

## Summary

Bearings play a key role in various types of machines. Unexpected bearing failure can be prevented by bearing condition monitoring. Depending on the bearing type and operating conditions, appropriate methods should be applied to monitor the bearing's condition.

Bearing's failure before its expected lifetime can have several causes:

- Lubrication contamination is a common cause for bearing failure. Contaminants (liquid, hard, or soft) can increase friction and wear.
- Surface fatigue is another important cause for bearing failure. Signs of surface fatigue are spalling and pitting.
- Overheating can also cause early bearing failure and indicates problems with bearing mounting, lubrication, wear, maintenance, etc.

In case a bearing has a defect in one of its elements, force impulses are generated during bearing operation. The defect's influences on a bearing can be measured with various techniques:

- Vibration monitoring is a commonly used technique and it is based on kinematic or force measurements.
- Bearing temperature monitoring can also be applied for bearing's condition monitoring. Techniques are available for measuring bearing's lubricant, housing, or cage temperature.
- Ferrography (technique to analyze the particles present in fluids) is another technique used for bearing's condition monitoring and it is even capable of determining the damage type.
- Acoustic Emission (AE) monitoring is based on measuring stress waves in bearing's material. Various sources of AE and the propagation rate of bearing damage can be monitored.
- Sound pressure monitoring identifies bearing's fault type depending on its characteristic noise. Bearing noise can be produced by its cage, races, rolling elements, contaminants, seals, or a combination of them. Installation and operating conditions can also influence the noise level.
- Laser vibro monitoring doesn't require direct contact with the bearing to monitor its condition. This technique is especially suitable for bearings that are difficult to reach.
- Stator current monitoring of an electric machine can be used as a bearing fault indicator. Bearing faults cause radial movement of the rotor and torque variations. The effects of these changes can be seen in the stator current signal.

Data collected by condition monitoring techniques have to be analyzed. First it has to be transformed into a reduced set representation of features which are characteristic for bearing's performance. The process is called feature extraction. Then a feature ranking has to be created based on the mutual information content between the features and bearing's state. Now an optimal subset has to be extracted from the obtained ordered features by training classifiers. When a classifier is trained properly, it can be used for processing new data and determine bearing's performance.

Classifying a bearing as being healthy or faulty and determining its residual life are important indicators for bearing performance. An Artificial Neural Network can be trained to classify a bearing as healthy or faulty. Bearing's remaining life can be estimated with a feedforward backpropagation network undergoing supervised learning.

To conclude, bearing failure can have many causes. Some of them may be avoided, others are inevitable after a period of time. Bearing's condition can be monitored by various techniques. Depending on the condition monitoring requirements and operating conditions of the bearing, most suitable method has to be chosen. When measurement data are analyzed and measures are taken to reduce the risk and effects of bearing damage, costly downtime of machines can be avoided.