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Real Time Fault Monitoring System on a Rotating Machinery using JADE

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Abstract: Fault Monitoring on rotating machinery have been employed in the field of Machine diagnosis. Although several different methodologies have been established, there is a gap of knowledge existing on novel, ideal and speed in real time system. The present study was an attempt on development of new machine diagnosis tool using Multi agent Software. In this present study the focus is towards bearing of any rotating machinery. A piezo electric sensor is placed on the rear side of the bearing, based on the sensor output wear and tear of the bearing is predicted using multi agent software. The machine condition monitoring tool is designed using **Java Agent Development Framework (JADE),** which is a software framework that facilitates the development of agent applications in compliance with the FIPA (Foundation for Intelligent Physical Agents) specifications for interoperable intelligent multi-agent systems. The JADE agent platform tries to keep the high performance of a distributed agent system implemented with the Java language.

Keywords: Machine condition monitoring, Multi agent software, Java Agent Development Framework (JADE).

I. INTRODUCTION

In recent trend many research papers have been written on fault detection. In general state of the art in rotor dynamics. The heart of fault diagnosis lays on the model-based approach, whereby as many variables and system parameters are taken into account as possible, in order to paradigm a detailed mathematical model of the system under observation. Once the dynamic performance of the system has been "reasonably" modeled it should, hypothetically, be possible to detect faults via analysis of changes in input parameters to the model. Observer-based fault detection is one of the most widely used model-based approaches. We deploy this technique, "knowledge observers" - a control configuration equivalent to that of an analytical observer - generate signals known as residuals. Faults are detected when pre-determined threshold levels assigned to each residual are reached [1].

The complete survey of design methods for Fault detection, which, although designed for linear systems, may be carried over to nonlinear applications in many cases [2]. The detection of process faults based on modeling and estimation methods, involving the estimation of imperceptible process parameters and variables [3]. A relatively new approach to system modeling, tending to become more and more popular, is the use of fuzzy logic and neural networks. A research review article briefing the most up-to-date developments in artificial intelligence for fault diagnosis; particular emphasis being placed on the use of fuzzy models and fuzzy logic for problem evaluation and also introducing the knowledge observer concept described above [4]. An extremely widespread overview of the state of the art in fault detection [5] gave a review of recent trends in model-based fault detection and diagnosis.

The fault diagnosis methods are summarized under various classification and inference methods applicable to automatic fault diagnosis, again focusing on fuzzy logic and neural networks, leading to the consideration of neuro-fuzzy algorithms and also to the development of a new algorithm [6]. Observer-based fault diagnosis of nonlinear systems was designed and the extension of linear methods to nonlinear systems and also looked at the heftiness to unknown inputs [7].

The vibration analysis of faults in rotors, bearings, seals, dampers and foundations were elaborated with many aspects [12]. A broad survey of the literature concerning damage identification and health monitoring of structural and mechanical systems from their vibration properties were analyzed [11].

In early decades a complete survey of a broad range of topics concerned with the fault diagnosis of dynamic systems is elaborated with different techniques, which stayed as a vital role in fault dynamics of a mechanical system [10].

Even though there are many different techniques adopted for machine condition monitoring. There is currently a fatigue for general application of real time condition monitoring.

In this scope of research real time software is designed using **Java Agent Development Framework (JADE).**

II. MATERIALS AND METHODS

The present study focuses towards the bearing in the rotating machinery. Here in this study we took bearing because it is the key or important part in any rotating machinery and major technical failures happen through bearing only.

A. Bearing:

A surprisingly large number of bearings can be found all around us. Take automobiles, for example: there are 100 to 150 bearings in a typical car. Without bearings, the wheels would rattle, the transmission gear teeth wouldn't be able to mesh, and the car wouldn't run smoothly [8].

Bearings are not used only in cars, but in all kinds of machinery such as:

a. trains
b. airplanes
c. washing machines
d. refrigerators
e. air conditioners
f. vacuum cleaners
g. photocopy machines
h. computers
i. satellites

Bearings enhance the functionality of machinery and help to save energy. Bearings do their work silently, in tough environments, hidden in machinery where we can't see them. However bearings are crucial for the steady operation of machinery and for ensuring its high importance.

The word "bearing" incorporates the meaning of "to bear," in the sense of "to support," and "to carry a burden." This refers to the fact that bearings support and carry the burden of revolving axles.

The basic function of bearings is principally to reduce mechanical friction. Reducing friction means:

a. machinery will run more efficiently
b. there will be less frictional wear, extending the operating life of the machinery
c. preventing abrasion burn, avoiding mechanical breakdown

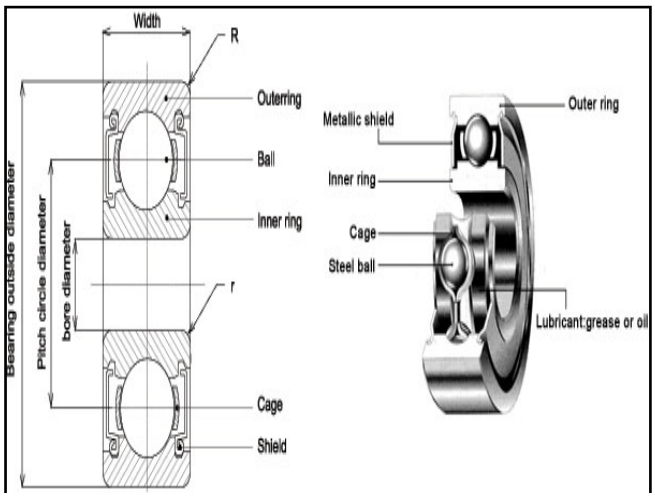

Figure 1. Bearing view

Figure 1 show the bearing which we used for an experimental setup.

Bearings also contribute to lower energy consumption by reducing friction and allowing the efficient transmission of power. This is just one way in which bearings are environmentally friendly. Bearings are classified by different type as Ball Bearings, Clutch Release Bearings, Cylindrical Bearings, Cylindrical Repair Bearings, Needle Bearings, and Tapered Roller Bearings etc [8].

B. Piezoelectric Transducer as a Sensor for fault diagnosis:

Piezoelectric transducer uses the piezoelectric effect to realize transduction between electric and sound energy. It comprises a radiation head, electrode, cap, pre stressed bolt, piezoelectric chip and an insulating tube. It possesses high efficiency, the transduction efficient between electricity and sound above 95%. The transducer strength is improved by fixing the high speed vibrator directly on the base of washing groove with bolt. Compare with a magnetic expansion vibrator, its amplitude can be improved above 50%. It is a good heat resistant which works under a large range of working temperature, low resonance impedance and heat productivity.

The AE (**Acoustic Emission**) sensor is a non-directional technique, one AE sensor is sufficient to perform the task in contrast to vibration monitoring which may require information from three axes.

Sources of AE in rotating machinery include asperities contact, cyclic fatigue, friction, turbulence, material loss, cavitations, leakage, etc.

The selection of input features and the classifier parameters are optimized using a classification algorithm approach. The Classification algorithm is selecting based on mobile agent adapted functionalities. These features, namely, mean, root mean square, variance, skewness, kurtosis, and normalized higher-order central moments are used to distinguish between normal and defective bearings [9].

In our project the Training dataset which can be consist of AE variables frequency rate, radius of the machinery index and revolution of the axis. These predefined data sets can be used for predict and classification of material quality. Depending on the spectrum frequency the friction of materials is detected.

C. Mobile Agent:

This present work is done by using Java mobile agent.

A Mobile Agent, namely, is a type of software agent, with the feature of *independence*, *socialability*, knowledge, and *mobility*.

In the field of computer science and Engineering, a mobile agent is nothing but a composition of computer software and data which is able to migrate or move from one computer to another autonomously and continue its execution on the destination computer.

The Dataset Approximate Attributes includes:

a. RPM
b. Frequency
c. Friction rate
d. Diameter of circle

In this study the attributes are set to a prominent value as given below:

a) Outer race velocity:

Min:>50,NormalValue:50-100, Max: <100

b) Inner race velocity:

Min:>50,NormalValue:50-100,Max: <100

c) Cage velocity:

Min:>50,Normal Value:50-100,Max: <100

d) Bearing peach diameter:

Min:>50,Normal Value:50-100,Max: <100

e) Role element diameter:

Min:>50,Normal Value:50-100,Max: <100

f) Contact angle:

Min:>5,Normal Value: 60 -5,Max: <60

g) Rpm frequency:

Min:>10,NormalValue:10- 20,Max: <20

h) Total friction values:

Min:>5000,Normal Value: 5000-10000
Max: <10000

The values are determined based on the wear and tear of the bearing inside the machine and these values are set in way that the maximum threshold that a bearing can withstand at any condition.

III. IMPLEMENTATION PROCEDURE

The figure 2 shows the implementation model of the proposed work

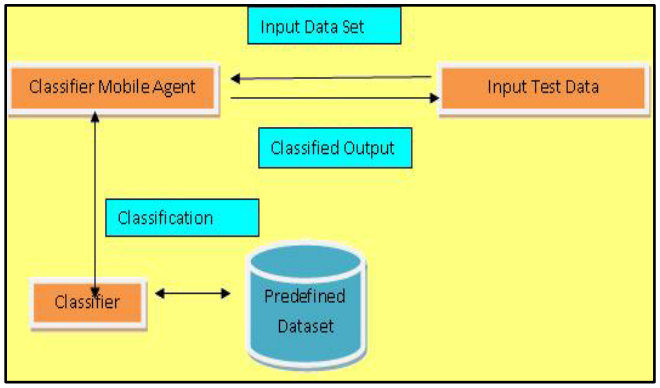

Figure 2. Implementation model

In this module we are monitoring the fault diagnosis of a bearing in rotating machinery. It follows the following implementation procedure

a. Client Server architecture is a build classifier as Server.
b. We are deploying classifier mobile agent with the predefined dataset as a server.
c. Input mobile agent as client side.
d. Request flow from Client to server and classified output is given as server response.
e. Input can be supplied through a separate mobile agent (Client Side) to the classifier agent.
f. The classified output about the friction and the quality of the material can be given as output.

The figure 3 below shows the JADE Remote Agent Management GUI designed for monitoring the fault detection of a bearing in rotating machinery.

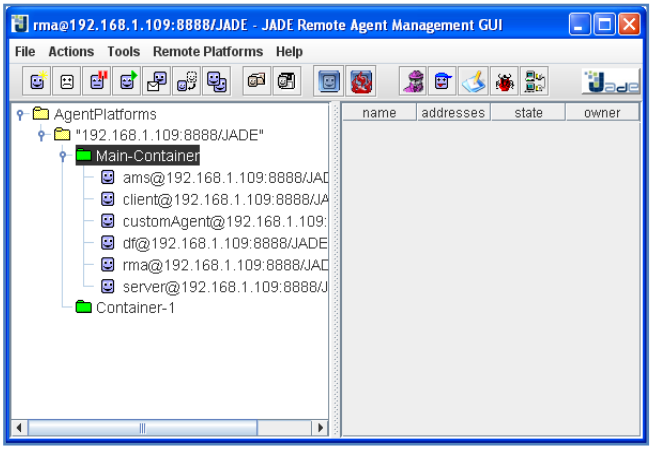

Figure 3. Jade remote agent management gui

IV. RESULT AND DISCUSSION

The Input from the machine which is working in the factory is obtained through the Client and it is fed in to the Mobile agent. The input parameter includes the velocity, inner race velocity, cage velocity, bearing peach diameter, role element diameter, contact angle, rpm frequency. Based on this input we are calculating the friction rate of the bearing which can withstand during the working condition.

Figure 4. Input screen for a fault monitoring system

The friction rate of the bearing is calculated using the formula given below:

Float Friction Rate = (InnerRaceVelocity - OuterRaceVelocity + CageVelocity) * (((RoleElementDiameter * BearingPeachDiameter) / 2)) / RPMFrequency;

Resp = Float.toString(FrictionRate);

Based on the friction rate a statistical ratio is plotted in the graph as shown in figure 5

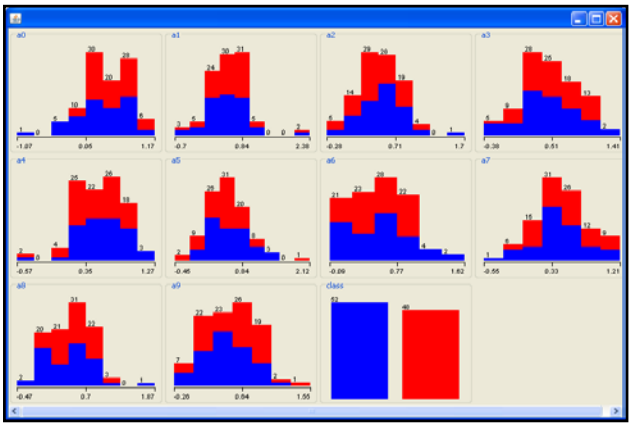

Figure 5. Statistical ratio

Based on the statistical ratio the bearing condition is analyzed from the database and the friction value is calculated as per the formula given above and displayed as in figure 6 shown below:

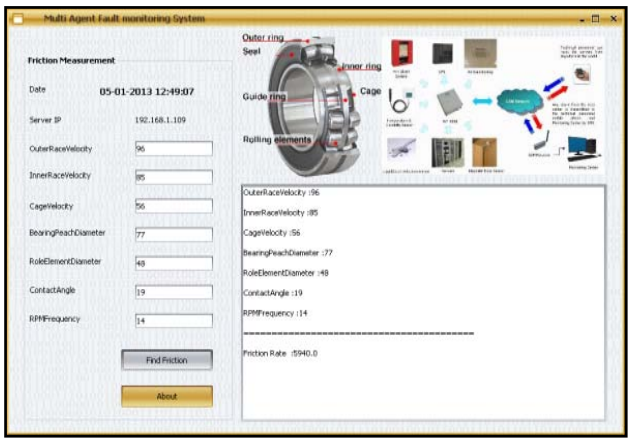

Figure 6. Resultant output of friction rate

If the output level exceeds the threshold value the complete machine is stopped and the message is given to the service provider as well as to the maintenance Engineer for service and the bearing is immediately replaced.

V. CONCLUSION

In this Present Study we used the analysis of fault monitoring for bearing alone and it is found to be effective from other cases. Since the entire system is built using multi agent there is no way of fault during the running operation and the machine is kept safe, so there is no loss in production and the defective message is immediately sent by Short Message Service (SMS) to the service Engineer. In this system the entire operation of connectivity from machine to the service provider and the owner is connected by GPRS for quick message transaction.

VI. ACKNOWLEDGEMENTS

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