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IDENTIFICATION OF VIBRATIONS AT MISALIGNMENT

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Abstract: Misalignment is an important cause of damaging spare parts. The misalignment can exist between different parts of the equipment with rotation moves. A rigid coupling of the two shafts is considered incorrect when the guiding shaft (motor) of the actuating equipment is not in line with the guided shaft of the actuated equipment. There are the possible types of coupling with misalignment: parallel misalignment, angular misalignment and combined misalignment.

Misalignment is an important cause of damaging spare parts. For example, if at coupling of the actuating shaft of an electric motor to the main shaft of the equipment there has been no alignment carried out previously according to foreseen alignment deviations, than the axle box bearing or bearing of the two coupled equipment is worn out as soon as the deviations are bigger respectively the alignment is more incorrect.
The misalignment can exist between different parts of the equipment with rotation moves.
A rigid coupling of the two shafts is considered incorrect when the guiding shaft (motor) of the actuating equipment is not in line with the guided shaft of the actuated equipment. There are the possible types of coupling with misalignment: parallel misalignment, angular misalignment and combined misalignment.
The mentioned types of misalignment are met at rigid coupling. When assembling two shafts with flexible coupling the undesired consequences of misalignment are eliminated but from technical and economical point of view such coupling is not always possible.
In order to identify the type of misalignment the horizontal, vertical and axial vibrations are measured, in both bearings of actuators and actuated equipment. In the first three rotation frequency harmonic can occur in the spectrum of measured vibrations on a certain direction as follows:

a) On horizontal direction; if there is a vertical parallel misalignment;
b) On vertical direction: horizontal parallel misalignment
c) Axial direction: angular misalignment
d) On all three directions, combined misalignment.

There are many types of combinations and degrees of misalignment. The signals can vary depending on the coupling type, size and diameter of the shaft and rotation speed.

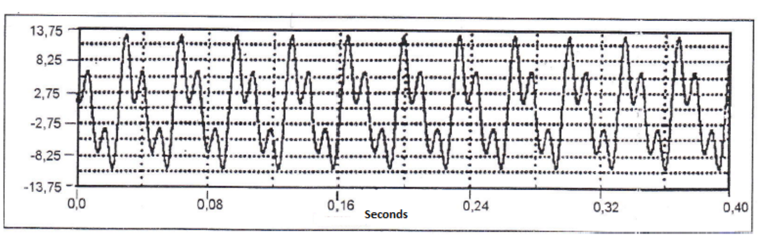

Fig. 1 The time and frequency of a misalignment.

Insufficient tightening or loosening of mechanical joints can take place in different forms according to type of loosening, size of clearance as well as cause of vibrations that are added to as it is unbalance, misalignment, faulty bearings, etc.

The typical cases of insufficient tightening or loosening of mechanical joints are often met in practice at the tightening of fixing screws of equipment support, screws of bearing casing on supports, etc. In all these situations we find in the frequency spectrum of radial vibrations the increase of amplitude corresponding to the rotation frequency and its harmonic as presented in diagram 2. In this diagram the time signal and frequency spectrum of vertical vibrations is represented, measures on the bearing casing of a fan with a speed of 1780 min^{-1}, where by functioning a screw of bearing casing has been loosened. The more the loosening, respectively the jointure clearing is higher the more the amplitude of harmonic is increasing and the amplitude corresponding to rotation frequency and the level of root mean square (RMS) of vibrations can decrease.

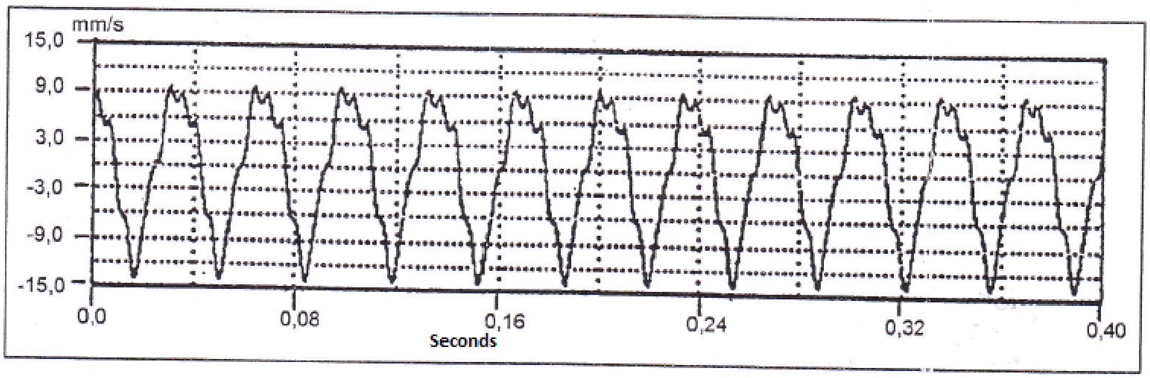

Fig. 2

A more advanced loosening of mechanical joints is noticed by the appearance in the frequency spectrum of radial vibrations of equipment of a spectrum levels (amplitude) at factionary values of rotation frequency. Consequently we can have spectral levels of equal values with ½, 1/3, ¼ of rotation frequency according to type and degree of loosening of joints.

At loosening of the interior ring of a bearing on the shaft, the type of signal generated depends on the type of transmission of engine coupling from the electrical motor to the actuated equipment. If the interior ring of the bearing is not well set on the electric actuating motor shaft and this conveys the motor coupling to the actuated equipment through angular belts, in the frequency range of the radial vibrations of the two machines, measured on the casing of bearings there is a high amplitude at the rotation frequency of the shaft as in the case of an unbalance. However the time signal is somehow distorted. Thereby the amplitude of time signal can vary, be truncated, contains harmonic, contains beats or the duration is different at each half period.

At direct coupling of the two equipment if the interior ring of the bearing not being perfectly fixed on the shaft is turning on this as little as possible, the frequency range of radial frequency, measured on the casing of equipment bearing can contain a spectral line at the rotation frequency of the shaft and another spectral line of a lower amplitude. The frequency where a lower spectral line appears is exactly the rotation frequency of the interior ring of the bearing. The difference between the values of the frequency of the two mentioned spectral lines indicates the frequency of relative rotation of the interior ring of the bearing on the shaft as presented in diagram 3.

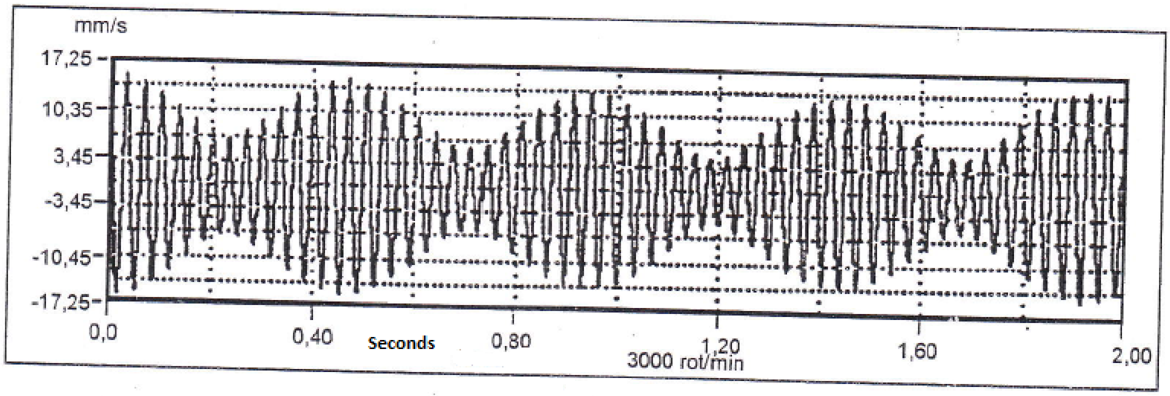

Fig. 3

The last stage of loosening of mechanical joints is found through noise. The noise can be of wide-range bandwidth or narrow bandwidth. In this case the rotator is spinning of an unpredictable manner and in the frequency range there are all possible frequencies appearing.

Identification of resonance frequencies

The resonance appears when the frequency of a pulse force applied to a system is adjusting to the own frequency of the system causing a higher amplification of the systems vibrations.

The resonance is recognized through the amplification of amplitude and change of transit angle of vibrations. Thereby at resonance, in the point in that the pulse frequency matches the resonance frequency we notice a change of phase with 90^o and the value of this difference is close to 180^o when the equipment passed through resonance (depending on damping of the system).

The resonance frequency can be determined by three ways:

1) Calculation using modal analysis;
2) Practical tests using a hammer, through impact;
3) By analyzing the data of vibrations measures during start-up or stoppage of equipment, at machines that are functioning in steady-state regime with a higher rotative speed than number of turns of critical turns.

Generally, if during functioning in steady-state regime of an equipment with rotating moving parts it is found that the rotation frequency, from different causes, is very close to the own frequency of the system and can lead to resonance, it is necessary to alter the own frequency by one of the known methods of modal analysis.

Identification of vibrations at friction, vibration with pulses

When rubbing two surfaces together with calorification, the generated noise, respectively the generated vibrations are in broadband.

A form of friction met in the activity of monitoring vibrations is friction of the rotator.

The friction produced by touching / hit of a fix part by a moving part is highlighted in the frequency range of such vibrations by a series of spectral lines. The difference between the frequencies of two adjacent spectral lines is equal to the spinning frequency of turning part.

An impulse is caused by a touch or an impact. The total number of repetitions indicates how often an impulse takes place. If during a period of time there is only one impulse than the frequency of this is equal to spinning frequency. When there is more than an impulse in each period the impulses can occur randomly in each time limit. The frequency range will contain a series of spectral lines and the difference between the frequencies of two adjacent spectral lines will be also equal with the spinning frequency. If there are two impulses during a rotation, each second spectral line will have the higher amplitude as presented in the frequency range of radial vibrations of the fan from diagram 4. If there are four impulses at each rotation, each fourth spectral line will have the highest amplitude and so on.

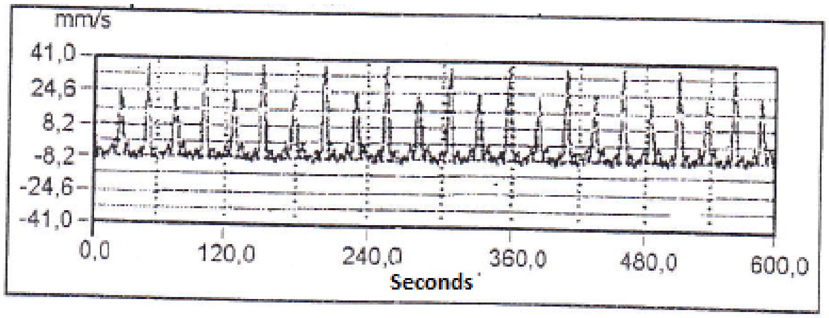

Fig. 4

The impulses can take place also at other frequencies as for example the frequency of rolling the balls of a bearing on the inside or outside ring of this, frequency of joining two gear wheels, etc.

Impulses can take place also randomly. When random impulses occur, in the frequency range occur broadband vibrations, the rotating part wobbles and makes noise; in this situation the damage is imminent.

Immediately after the parameters of the impulses have been found, in some cases it may be difficult to identify the respective damage. This is due to the fact that more defects can cause impulses at the rotation frequency. In these cases the characteristics of time signal and spectral lines in the vibration's frequency range should be carefully analyzed.

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