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SOME RECENT APPLICATIONS OF THE IMA INFRARED TRANSDUCER IN THE ANALYSIS OF VIBRATING MECHANICAL SYSTEMS

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1. INTRODUCTION

The basic concepts underlying the construction and operation of the IMA infrared transducer specially developed for analyzing vibrating mechanical systems were presented in recent publications [1, 2].

The transducer's main advantage is that it does not require physical contact with the vibrating object. Certainly this can be accomplished using proximitors but they require that the object under investigation be of metallic, ferrous nature.

On the other hand, laser-based measurement systems are more universal and accurate in their scope of application, but require a considerably more expensive and sophisticated experimental set-up than the infrared IMA transducer [1], which is made of, basically, an infrared emitter diode and a receiver diode, Figure 1. The infrared incident ray is reflected by the vibrating element according to its relative motion with respect to the transducer. The intensiy of the reflected ray is modified as a function of the displacement of the vibrating element. This, in turn, allows for the determination of the frequency of the vibrating object from extremely low frequencies (approaching the static case) to any frequency value. Two recent applications are discussed in the present paper: (1) analysis of a rotating system, (2) tuning a dynamic absorber.

It is felt that the wide range of possible applications of the IMA infrared transducer will be of interest to mechanical, naval and ocean technologists in a great variety of situations.

2. APPLICATION TO A ROTATING MECHANICAL SYSTEM

Figure 2 depicts the application of the infrared transducer to the determination of the vibratory motion of the shaft of an electrical generator. The motion is referred to a fixed co-ordinate system. A typical spectrum is shown in Figure 3 and has been obtained using a Spectral Analyzer CSI 1900. The maximum peak amplitude is 125·7 μm at a frequency component of 105·3 Hz, in the x direction (see Figure 3). Obviously the orbital motion can be plotted if one places a second infrared transducer at 90° from the first one.

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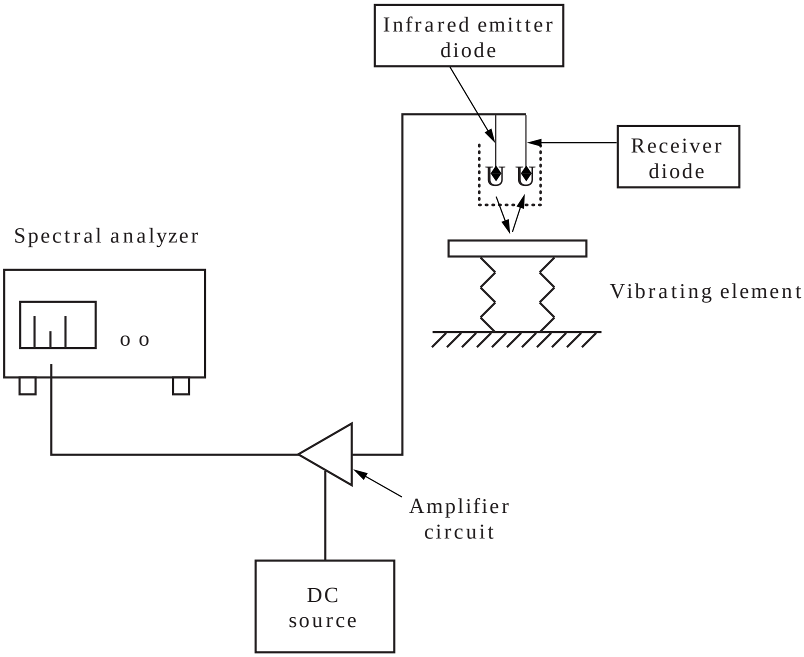


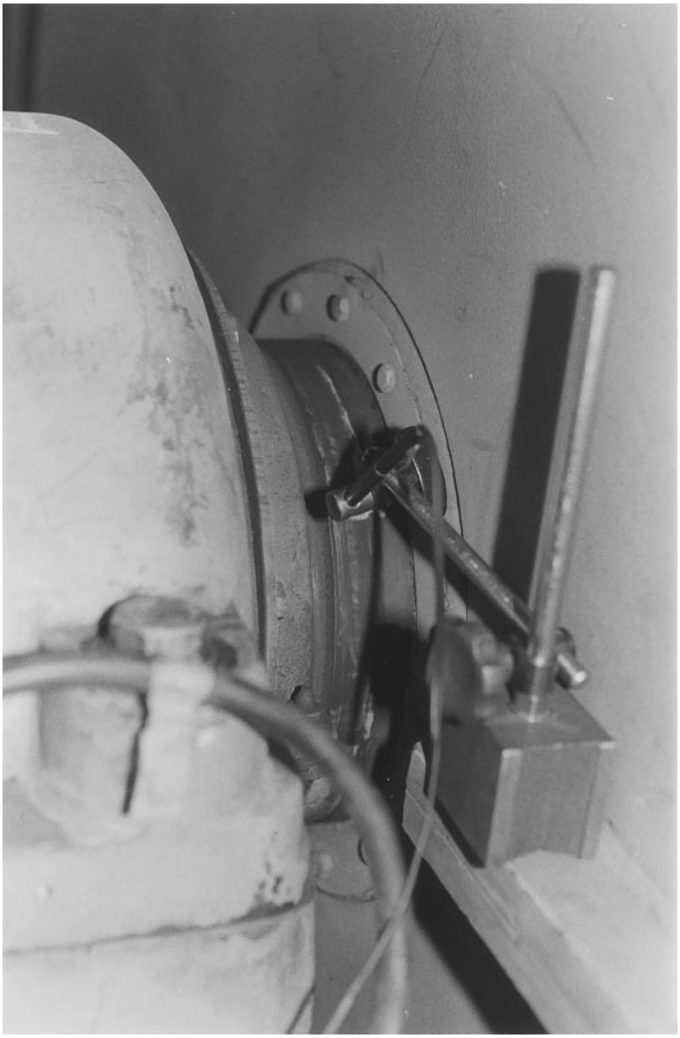
Figure 1. Infrared IMA vibration transducer: basic set-up.

3. TUNING A DYNAMIC ABSORBER

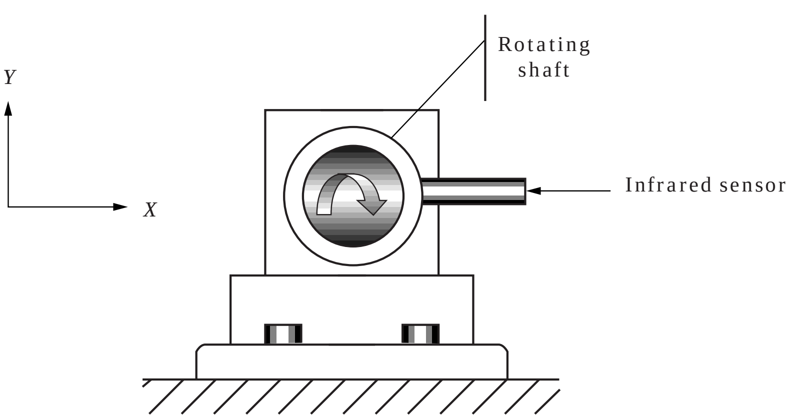
This application is an ideal one for the infrared transducer since no physical contact is desired (experience indicates that placing even a very small accelerometer alters the behavior of the damper). The set-up is shown in Figures 4–6. Figure 5 also depicts the measuring system used (also a Spectral Analyzer CSI 1900).

Table 2 shows the displacement components in the x, y and z directions of the vibratory equipment, before tuning the dynamic absorber and after the tuning operation. These components have been obtained by means of accelerometers acting in the appropriate directions. Table 2 also depicts the displacement amplitudes of the dynamic absorber, determined using the IMA infrared transducer.

One concludes that once the dynamic absorber has been tuned, the displacement components in the x and y directions experience a small reduction in magnitude while the z component is reduced to practically one-third of its original value (from 112·7 to 36·59 μm). As it was to be expected the amplitude of vibratory displacement of the dynamic absorber is considerably larger once the absorber is operating properly (almost 14 times larger than the original value).



(a)



(b)

Figure 2. Study of a rotating system: (a) determination of the vibratory motion of the shaft of an electric generator; (b) shaft and co-ordinate system.

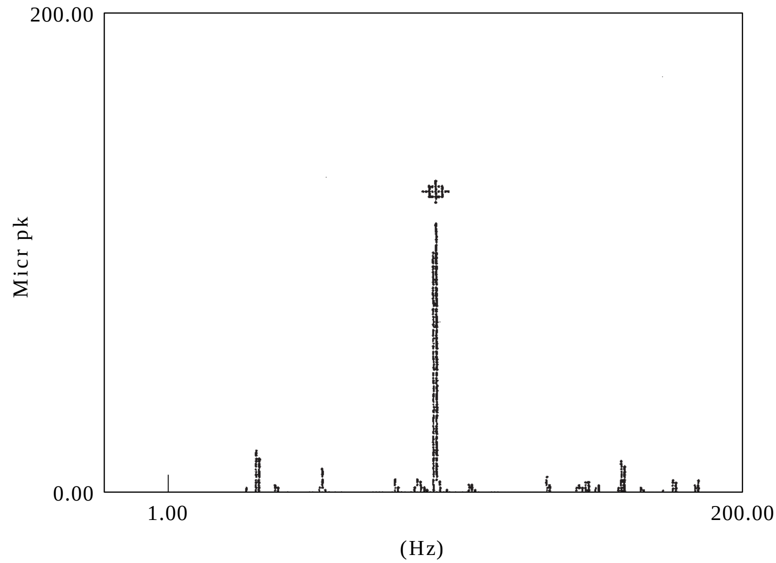


Figure 3. Typical spectrum of the vibratory motion determined using the IMA infrared transducer.

Table 1

Peak vibrational displacements in the x-direction of the rotating system shown in Figure 2

Frequency	Peak	Frequency	Peak	Frequency	Peak	Frequency	Peak
46·46	2·140	100·1	5·900	139·4	7·160	162·7	14·33
49·67	18·62	102·1	1·990	149·1	3·860	168·6	2·412
55·63	3·470	105·3	125·7	151·8	5·187	175·0	1·476
69·71	11·25	108·5	1·425	154·9	3·209	178·6	6·218
92·95	5·899	116·2	3·854	161·0	2·020	185·9	6·154

Note: maximum peak value = 125·7 μm at 105·3 Hz.

4. CONCLUDING REMARKS

Two novel applications of the IMA infrared transducer are described in the present study. In the case of a rotating shaft the operation is quite simple, as compared with the use of proximitors, since under this circumstance the surface of the shaft must be specially prepared. Another inherent advantage of the IMA infrared transducer is the fact that the shaft does not need to be of a ferrous material; it can be used in the case of bronze, composites, non-magnetic stainless steel, etc.

When dealing with the operation of a dynamic absorber the infrared transducer is extremely advantageous in view of the fact that physical contact is not required.

Finally, the infrared transducer is quite economic and simple, at least when compared with laser set-ups. This point is of the utmost importance in developing countries.

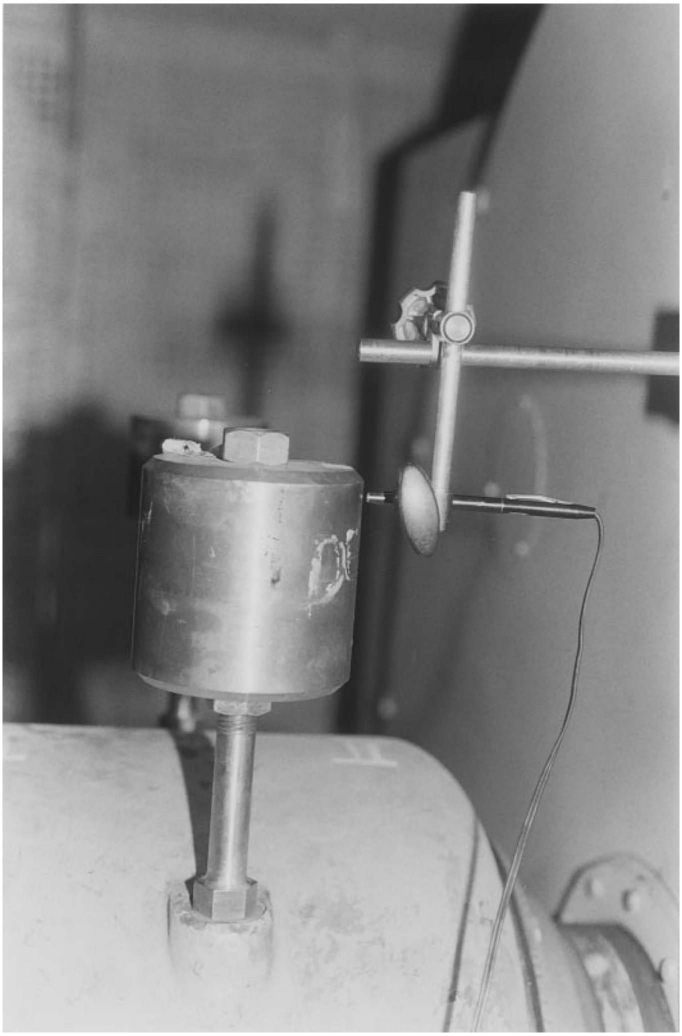


Figure 4. Tuning a dynamic absorber.

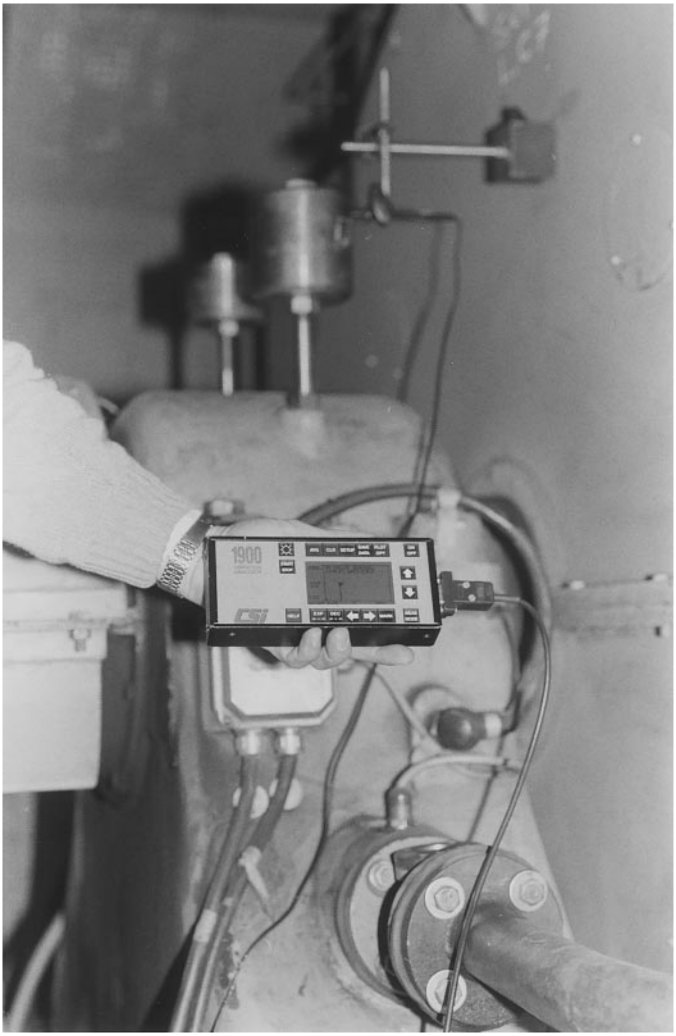


Figure 5. Experimental set-up used when tuning a dynamic absorber.

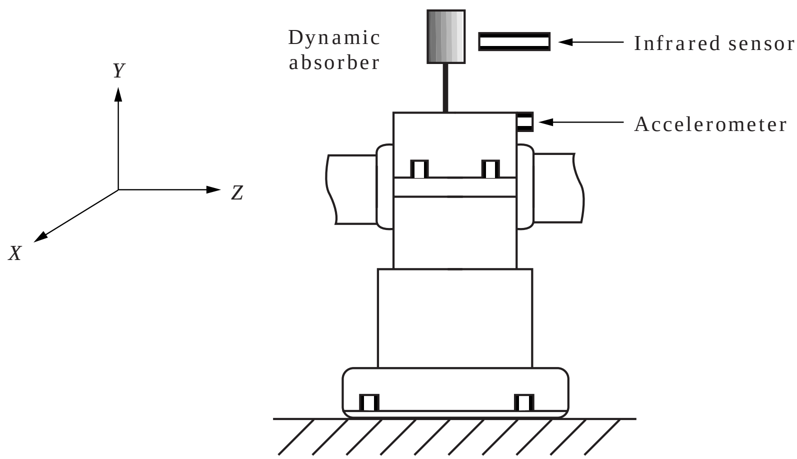


Figure 6. Machinery, its dynamic absorber and co-ordinate system.

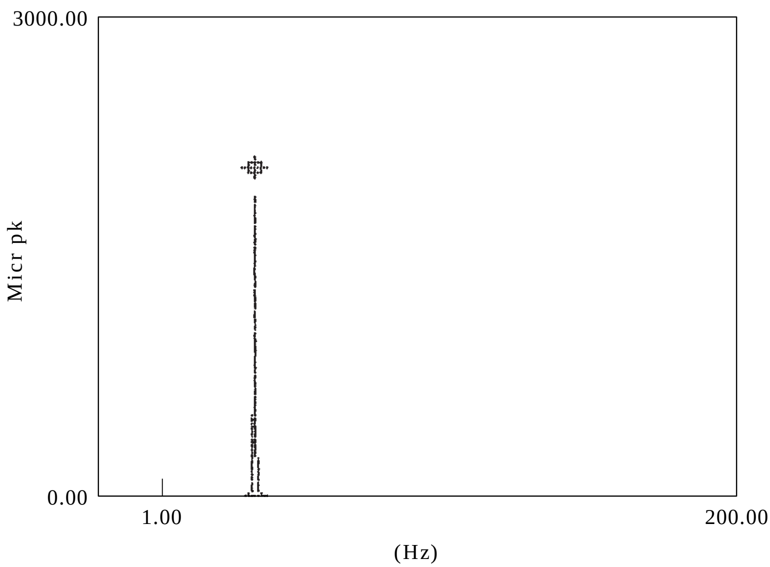


Figure 7. Spectrum of the motion of the dynamic absorber once the system has been tuned. Note: maximum displacement in the z direction is 2044 μm at 50·19 Hz.

TABLE 2

Displacement amplitudes (in μm) of (A) vibratory equipment and (B) dynamic absorber, before and after tuning the absorber

System	Before tuning			After tuning		
	x	y	z	x	y	z
(A) Vibratory equipment	35·6	28·3	112·7	33·1	27·3	36·59
(B) Dynamic absorber	–	–	155·8	–	–	2044

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