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Sensor placement in the vibration analysis: application to the case of coupling faults.

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A B S T R A C T

In practice, the recorded vibratory signals are the result of a mixture of different sources corresponding to the various components of the machine, which makes it difficult to interpret the damage state of a particular component and essentially depends of the location choice of the sensors measurement points, we will focus exclusively on accelerometer sensors because these are the sensors most used in vibratory analysis and also those used throughout this study.

The objective of our work is to separate various vibratory sources contribution directly related to a failure of a mechanical component, based on several measurements made using the accelerometers, according to an experimental analysis of coupling defects by vibratory analysis.

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Introduction:

Vibration analysis is the tool of conditional preventive maintenance, which is successfully applied in the industrial field. Its purpose is to serve three levels of analysis: surveillance [1], diagnosis and damage condition monitoring of the equipment [2] and makes it possible to estimate remaining lifetime of the component under the given operating conditions from damage laws knowledge [3].

This separation will not only locate the defects on the components and monitor the damage evolution of each of them but also to improve the diagnosis and determine the positioning zones of the sensors [4]: This is the objective of our work which consists of studying the influence of misalignments of different types of drive mechanisms coupling on the vibration speeds. In this study, we studied the influence of rotation speed while varying the following parameters:

-The direction of measurement (Horizontal and Vertical).

-The type of coupling: Rigid plate coupling (untainted, flat defect, radial defect).

Experimentation:

Experimental device:

The experimental device used is illustrated in Figure. 1 and consists of a three-phase motor unit with encoder mounted on a base plate with alignment device.

The motor control contains a frequency converter for gradually adjusting the speed of rotation. In addition, it has a speed indicator and an indicator for the power absorbed by the engine.

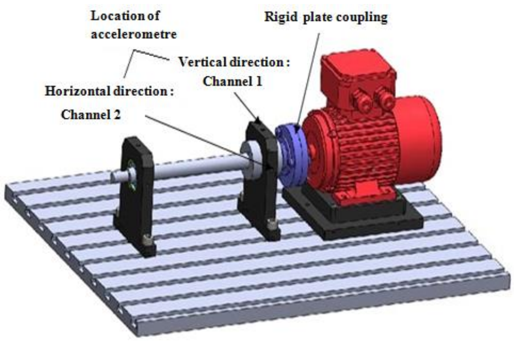

Fig. 1: Experimental device

In order to simulate vibrations with the basic device and carry out the tests, the following parts are required in the assembly:

- Two full rigid supports with ball bearings (P1 and P2):

P1: Rigid bearing placed on the motor side, secured by two locking rings, tightened on the shaft for axial fixing, in order to prevent the shaft from moving.

P2: Free rigid bearing at the end of the shaft.

- Two piezoelectric acceleration sensors fixed in two directions (horizontal, and vertical). The latter convert the measured vibrations into signals. They allow the transformation of the acceleration into an electrical signal proportional to the acceleration of the measurement at the amplitude as a function of the frequency.

- A reference sensor consisting of a direct reflection cell whose function is to instantly record the rotation speed.

- Rigid plate couplings.

- A measuring amplifier is used to power the acceleration sensors. The signal is scanned into the USB meter and transferred to the PC.

Operating method:

The tests carried out on the experimental device previously presented are carried out under the same conditions (1000, 1700, 2400 rpm) while changing the different types of couplings.

Three models of rigid plate couplings were used in our study (Figure 2).

- The first model (a): Rigid coupling without defect (ARSD).

- The second model (b): Rigid plate coupling with radial abutment, in which case the shaft bore is off-centered from the bore of dy = 0.2 mm (ARDR).

- A third model (c): A rigid coupling with axial depression, this model with an axial abatement dx = 0.4 mm, which corresponds to an inclination of the shaft by an angle of 0.25 ° (ARDP).

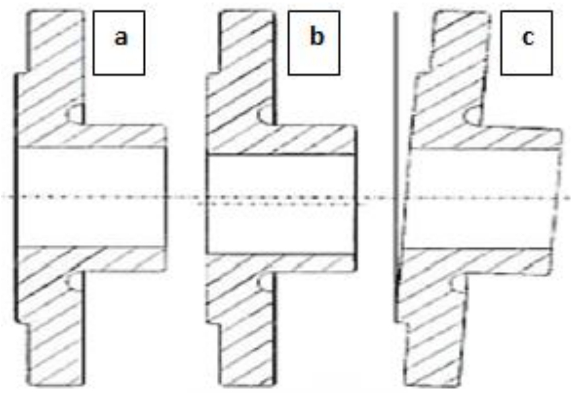

Fig: 2. Half Plate Coupling

Results and discussions:

Shaft misalignments represent up to 50% of failures cost in rotating machines. Accurate shaft alignment can not only reduce the number of unplanned shutdowns but also result in significant production gains. A company today is subject to strong constraints: to optimize the efficiency of its equipment and reduce its costs. A precise alignment of shafts becomes essential.

Figures. 3, 4 and 5 show the variation of vibration speed as a function of three models: rigid plate coupling (untainte "ARSD", plane defect "ARDP", and radial defect "ARDR").

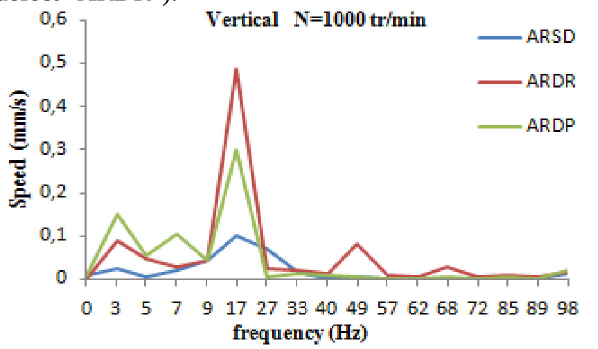

Fig. 3: The measurement curves (AR) for N1 = 1000 rpm channel 1.

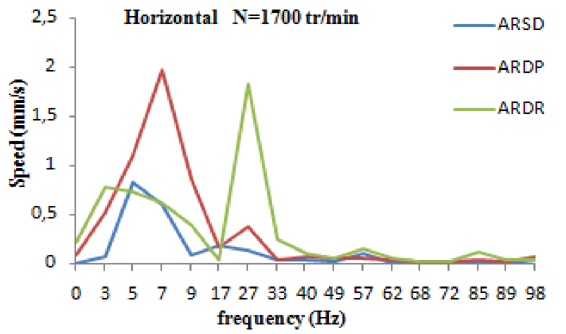

Fig. 4: The measurement curves (AR) for N2 = 1700 rpm channel 2

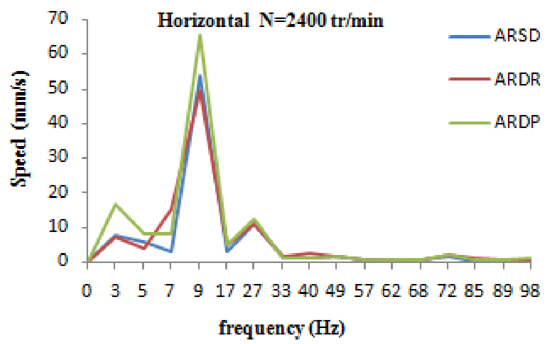

Fig. 5: The measurement curves (AR) for N3 = 2400 rpm channel 2

Examination of the different curves obtained at different speeds shows that for a faultless coupling, the frequency is always less at the base frequency.

At different rotational speeds, an increase in amplitudes is observed in the case of the plane defect and the radial defect, but in the case of the plane defect they are more marked compared with those of the radial defect and this in the vertical direction (channel 1) and the horizontal direction (channel 2).

Positioning of the sensors (vertical direction: channel 1 and horizontal direction: channel 2).

Conclusion:

When the structure is balanced, only weak vibrations occur. With the aging of the machine, the foundations collapse, the organs are degraded and, consequently, the dynamic properties of the machine change.

The aim of our work was to study the influence of different coupling misalignment types of the drive mechanisms on the vibration speeds and the study of the influence of the positioning choice of the sensor. We can conclude that:

- The method of attachment and the location of the sensor in the vertical direction or the horizontal direction influence the results, and according to this study the sensors must be placed in the most direct mechanical connection with the movable element and fixed on the bearing on the transmission side (on the side of the maximum load) in the vertical direction.

-The effect of the pairing of vibration velocity amplitudes at low frequencies at high velocities due mainly to the effect of the hardness of the material in vibration damping.

-The slope of the curves increases with the driving speed, and the positioning direction of the piezoelectric sensors (vertical direction and horizontal direction).

- The three curves of Figures. 3, 4 and 5 show that for a defect less coupling the vibration velocity increases substantially, however, for the coupling with plane or radial defect, it increases considerably.

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