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The effective vibration speed of web offset press

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Abstract

The purpose of this study was to investigate the existing maintenance models of web offset presses, and to propose the method which increases the reliability of the printing press exploitation, but does not require big investments. Doctor motors allowed constant monitoring by measuring instruments, which allowed insight in current status of motors at any time, so they could be repaired or replaced before malfunction. The effective vibration speed (v_{RMS}) was measured a few times during the year 2006. Standard ISO 2372-1974 (E) defines values and boundaries of the effective vibration speed (v_{RMS}). Results of measuring effective vibration speed indicated the emersion of nuisance energy with deterioration. To determine the state of bearings, and check if they cause the increase of effective vibration speed, an envelope analysis - FFT of the acceleration specter is conducted. This decreases the probability of motor malfunction and greatly increases the reliability of the whole system.

Keywords: offset rotation, printing, maintenance

1. Diagnostic monitoring systems

The purpose of diagnostic monitoring is a more detailed analysis of a signal from the measuring instrument, storing of all data (building a database), reviewing and additional analysis and statistical analysis of the data. The purpose of these systems is getting an insight of the facility performance, classification of performance and the setting of criteria of normal performance.

Based on the set criteria, the monitoring system signalizes the so-called diagnostic alarms, which do not have an executive function, but they signalize that the machine performance is changing, and that it requires detailed inspection of the stored data. These changes are usually significantly smaller than those specified by standards, or refer to measures which are not even mentioned in standards (e.g. signal phases), but they do indicate changes.

Based on the collected data and results of diagnostic monitoring systems, maintenance interventions (ordinary and extraordinary) can be planned, and savings can be made by using the collected data. That means that these systems are useful even when there is no indication of any changes, because they make a solid base for evaluation of machine reliability. Further, based on the analysis of collected data, it is possible to localize the cause of irregular machine performance, and to get detailed data of what actually happened during critical situations, [1].

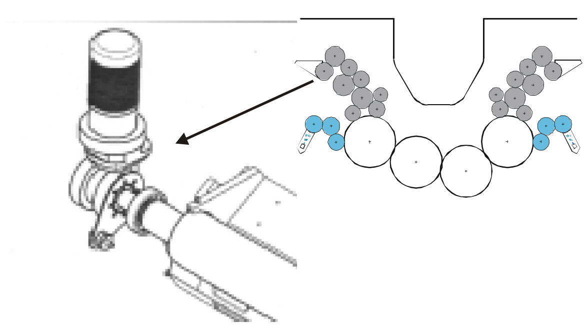
The development of diagnostic monitoring systems began with the diagnostic vibration monitoring systems. It showed that the conventional vibration monitoring, which only measured overall value, as useful as it was for alerting, was not sufficient for a reliable estimation of the machine state.

Therefore, diagnostic methods were developed. Methods are mainly based on spectral analysis, which facilitates a precise diagnose of the vibrodynamic state. The development of computer and measuring techniques, from simple one-channel devices, over two-channel and n-channel FFT analyzers to n-channel devices for measuring, analysis and storing (logging) of data, lead to creation of systems that are capable of constantly measuring and analyzing data, identifying results relevant for evaluation of the state, and permanently storing the collected data. That is the way to attain the objective of permanent diagnostic monitoring. It practically means that the signal analysis, which was priory conducted as a sequence of complex and expensive tests, is now part of the process, and its results are being selectively stored in databases, [2].

The basis of vibration analysis in diagnostic monitoring systems is the harmonic analysis of signals, which means that the program calculates amplitudes and phases of all harmonics from measured wave forms. Sampling of signal always starts with a “marker” placed on a fixed position on the aggregate axle. By passing the sender (usually identical to the relative movement sender), marker triggers one impulse per axel turn, which triggers the recording of the signal sample needed for the analysis, and the vibration signal phases and amplitudes are calculated from the marker position by the fast Fourier analysis.

2. Description of measuring the state of doctor motors

Picture 1 shows doctor motor and the printing unit on which the measurement were made. Motors which drive doctors are low-power motors (0.37kW). They work constantly since commissioning of the machine. During the printing process they work at approximately 600 rpm, and during stand-by time their speed is reduced to 20 rpm. It is expected that the number of malfunctions will increase after a few years of exploitation, because bearings are expected to wear-out. Bearings are SKF 3204-2Z, sealed, [3], which makes lubricant change impossible.



Picture 1, Doctor motor in a segment of a printing unit

On bearings, the magnitude of stroke impulse is proportional to the rotation speed of a bearing. A bearing which rotates al low speed will give low level stroke impulses, and the bearing which rotates at high speed will give high level stroke impulses. That is the reason for performing a normalization of measuring, so that the evaluation of the bearing state does not depend on the bearing rotation speed.

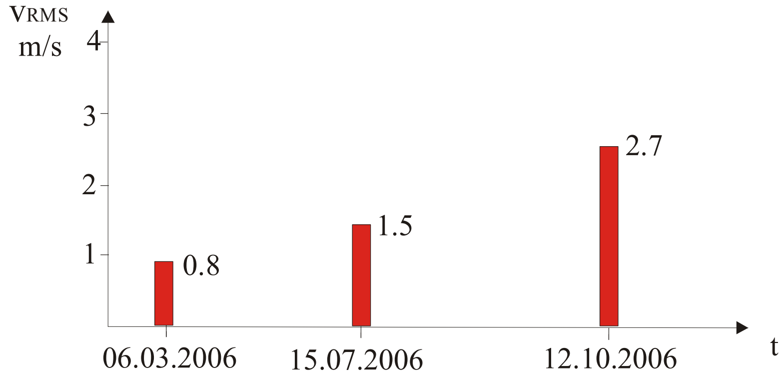
Vibration measured on a new or valid bearing is low level and appears as random noise. Measurement results which were within tolerable boundaries are not displayed. As the bearing wears out, vibrations are changing. Every time the rolling element comes across an irregularity, a stroke and an impulse are generated. The resulting impulses are periodically repeated in periods determined by irregularity location and bearing geometry. These periods of repeating are known as bearing frequencies.

The following frequencies differ from one another:

- the Ball Pass Frequency Outer Race (BPFO) for faults in outer bearing race
- the Ball Pass Frequency Inner Race (BPFI) for faults in inner bearing race
- the Ball Spin Frequency (BSF) for faults on the ball
- Fundamental Train Frequency (FTF) for faults on the cage, [4].

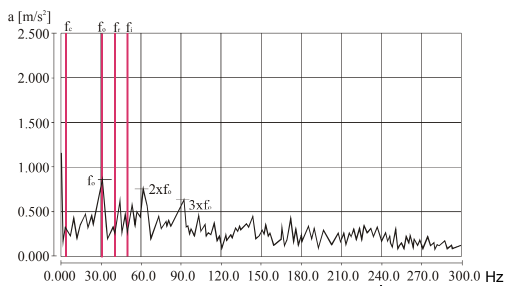
Bearing frequencies are calculated from the bearing geometry. The first sign of deterioration of a rolling-element bearing is usually the increase of amplitude of the frequency specter between 5 kHz and 20 kHz. The reason is that every time a ball comes across an irregularity, the resulting stroke excites natural frequencies within the structure. Frequencies of balls passing across irregularities and their first harmonics are often covered with background vibration, and are therefore difficult to detect. Further, because of small speed changes and sliding between bearing elements, higher harmonics will widen and eventually smear. This hardens the determination of the repeated frequency of irregularity by zooming into the scope of resonance to determine the harmonic separation. Envelope analysis solves this problem by isolating strokes and allowing precise measuring of their repeated frequency. Envelope analysis can distinguish periodic strokes. It can distinguish those strokes made inside the damaged roller bearing or those from vibration signal of the machine. It can even distinguish strokes when they are of low energy, and blended with other vibrations of the machine.

Envelope analysis is a technique used to investigate amplitude changes of the vibration signals of machines. Standard ISO 2372-1974 (E) defines values and boundaries of the effective vibration speed (v_{RMS}). The response of this measurement is the effect of nuisance energy, which emerges with deterioration. The magnitude of the effective vibration speed change itself is not an indicator of the real state of a bearing (Picture 2). Magnitude of the effective vibration speed defines the overall state of the motor.

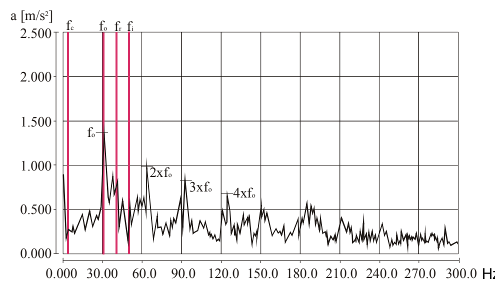


Picture 2, Analysis of v_{RMS} speeds measured on doctor motor

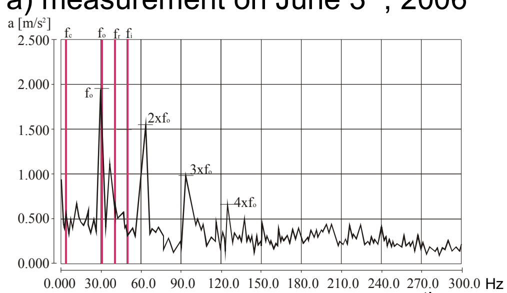
To determine the state of bearings and inspect if they cause the increase of effective vibration speed, an envelope analysis, FFT of the acceleration specter is conducted (Picture 3).



a) measurement on June 3rd, 2006



b) measurement on July 15th, 2006



c) measurement on October 12th, 2006

Picture 3 Frequency components of acceleration obtained by FFT analysis for doctor motor

Characteristics of a SKF 3204-2Z bearing built in this motor:

fi=48.46 Hz……………..frequency of the inner ring of a bearing,
fo=31.54 Hz……………..frequency of the outer ring of a bearing,
fr=40.91 Hz……………..frequency of the bearing ball,
fc=03.94 Hz……………..frequency of the bearing cage, [3].

ISO standard 2372-1974 (E) classifies this motor as Class I.

3. Conclusion

Measuring the doctor motor showed the deterioration on outer ring of a bearing. On June 3rd, 2006, the measured effective vibration speed was v_{RMS}=0.8m/s. That is Area B in Table1, and the bearing could possibly be slightly deteriorated. FFT analysis (Picture 3a) showed a slight increase of the acceleration value for the frequency of outer bearing ring. On the acceleration scale ranging from 0 m/s^2 to 2.5 m/s^2, that is approximately 30%. These results might show the inception of malfunction, but they could also occur as the result of a measuring fault. With open bearings, a slight increase of the effective vibration speed out of tolerated boundaries could occur because of a lack of lubricant. This small intervention often results in decrease of the effective vibration speed. These motors use sealed bearings which are replaced after the lubricant viscosity decreases, or the lubricant is exhausted. On July 15th, 2006, repeated measuring showed further increase of the effective vibration speed (v_{RMS}=1.5m/s). Conducted FFT analysis confirmed the increase of deterioration of outer bearing ring. Picture 3b shows that the acceleration for the outer bearing ring frequency totaled approximately 50% of the acceleration scale ranging from 0m/s^2 to 2.5m/s^2. The deterioration still does not require intervention. On October 12th, 2006, the repeated measuring showed even greater increase of the value of effective vibration speed (v_{RMS}=2.7m/s). As this is the beginning of Area C in Table1, the state is not alarming, but it is recommended to replace bearings and repair doctor motor soon. FFC analysis showed in Picture 3c confirmed this claim. The acceleration for the outer bearing ring frequency totaled approximately 80% of the acceleration scale ranging from 0m/s^2 to 2.5m/s^2.

Table 1 Values of V_{RMS}- effective vibration speed for doctor motor, ISO 2372-1974 (E), [4]

V_{RMS}- *effective vibration speed*	Description of the motor state
0.28	**A** - motor works in valid regime of work
0.45	
0.71	
1.12	**B** – malfunction is possible, but the state is not alarming
1.8	
2.8	**C** – great probability of malfunction, maintenance intervention is necessary
4.5	
7.1	**D** - motor damaged

For doctor motor, [5]:

- BONOR ASYNCRNOUS -ALTERNATING
- IP 55 T.amb 40^0 C
- 0,37 kW
- 1380 rpm

Table 1 shows effective vibration speeds and boundaries of certain states.

This method of monitoring increases the machine reliability and maintenance quality, and decreases maintenance costs. Savings are made in two segments: Preventive maintenance is not needed, so valid parts are not replaced, and the possibility of malfunction is minimal.

References

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