ALIGNMENT OF VIBRATION EFFICIENCY ON AXIAL FAN FUNCTIONING. CASE STUDY.

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Abstract: Shaft misalignment is a common cause of machinery failure. Given the importance of long shaft alignment, the mechanical vibration spectrum of mining fans is not well documented. This article presents research on the mechanical vibration level for misalignment for different operating conditions, coupling types. The axial mining fan type VOD 2.1 was studied to create variable mechanical conditions. Triaxial vibration measurements were performed at each end of the coupling on the motor and rotor bearing housings. The results indicate that air velocity, coupling type and stiffness have a strong effect on the vibration spectra. The level and type of misalignment had a significant effect on the mechanical vibration signature.

Key words: mechanical vibration, axial fan for mining, alignment, signal processing.

1. INTRODUCTION

The safety and stability of underground mining conditions mainly depend on the ventilation system. The specialized literature has shown that the axial fans used in the mine ventilation system have a utilization rate of 30%.

Since the most important element that determines the life of a machine is the design, the construction of various metal and mechanical assemblies, it is necessary to develop a methodology of real analysis of the dynamic system to determine the period of their safe use. A number of factors act on the equipment such as overload, shock, material fatigue, corrosion, etc., all of which lead to the destruction of sub-assemblies.

The problem of the destruction of foundations, buildings began to be carefully studied only after a serious technical accident occurred with the destruction of the fan.

The analysis of these accidents and failures, for complex welded constructions, strength and stability calculations, although necessary, are not sufficient to ensure safety, it is absolutely necessary that they are complemented by a series of mechanical vibration measurements.

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Misalignment is the common cause of machinery failure. A poorly aligned machine can cost a mine with its shutdown

Mechanical vibration measurements and thermography analyzes are widely promoted for studying machine failures. The specialized literature does not present a clear spectrogram of the characteristics attributable to misalignment. Different authors report different vibrational spectra. There are no reports of systematic, controlled experiments with variable parameters.

The purpose of this article is to establish modern methods of investigating key points in the operation of VOD 2.1 fans in the mining industry, to make proposals for mechanical vibration analysis to improve their alignment and to increase their performance and reliability. The paper presents a series of experiments aimed at elucidating the consistent characteristics, for two fans from the same operation. The fans were faultless except for misalignment.

2. EXPERIMENT

All tests were performed on two Russian-made VOD 2.1 axial fans (figure 1), from the Vulcan Mining Plant.

Fig. 1. The VOD 2.1 axial fans at EM Vulcan

The vibrations were measured with piezoelectric accelerometers placed in specific locations as presented in figures 2 (schema) and 3 (photo on actual location).

An optical tachometer was used to measure the speed. The X, Y, Z coordinate system was used to indicate direction.

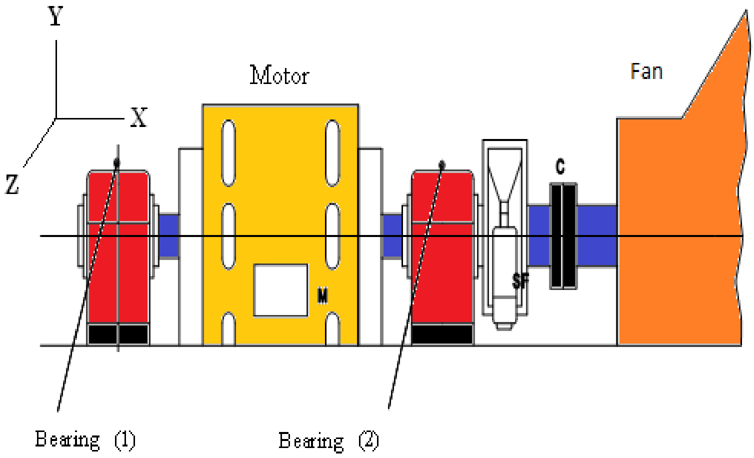

Fig. 2. Schema of the placement of the piezo accelerators

Fig. 3. The actual placement of the piezo accelerator in situ

The experimental design for this study included three different stiffness couplings. Four offset levels were used on the left bearing housing to simulate a combination of angular and parallel misalignments.

Equivalent offsets on the right side of the bearing housing gave parallel misalignment. The experimental design had a rotation speed of 600 RPM. The purpose of the study was to determine the effects of coupling stiffness, level and type of misalignment on mechanical vibration spectra.

In Figure 4 the measuring devices are presented.

 

Fig. 4. Presentation of the actual measuring device

The data were acquired with hardware and software specially developed at the University of Petrosani. Data were acquired for the maximum frequency of 2000 Hz at spectral resolution of 800 lines.

Five blocks of data were averaged to calculate the spectral functions. Software developed by the author was used to analyze the mechanical vibration signatures.

Typical vibration FFT spectra on the fan and the fan motor are shown in Figures 5 and 6. This shows the most predominant peak in velocity (mm/s and Hz).

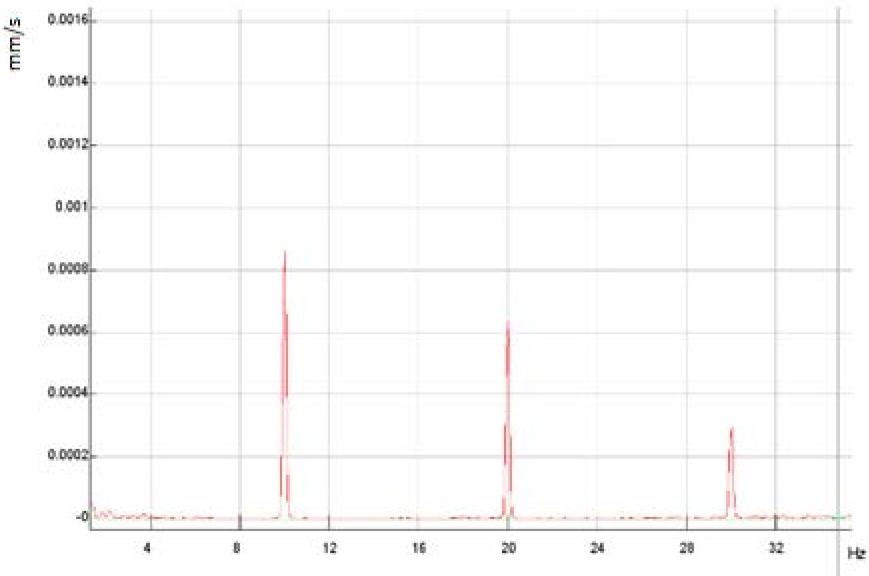

Fig. 5. Vibration FFT spectra on the fan

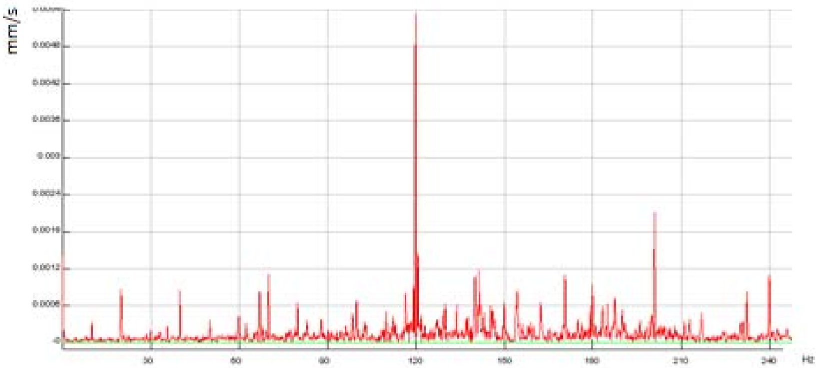

Fig. 7. Vibration FFT spectra on the fan of motor

3. RESULTS

The purpose of the access study paper is to examine the spectra due to misalignment between the motor and the fan rotor. Spectral comparisons were made between coupling measurement points on the left bearing housing and the engine. Data were compared in vertical, horizontal and axial directions. Results are limited to 600 RPM only. A correlation between the misalignment and the vibration signature could not be discerned. In all cases the spectra have a higher content of harmonics. Both axial and lateral vibrations were present in all cases. The fundamental harmonic varied from one condition to another. It can be said as a general rule, increased misalignment produces increased mechanical vibration peaks. However, there are exceptions to this rule. High speeds generated a number of high-amplitude increased harmonics. The fundamental vibration had larger peaks, but in most cases the second and fourth harmonics appeared to have the largest amplitude. The accelerometer mounted on the motor revealed mechanical vibrations with a higher frequency than the bearing housing. A frequency modulation was observed at higher harmonics.

Coupling stiffness has an effect on mechanical vibration spectra. For a given speed and level of misalignment, the steel coupling produced the most vibration, followed by the toothed coupling. Thus, it can be concluded that a stiffer coupling produces more mechanical vibrations than a softer coupling. The effect of the degree of misalignment was not as significant, except for the steel coupling. But the very stiff steel coupling showed high levels of vibration even under 0.508mm of misalignment. No significant difference was observed between parallel and the combination of parallel and angular misalignment.

4. CONCLUSIONS

The misalignment conditions show a significant variation in the mechanical vibration spectra depending on the misalignment conditions. Both the amplitude of the peak at the fundamental frequency and its location along the frequency axis change in a non-linear way. Based on the sweepers and the analysis of a single spectrum, it is not possible to conclude the cause of the machine failure, especially the misalignment. Careful force examination is necessary to differentiate misalignment from other sources of mechanical vibration. Some cross-correlation analysis in conjunction with a rotor dynamics model may be necessary to make a complete diagnosis. The results of this study show that when two misaligned shafts are joined by a coupling, the machine structure is subjected to mechanical deformation. The deformation differs for each angle of rotation, depending on the type of misalignment. The mechanical tension will depend on the rigidity of the machine structure.

For predictive maintenance applications where the goal is to monitor the condition of machines, it is enough to determine if the problem is complex. One can routinely analyze the vibration spectra until the machine condition becomes critical. The vibration induced by the misalignment is very complex. The changes that occurred with changes in speed, airflow, and misalignment do not show a typical spectrogram for misalignment vibration spectra. The data show that a machine can have parallel misalignment without exhibiting second-order harmonic vibration. Analysis of a vibration spectrum at a single point and for a certain operating condition does not give a good indication of machine misalignment. Nonlinear modelling may be necessary for a full understanding of misalignment effects.

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