



Measures for preventing catastrophic failure of rotating parts

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Abstract: Rotating parts are very widely used as a part of mechanical systems in different industries to perform a large number of functions. Unexpected and instantaneous interruption in performing the main function of rotating part, i.e. transmission of rotating movement very often caused catastrophic failures of particular parts or complete mechanical systems mainly due to inertial forces. Great importance in prevention of rotating parts failures is associated not only with suppressing the injuries, but also with assuring the safety of people. This paper focuses on important measure for preventing catastrophic failure of rotating parts.

Keywords: Rotating parts, catastrophic failure, condition monitoring, Temperature, lubrication

I. Introduction

Rotating components experience significant quality and performance improvements when balanced. Balancing is the process of aligning a principal inertia axis with the geometric axis of rotation through the addition or removal of material. By doing so, the centrifugal forces are reduced, minimizing vibration, noise and associated wear. Virtually all rotating components experience significant improvements when balanced. Balancing can contribute to more efficient, more powerful, quieter, smoother running and longer lasting equipment and is one of the most cost effective means of providing value to our customer. Smoother running of rotating parts will ensure longer life thereby increasing productivity to a greater extent.

II. Importance of Rotating Part (Spindle Design)

The rotor of the spindle is supported by two pairs of angular contact ball bearings. To drive this spindle bearing system, an integral induction motor is located between the front and rear bearings. A drawbar is mounted inside the hollow shaft to change tools. The hollow shaft, the drawbar and the bearings constitute a typical double-rotor dynamic system. In an effort to choose the factors that avoid chatter and to attain the better surface finish, accurate dynamic models of tool-holder-spindle assembly are required. Such a dynamics reflected at tool tip can be acquired by modal testing, but entails a huge number of tool-holder arrangements in a manufacturing facility. The measurements are time taking and at times, problematic as in the case of micro-end mills. Few studies are reported in view of analytical and experimental works related to modelling of the spindle.

An experiment can be conducted an in-depth analysis of the radial stiffness of machine-tool spindles. He concluded that shortening the overhang, and increasing the area moment of inertia of the spindle and the stiffness of the front bearing, can enhance the static stiffness of spindle systems. The addition of the third bearing may change the dynamics of the spindle, depending on the forces and moments exerted on it.

There is one of the earliest researchers to use the finite element method for modelling of rotor systems. The model includes translational inertia and bending stiffness but neglects rotational inertia, gyroscopic moments, shear deformation, and axial load. Beam theory can be used to establish shape functions and formulate system matrices, including the effects of rotary inertia, gyroscopic moments, shear deformation, and axial load.

A particular criteria is used which is DeMul's bearing model and the model was formulated & developed for a spindle supported by a pair of angular contact bearings, including cutting-load effects. The cutting load is divided into static and dynamic components.

III. Measures

1) Condition monitoring

Condition monitoring is the process of collecting operating information from a machine while it's running to detect changes in the machine's condition that may lead to failure. When such changes are detected, users analyze this data to determine the cause of the problem, pinpoint the faulty component, and predict when it will fail. With sufficient warning of an impending problem, maintenance personnel can inspect the equipment, evaluate options, and take the best corrective action. They can schedule repairs at a convenient time long before the machine fails. This method of combining machine condition monitoring with predictive maintenance reduces the possibility of

catastrophic failure, keeps machinery running for longer periods, reduces downtime, and minimizes spare parts inventories. The condition monitoring approach sure beats the old run-to-failure method with its unexpected downtime and costly repairs! It also avoids some of the drawbacks of preventive maintenance programs, which typically consist of periodic machine inspection, followed by overhaul and parts replacement to prevent failure. Though preventive maintenance reduces unplanned shutdowns, repairs may be premature, causing unnecessary downtime and cost. Almost any manufacturing process can benefit from a condition monitoring program. Such programs keep production on schedule by preventing unplanned downtime and repairs that would otherwise increase costs, reduce productivity, and ultimately lose customers.

Condition monitoring is even more vital for small companies because a catastrophic failure or long-term shutdown can have a greater economic impact here than on a larger company. In an essential facility, such as a power plant where a shutdown would cause serious consequences, you can't afford to be without condition monitoring.

2) Acoustics

Some machine problems occur at ultrasonic frequencies (about 150 to 500 kHz), which are above the range of conventional accelerometers. But new high-frequency acoustical sensors that use Spectral Emitted Energy (SEE) technology can detect defects in the ultrasonic range.

This type of sensor detects the impact between two components, such as a bearing ball and outer race, when they penetrate the lubricant hydrodynamic film between them (metal-to-metal contact). It also can detect excessive dynamic loading, contamination, or bearing defects.

The sensor detects defects when they are very small, hence at an early stage. With this early warning, users can often correct operational conditions (improper loading, minor misalignment, improper lubricants) to extend bearing life.

3) Temperature

When a bearing starts to fail, excessive friction causes its temperature to rise. Thermocouple sensors on the bearing housing or in the lubricant detect this temperature rise, which signals impending bearing failure. When combined with other data, temperature measurement (thermography) helps you recognize problems at an early stage.

4) Lubrication

Oil analysis also provides important clues to machine condition. Foreign substances degrade the lubricating properties of oil and cause bearing failures. Measuring the quantity and size of foreign particles helps you determine if a wear problem exists, and even which part of the machine is wearing and how fast&which part of the machine is wearing and how fast.

5) Spectrochemical analysis

It indicates lubricant quality based on the condition of its additives and on materials suspended in the lubricant. This type of analysis also provides viscosity data plus information on the presence of harmful dissolved solids and water.

Wear particle analysis, or ferrography, which quantifies large (>5 microns), small (<5 microns), and total number of wear particles, both ferrous and suspended nonferrous types. This technique is sometimes followed by microscopic examination to determine the type of wear.

6) Portable data collectors-analyzers

These small, lightweight instruments perform more extensive functions. For example, they record vibration data for later analysis, freeing users from manual recording chores. Many types display vibration trend plots and abnormal measurements.

An operator carries a data collector to each measurement point on a machine and measures vibration with a probe or permanently attached sensors. Multiple channel data collectors permit several types of analysis, such as acceleration enveloping and SEE, and they can be used for other functions.

For example, an operator may use a data collector not only to inspect machinery, but also to enter other process measurements, such as temperature or flow, during daily rounds of a plant. The data collector then performs plant performance trends or is linked to a database management software program for storage and further analysis.

7) Online data acquisition and analysis

Online systems continuously measure data via sensors that are permanently attached to strategic measuring points, thus providing an ongoing means of detecting machine problems. Each data acquisition unit monitors and collects data from a number of sensors. Then it uploads information to a computer for display or later analysis by a database management software program.

Some units have a protection feature that trips a machine off when measurements reach a preset level, thus preventing damage. These devices are useful for continuously monitoring critical machines or those with high consequences of failure.

8) Software programs

Condition monitoring software programs aid in the collection, management, and analysis of machinery data. They perform various types of analysis, such as plotting data trends to show changes in a machine's condition or comparing data levels with alarm set points.

New, sophisticated programs, called Computerized Maintenance Management Software programs (CMMS), identify costs associated with a particular machine, including parts, repairs, and scheduling, and integrate this information with the company's overall planning process. The type of software you choose depends on the type and number of machines being monitored, and the type of monitoring equipment. When evaluating a software program, make sure it has the ability to customize reports and adapt to your plant operation, not the other way around. Also look for a program that can interface with other software and new equipment, so it won't become obsolete as your condition monitoring program expands.

9) Methodology for monitoring replaceable components of rotating systems

Rolling-bearings, as the essential elements of mechanical systems, exert significant influence on the system lifetime since the premature failure of the rolling-bearings provokes the malfunctioning of the system as a whole. Furthermore, rolling-bearings can be used as indicators of some errors and irregularities on other mechanical components (rotating elements, shaft and others) and thus to monitor the condition of mechanical systems and prevent the failures, it is essential to monitor the condition of the built-in rollingbearings. Hence, one phase in defining the maintenance measures and systematic application of the proposed methodology is the knowledge and the use of all relevant data in setting-up the "identity card" for a specific rolling-bearing.

Condition of rolling-bearing before installation. Rolling-bearings made by the same and particularly by different manufactures differ in quality and thus the same rolling-bearing (same type and series, with the same built-in dimensions and carrying capacity) can have different lifetime under the same operating conditions. Quality of rolling-bearings depends on 1. - Construction determined by the internal geometry complying with contradictory criteria (minimal dimensions and mass but maximal carrying capacity, speed limit and others). 2. - Materials, 3.- Production and assembly technologies (accuracy of dimension, shape and position of rolling-bearing components). In additions, the quality that is shortening of rollingbearing lifetime reduction is affected by the damages caused by improper transportation and storage.

Incorporation of rolling-bearing. The most important incorporation factors impacting the rollingbearing lifetime are as follows: *f* Positioning in respect to other parts of rollingbearing within the position tolerances. In case of improper assembling of bearing, relative angular misalignment of rings and cage can occur thus provoking excessive friction in the bearing, jamming of rolling bodies, cage damages etc. *f* Proper fitting of the inner bearing ring and shaft sleeve, as well as cage openings and outer bearing should be firm. Appearance of clearance between inner bearing ring and shaft sleeve can cause slip of rings, increased friction and heating of contact surfaces. Bearing arrangements are often designed to allow insertion of an adapter sleeve which in turn lowers the system reliability due to the presence of an additional fit thus increasing the probability of assembling errors and operating irregularities. *f* Requirements: 1.- Complete fixing of the rollingbearing in immovable shaft support in the axial direction to avoid vibrations (occurring due to clearance presence) and possible damages of the bearing components, 2. – Assuring the optimal axial clearance in the movable shaft support which, if it is not properly dimensioned, can be lost with increasing operating temperature thus leading to additional, unforeseen axial loading and its premature failure. *f* Sealing is important for two reasons: preventing leaking of lubricant essential for proper operating of a bearing and preventing the ingress of dirt particles (can cause severe damages of the working surfaces even sudden outage), vapor, water or other liquids (can change the lubricant quality and oxidation of bearing parts) into the bearing.

For reliable monitoring and lasting operation of a mechanical system the input data should incorporate the real operating conditions when selecting a particular rolling-bearing, load, rotation frequency, operating temperature, characteristics of lubricating and filtration systems, lubricant properties, and the degree of contamination of the working medium. In case of unplanned and unforeseen disturbances in working conditions, such as changes in load direction, tendency and intensity, shocks, vibrations, sudden and high temperature changes of the contacting parts fit changes – tight fit transforms into loose and vice verse) poor quality, purity and quantity of lubricant can cause premature outage of rollingbearings.

IV. CONCLUSIONS

Above mentioned measures clearly indicates various methods for a preventing catastrophic failure of rotating parts since their safety is very important. Rotating parts are life of any system so its safety and maintainence is very important. These methods will analyse various impacts on rotating parts and will predict unexpected failure of parts thereby saving time for its replacement. If the failures of rotating parts are analyzed before its failure time

cost will be saved and productivity will rise to a great extent. Since fatigue is root cause of failure of components it should be eliminated and prevented before it reaches its final stage. So the above mentioned measures should be adopted for smooth functioning of rotating parts. From many aspects, complete consideration of outage prevention is rarely treated fully, while the search for the real causes of an outage is even rarer. Based on detailed analysis of the high capacity and high-priced rotating mechanical systems, the above mentioned measures should be implemented.

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