cases of vertical vibration mode (rubber in compression) Fig. 7. and horizontal rocking mode (rubber in shear), Fig. 8.

## CONCLUSIONS

As far as the results of the experiments reported here in are concerned, the following conclusions and recommendations are drawn.

1. Use of rubber mounts as vibration isolators is justifiable in frequency ranges (30 - 100 Hz).
2. The size and hight of the rubber mount should be worked out properly to satisfy the condition of isolation in concern, the change in rubber size and hight reflects change in transmissibility.

3. Square cross-section's of rubber mounts are preferable for vertical vibration isolation, while circular cross-sections give better responses when the rubber is in shear (e.g. horizontal rocking modes).
4. The use of double isolators (when possible) reduces the transmissibility marginally.

## REFERENCES

1. Hsiao,M.H., Haug,E.J.Jr., and Arora, "A State Space Method for Optimal Design of Vibration Isolators", ASME, Journal of Mechanical Design, Vol. 101, April 1979, pp. 309 - 314.
2. Rivin,E.I., "Principles and Criteria of Vibration Isolation of Machinery", ASME, Journal of Mechanical Design, Vol. 101, October 1979, pp. 682 - 692.
3. Willmert,K.D., and Fox,R.L., "Optimum Design of a Linear Multi-Degree-of-Freedom Shock Isolation System", ASME, Journal of Engineering for Industry, May 1972, pp. 465 - 471,
4. Baker, J,K,, "BVibration Isolation", Published for the Design Council, the British Standards Institution and the Council of Engineering Institutions by Oxford University, 1975.

## NOMENCLATURE

| | |
|---|---|
| B | mount width. |
| H | mount hight. |
| L | mount length. |
| ∅ | mount diameter. |

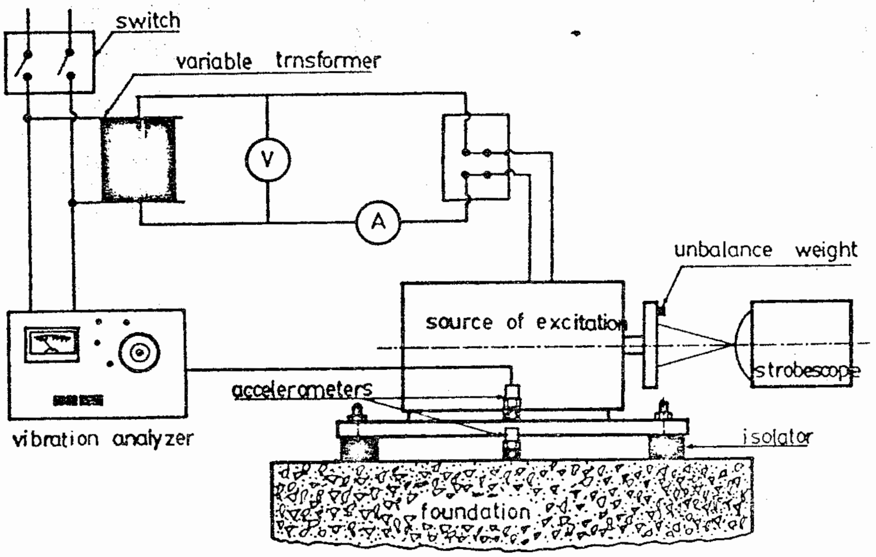

Fig. 1. Schematic diagram of the set-up.

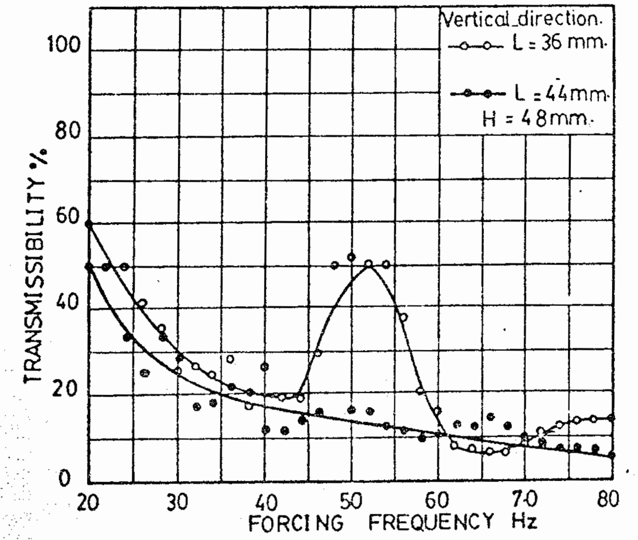

Fig. 2. Effect of isolator size.

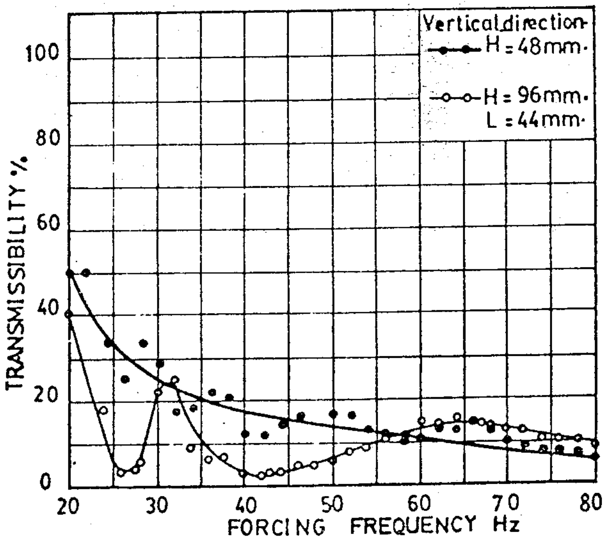

Fig. 3 . Effect of the hight of the mount.

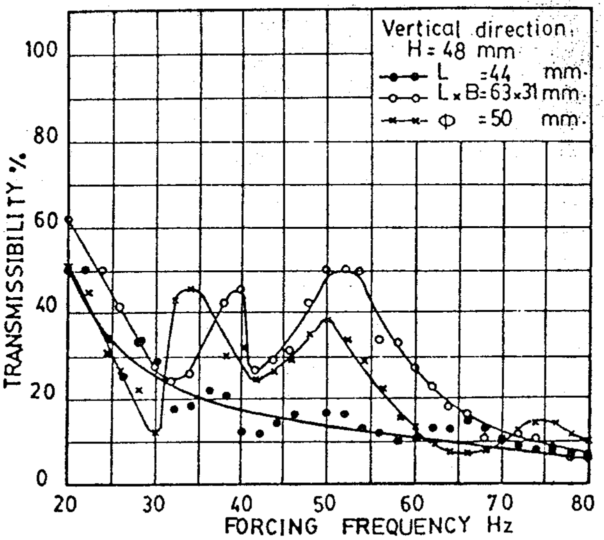

Fig. 4 . Effect of mount shape .

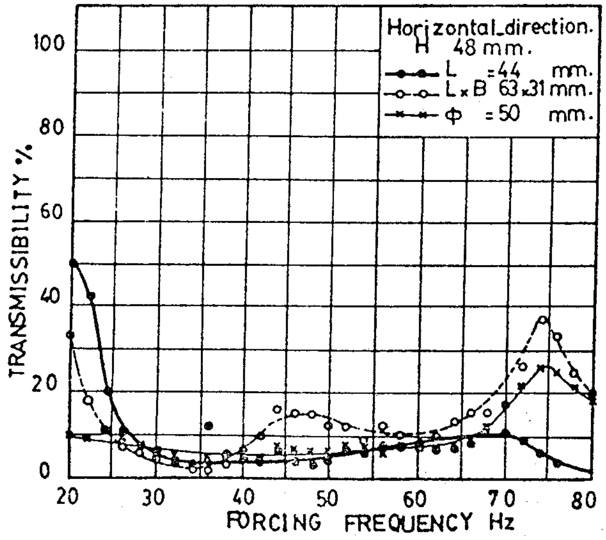

Fig. 5. Transimissibility Spectrum in the horizontal direction.

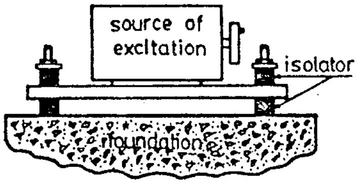

Fig.6. Schematic drawing of double isolation.

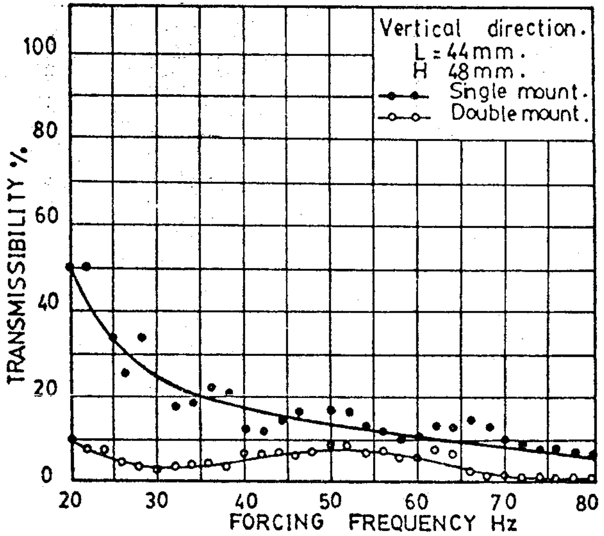

Fig. 7. Transmissibility spectrum.
(Double Isolation, vertical direction)

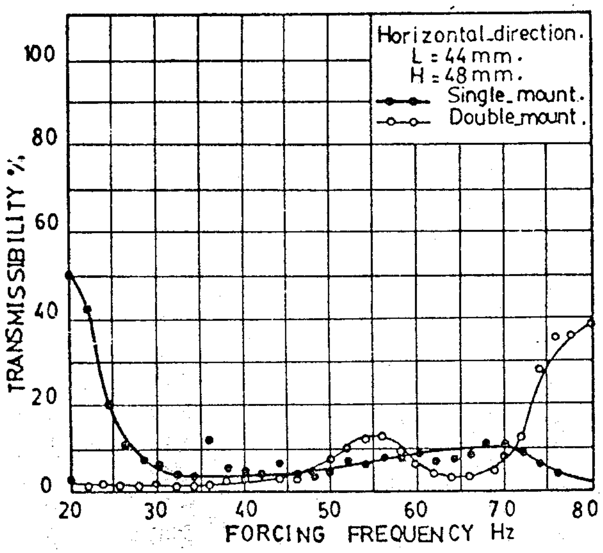

Fig. 8. Transmissibility spectrum.
(Double Isolation, Horizontal direction)