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EXAMINATION OF BALL BEARING USING STOCHASTIC INDEXES

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Abstract: In the last few years, progressions of statistical signal processing methods have provided effective and excellent tools to process non-stationary signals. This paper deals with a rolling element bearing test procedure which based on stochastic methods.
Keywords: *ball bearings, statistical analysis, stochastic indexes*

1. Introduction

Vibrations monitoring is one of the essential tool that allowsto determinethe mechanical health of different components in a machine. In order to prevent unanticipated bearing failures should be detected as soon as possible.When the assessment of a ball bearing is performed by vibration analysis, several signal processing techniques can be considered. These techniques can be performed within for examplethe time or the frequency ranges. Among these methodsthe time domain features are extensively usednowadays.

Statistical analysis methodsare the most appropriate with random signals, where other signal analysis methods are not suitable.These methods facilitate the fast data processing and computation.Diverse time domain statistical parameters have been used as trend parameters to detect the presence of incipient bearing failure.The most frequently used ones are root-mean-square (RMS) value, peak-to-peak value, skewness, impulse factor, shape factor, clearance factor, crest factor and kurtosis.These indexes for a defective bearing tend to be bigger than the values for a normal bearing [1].

2. Examination instruments

Bearings condition monitoring can be realized by using test device.A bearing test equipmentis used to perform the bearing fatigue and measurement investigations. This equipment is located at University of Miskolc, Department of Machine Tools [2]. Figure 1 shows this test device with itssubstantial parts.Pending the fatigue cyclesthe loadingshaft works at the given rotational speed. After the fixed-term fatigue cycles, the bearing was put over to the measuring axis. During themeasurement cyclesthe right side measuringshaft works at the given rotational speed. In both cyclesthe hydraulic cylinder exerts artificial load for the ball bearing.

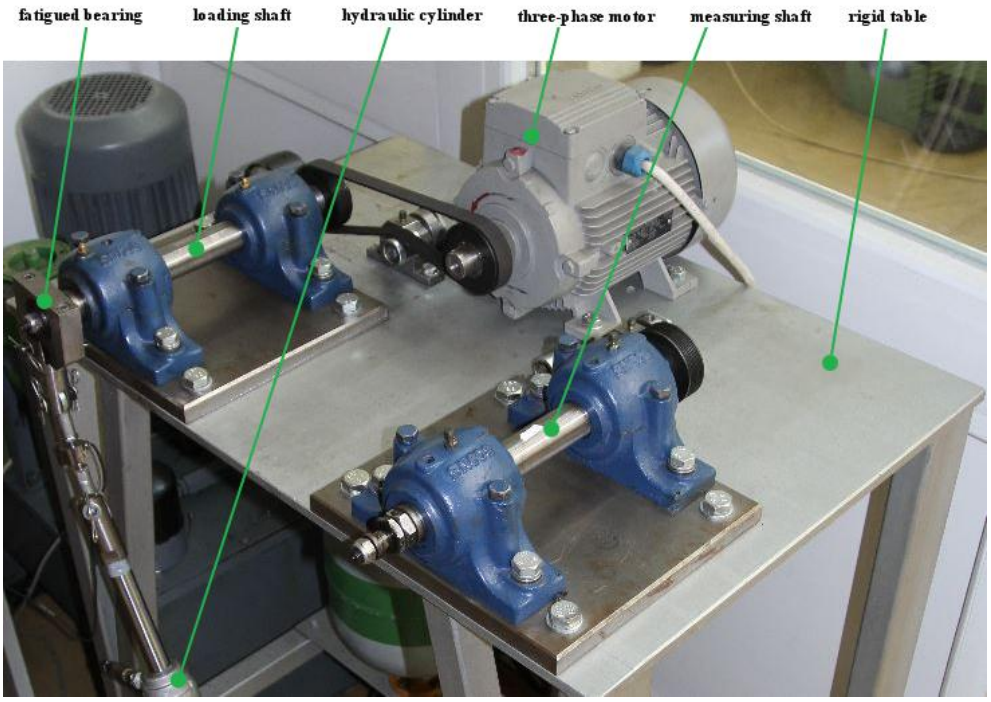


Figure 1. Experimental test rig

The measuring chain configuration always depends on the goal of the assessment. An assessment performed in an industry or laboratory systems require various configurations, and besides, the points of view of operability, economy and precision should also be considered. Nevertheless, each configuration is composed of at least one transducer, a preamplifier, a signal conditioning and a visualization unit.

The applied Kistler 8632C50 type accelerometer accuracy is classified as standard. It can be used under industrial conditions and it has got high sensitivity and excellent thermal stability.

A Kistler 5134 power coupler and an 8-channel HBM Spider8 measuring amplifier are applied. The sample rate is set to 9.6 kHz, so frequencies within the range of 0...4.5 kHz can be detected.

HBMCatman 4.0 measuring software is used to evaluate the sampled data. After the data registration the evaluation is always performed immediately.

The above-mentioned bearing testrig is used up to analyse an FAG 6303-2RSR, single row, deep groove ball bearing. That bearing is illustrated with some significant dimensions in Figure 2, all the values are in mm.

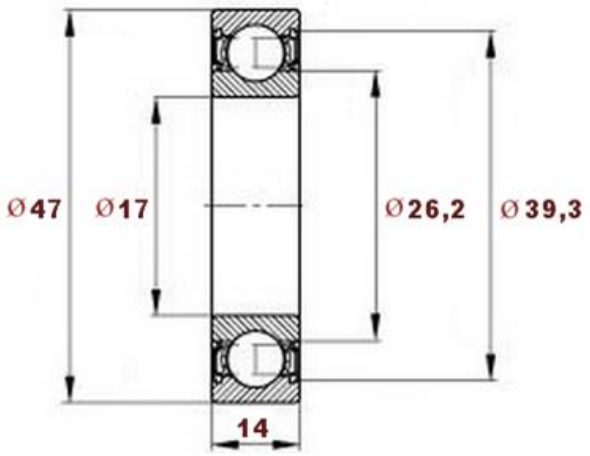


Figure 2.Bearing dimensions

The FAG 6303-2RSR ball bearing basic dynamic load is 14,4kN.Pending experiments always set on 1500 min^{-1} rotational speed and the equivalent dynamic bearing load is 6kN.Consequently, the tested FAG ball bearingwill havenear 154 hours lifetime with these data.

3. Measurements and analysis

Duringthe tests, after the fixed-term fatigue cyclesvibration specimens were taken from the bearing. Generally, the fixed-term fatigue cycles were 4 hours long. The measurement cycles are always performed at 9,6kHz sampling frequency. Five vibration samples and 16,384-elementsamples were taken within each measurement cycle. Statistical indexes (root mean square value, peak-to-peak value, crest factor and kurtosis) were calculated based on sampled values.The statistical indexeswerecomputed by a program code, which runs in Maple mathematical software.Lifetime curve is the temporal dependence of the statistical indexes.

Peak-to-peak value is a local extreme value in the time signal of the acceleration signal. It is the maximum acceleration in the signal amplitude. In Figure 3 the peak-to-peak value changeis shown.It is clearly visible that the passage of time the acceleration values increased.At between 168 and 172 hours there is a sudden increase in the graph.This might be due to the emergence of defects at one of the surfaces or the intense bearing exhaustion.

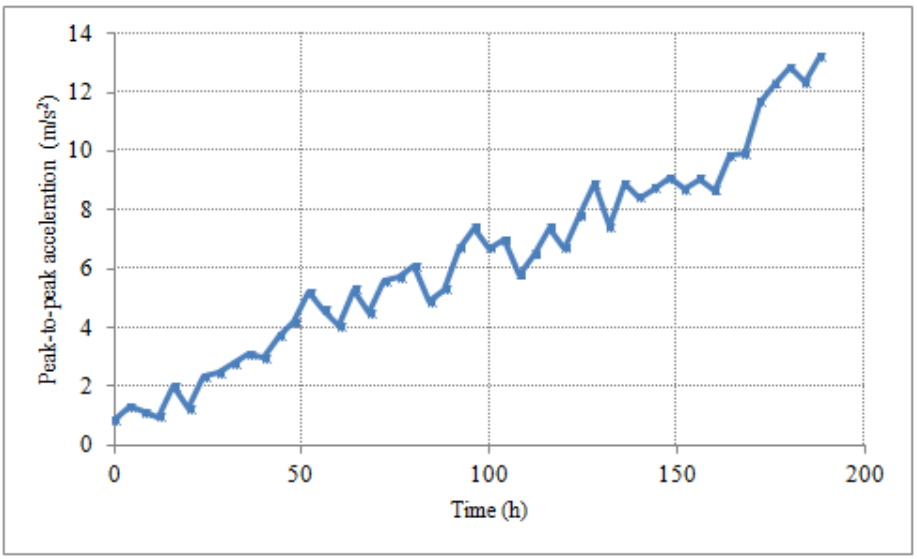


Figure 3.Peak-to-peak value history

The root mean square (RMS) history of vibrations is given in Figure 4. TheRMS graph seems quite similar to the peak-to-peak graph, but not observed sudden changes.It is apparent that RMS has good correlation.

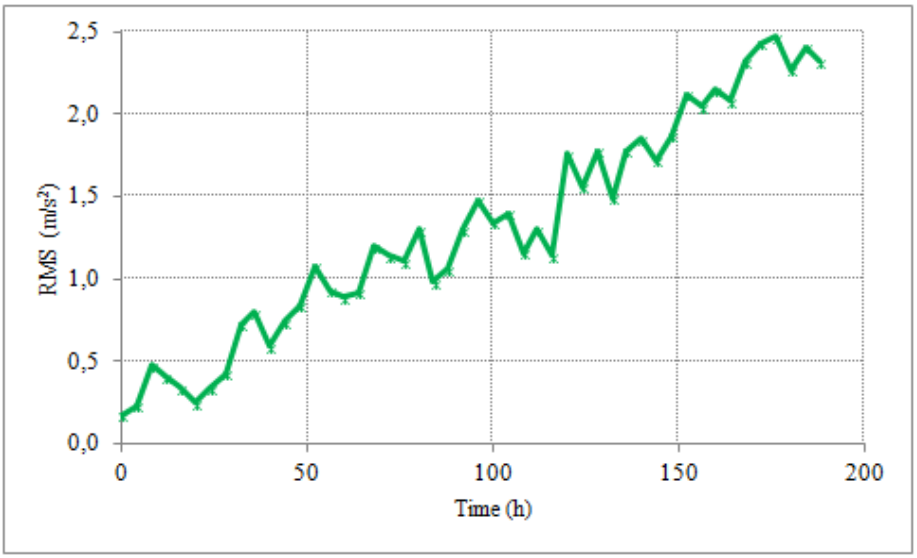


Figure 4.Root mean square value as a function of time

Crest factor is one of the scalar measures that is used to disclose the faults in bearings.If the Crest factor value is more than 5, there might be a fault in ball bearings[3].Crest factor change is illustrated in Figure 5.It is visible that after 160 hours Crest value isabove 5.

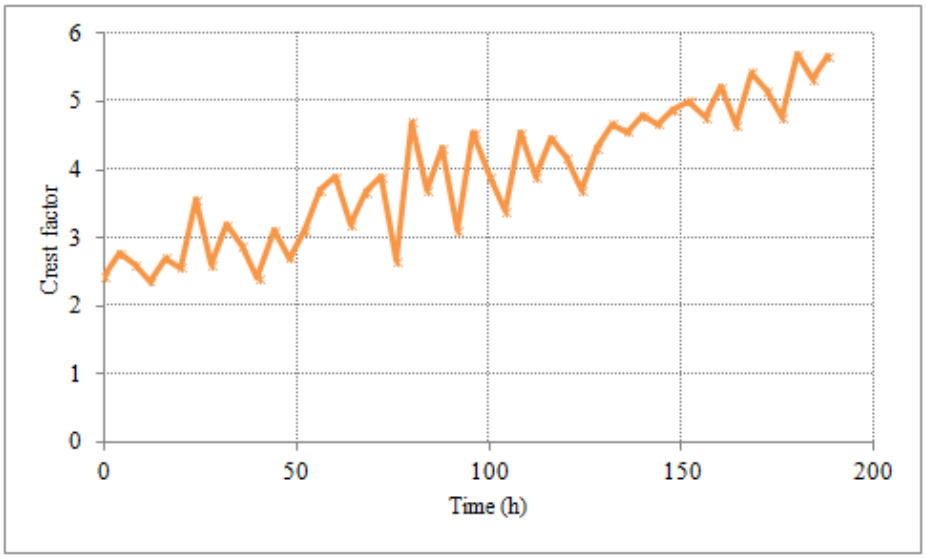


Figure 5. Crest factor changes

Figure 6 shows the Kurtosis value with its polynomial curve. It is not correlated as well as the previous indexes. Establish that the end of the test the Kurtosis values decreased.

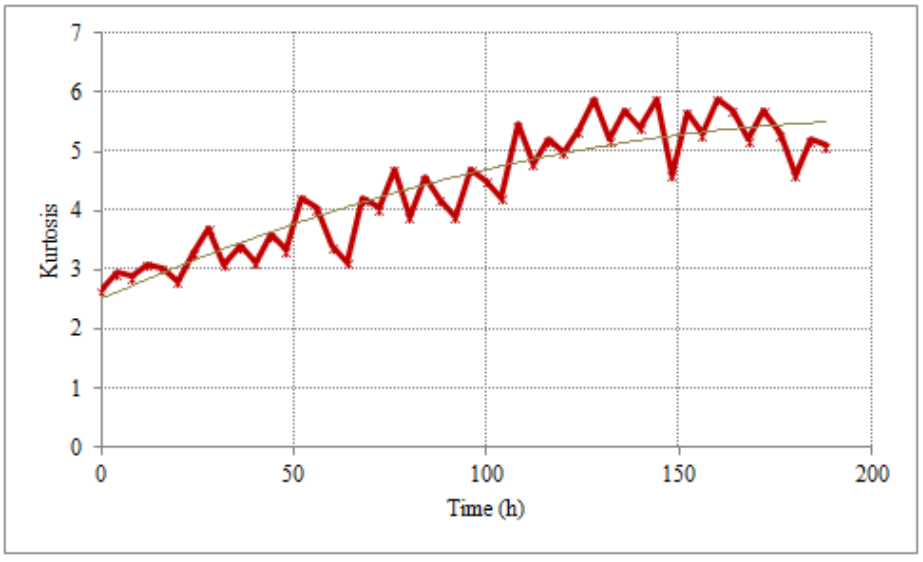


Figure 6.Kurtosis history of vibrations

4. Bearing fault

When the results of the time domain analysis indicatedand the bearing noise increased, the bearing wastaken apartto pieces.As predicted the time domain analysis after 180 fatigue hours the bearing indeed had a defect. The main reason of bearing failure was the inner ring defect. The smeared inside surface is seen in Figure 7.



Figure 7. Inner ring failures

5. Conclusion

The present paper shows that thetime domain techniques can be efficiently used in condition monitoring and fault diagnosis of ball bearings. The peak-to-peak value, RMS, Crest factor and kurtosis onlyindicated the defect at the ball bearing but didn't give information about the location of defect. The statistical analysis methods are reliable tools andthey allow fast data processing.

6. Acknowledgement

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