CONDITION MONITORING ON VIBRATION CHARACTERISTICS OF ROLLING ELEMENT BEARINGS

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Universiti Malaysia Sarawak
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CONDITION MONITORING ON VIBRATION CHARACTERISTICS OF ROLLING ELEMENT BEARINGS

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ABSTRACT

The useful life of rolling element bearings can be significantly shorter than their design life due to factors in their operating environment. To prevent potentially unexpected bearing failure effective condition monitoring is required. Vibration is a study of oscillatory motions. The ultimate goals of this study are to determine the effect of vibration on the performance and safety of systems, and to control its effects. With the advent of high performance machines and environmental control, this study has become a part of engineering curricula. The vibration and dynamics analysis of mechanical systems is becoming increasingly complex today, and it will continue to do so in order to meet the challenges and demands of 21st century technology.

This thesis entitled, **"CONDITION MONITORING ON VIBRATION CHARACTERISTICS OF ROLLING ELEMENT BEARINGS "** mainly focused on the vibration characteristics of different faults or wears introduced intentionally on the rolling contact bearings. The term rolling contact bearings refers to the wide variety of bearings that use spherical balls or same type of roller between the stationary and the moving elements. However, two types of roller bearings will be used in this project which is tapered roller and cylindrical roller bearing. The faults introduced on the bearings can be categorized mainly to two types of faults, which is faults along the roller of the bearings and faults occurring on the circumference of the roller within the bearings. Different faults are introduced intentionally from time to time in order to be able to monitor the characteristics possess by each types of faults.

Meanwhile, the equipment used for the purpose of monitoring the vibrations characteristics is the Bently Nevada Rotor Kit and the transducers for the collection of data and results is an oscilloscope or Bently Nevada, Data Acquisition Interface Unit 208 (DAIU 208). The analyser for the collected data and results is a computer with ADRE (Automated Diagnostics for Rotating Equipment) for windows software.

ABSTRAK

Jangka hayat sebenar bebola putaran pada amnya tidak sepanjang jangka hayatnya yang ditentukan secara teoritikal. Ini kerana, keadaan bahan tersebut didedahkan amat memainkan peranan yang penting dalam memendekkan jangka hayat penggunaannya. Justeru itu, pengawasan keadaan amatlah perlu untuk mencegah kemungkinan berlakunya kerosakan pada bebola putaran tersebut. Getaran merupakan suatu ilmu pengajian yang mengaitkan segala perilaku gerakan ayunan. Matlamat utama pengajian ini adalah untuk mengetahui kesan getaran terhadap keselamatan suatu sistem kejuruteraan di samping mengetahui cara-cara untuk mengawal kesan-kesannya. Dengan pembangunan teknologi yang kian berkembang dan penggunaan mesin-mesin yang kian canggih, pengajian sifat-sifat getaran semakin kompleks saban hari. Pengajian ini dijangka akan bertambah kompleks menjelang abad ke-21 hanyalah semata-mata untuk menandingi cabaran suasana kehidupan yang serba berteknologi tinggi.

Tesis ini yang berjudul, "PENGAWASAN KEADAAN BEBOLA PUTARAN" menekankan sifat-sifat getaran untuk pelbagai kerosakan yang hadir pada bahan yang dikaji. Namun begitu, kerosakan atau kecacatan yang dikaji sifat-sifat getarannya diperkenalkan secara sengaja pada bahan ujikaji iaitu bebola putaran.

Bentuk kecacatan yang diperkenalkan ke atas bahan ujikaji boleh diklasifikasikan kepada dua kategori utama iaitu kecacatan di sepanjang elemen putaran bahan ujikaji dan juga kecacatan pada permukaan lingkaran bahan ujikaji. Pelbagai bentuk kecacatan akan diperkenalkan dari semasa ke

semasa untuk mengetahui sifat-sifat getarannya. Pengawasan getaran dilakukan melalui kelengkapan yang diberi nama Bently Nevada Rotor Kit dan pemungutan keputusan-keputusan eksperimen dilakukan melalui Bently Nevada Data Acquisition Interface Unit 208 (DAIU 208). Keputusan-keputusan eksperimen yang dipungut dikaji melalui program khas yang berjudul Automated Diagnostics For Rotating Equipment (ADRE) .

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LIST OF ABBREVIATIONS

a	-	Contact angle
ADC	-	Analogue-To-Digital-Converter
BSF	-	Ball Spin Frequency
BPFI	-	Ball-Pass Frequency for Inner Race
BPFO	-	Ball-Pass Frequency for Outer Race
BPF	-	Bandpass Filtering
d	-	Rolling element diameter
D	-	Bearing pitch diameter
DAIU	-	Data Acquisition Interface Unit
dB_N	-	Decibel normalized value
dB_C	-	Decibel carpet value
dB_M	-	Decibel maximum value
F	-	Force
FFT	-	Fast Fourier Transform
FTF	-	Fundamental Train Frequency
h	-	Radial play
n	-	Number of rollers
N	-	Shaft speed in RPM
SE	-	Spike Energy
SPM	-	Shock Pulse Method
T	-	Time
v	-	Rotational speed

CHAPTER 1

ROLLING ELEMENT BEARINGS

1.1 DESIGN AND CHARACTERISTICS

Rolling element bearings are finished machine members ready for installation and direct applications. Their non-complex design allows precision manufacture and economical mass production. In addition, advanced manufacturing technology which are able to maintain tolerances of 2.5 μ m (0.0001 in.) or better is needed in order to have the best utilisation of this simple mechanism in today's high speed machinery.

Rolling element bearings are common subjects for condition monitoring as they are generally critical components and are prone to unexpected failure. Actual bearing service life can be significantly shorter than the design estimate derived from fatigue life studies. Bearing failure can be hastened by common operating factors such as lubricant contamination, shaft misalignment or improper loading. It has been estimated that only 10 to 20 % of bearings reach their design life.

The built-in precision of rolling bearings accounts for their incredibly high efficiency, normally exceeding 0.99 which relates to some benefits that enables bearings not to need any run-in period, since there are no high spots to wear off. Rolling bearings consist of two hardened steel rings called *races* as shown in Figure 1.1 below. The races form a narrow, dual, circular channel or track within which the rolling elements are confined during operation. For minimum wear and maximum load capacity, the rolling elements are likewise to be made of hardened steel. On the other hand, the separator or cage has the function to maintain alignment and ensure balance by equally spaced the rolling elements around the track.

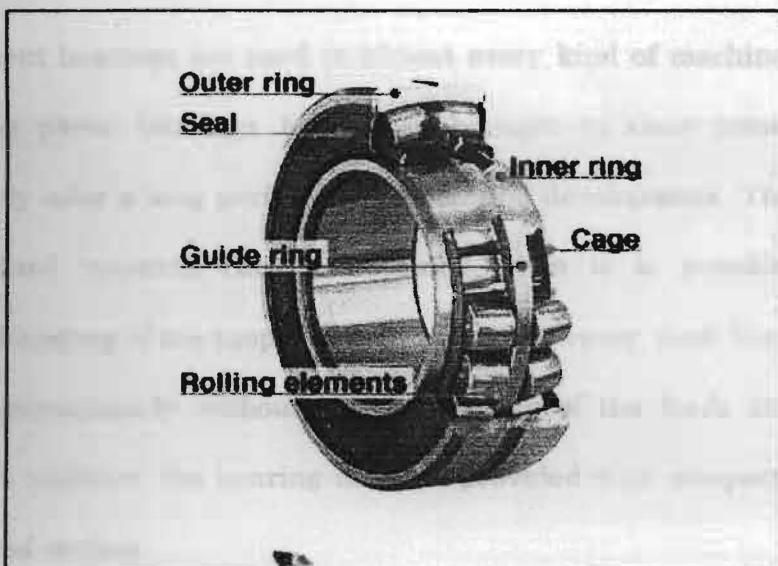

Figure 1.1 Main Parts Of Rolling Elements Bearing

One very important characteristics of the rolling element bearings, the shaft and housing dimensions for mounting rolling bearings are very critical. Both housing bore and shaft diameter must be carefully selected and diligently maintained to ensure the proper assembly fit. If the fit is too loose, the bearing may abrade the shaft or housing while if the fit is too tight, the bearing may be damaged because of heat generated while operating with an insufficient internal clearance. This condition is called *bearing preload.* Rolling bearings require minimum lubrications because friction is only a small part of the internal action. Some sliding does occur between the rolling elements and their retainer, and some friction is found at the rubbing surfaces of the lubricant seal. Although a rolling bearing does not generate very much heat, it does transfer considerable amounts, since it is the intermediary between a shaft and housing.

1.2 APPLICATIONS

Rolling element bearings are used in almost every kind of machine and device with rotating parts. Bearings have been brought to their present state of perfection only after a long period of research and development. The benefits of such specialized research can be obtained when it is possible to use a standardized bearing of the proper size and type. However, such bearings cannot be used indiscriminately without a careful study of the loads and operating conditions. In addition, the bearing must be provided with adequate mounting, lubrication and sealing.

In roller bearings the rolling elements are hardened steel cylinders or truncated cones that revolve in hardened steel races. Roller bearings are preferred when large loads are present. Their load capacity for a given space greatly exceeds that of ball bearings because the basic rolling contact is along a line, not a point. The load is thus spread over a larger area and produces less unit stress and deformation for a given load. The principle of rolling element is that, the transition from sliding to rolling was achieved by introducing rolling elements between sliding surfaces. The result of the usage of rolling elements between sliding surfaces is a very low resistance to movement and it can be continually reduced by constantly improving the accuracy of each contacting parts.

However, there may also be some rubbing friction present and the coefficient of rolling friction is simply the ratio of force to sustain lateral motion at constant velocity to the gravity force of the object itself. In general, cylindrical roller bearing (refer Figure 1.2) has greater radial load capacity but low thrust load capacity. Whereas, tapered roller bearing (refer Figure 1.3) are widely used in the applications for substantial thrust loads along with high loads.

Figure 1.2

Cylindrical Roller Bearing

Figure 1.3

Tapered Roller Bearing

Some of the advantages of rolling element are low starting friction (a desirable feature for intermittent service or for starting at low temperatures), the loads can be inclined at any angle in the transverse plane, low maintenance costs and the thrust components can be carried. At the same time, the roller elements in rolling element bearings can be easily replaced when worn out.

1.3 POSSIBLE FAULTS

In order to monitor the vibration characteristics of each faults on the roller element bearings, faults will be introduced intentionally to the bearings from time to time. Two major types of faults that will be introduced i.e. faults along the roller (longitudinally) and fault imposed on to the circumference of the roller within the bearings as shown in the schematic diagram below in Figure 1.4.

Due to the inability to get natural wears or faults produced by machines or other appliances on the bearings, damages like cracks, scratches, knock and indentation are introduced intentionally on the bearings. The faults are manually machined on to the roller of the bearings through the usage of different types of machining tools.

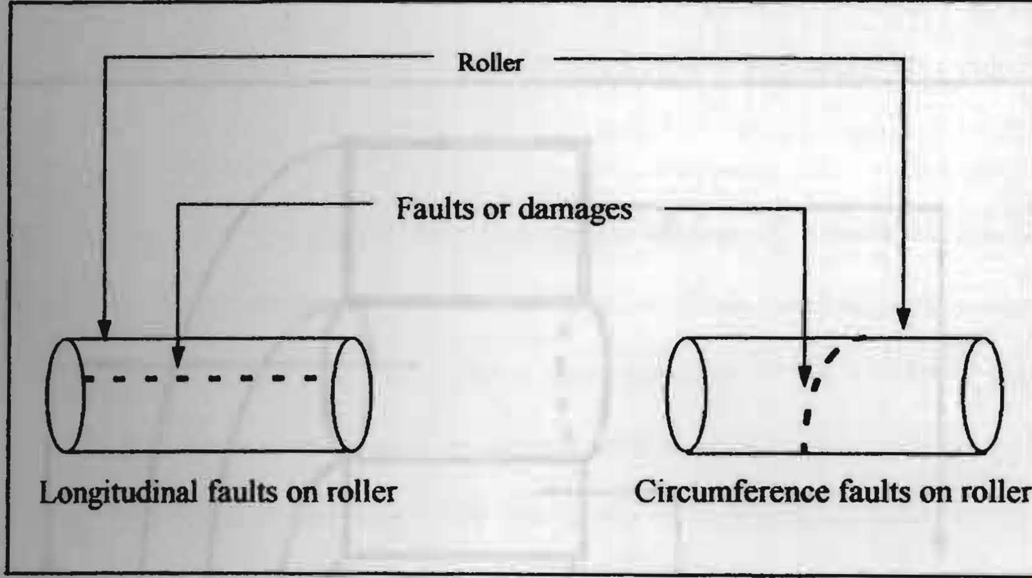

Figure 1.4 Faults On Roller Bearings

Apart from that, faults will also be introduced to the housing or casing of the bearings. However, extra care has to be taken in order not to impose any faults on to the roller of the bearings at the same time when faults are introduced to the housing. This is important in order to be able to make a clear differences between the vibration characteristics of faults occurring on the element or faults on the housing. The housing for rolling element bearings that needs faults introduction are the inner or outer races which confined the rolling elements during its application. Figure 1.5 below shows the location of the inner and outer races of a rolling element bearings.