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Condition Monitoring Using Shaft Analysis

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Abstract: ***Vibrations have been traditionally associated with trouble in machines. However, vibrations are merely symptoms of good or bad mechanical behavior. Today these symptoms are used to detect and solve many mechanical problems. To prevent the great loss in production due to motor failure, early detection of faults with diagnosis of its root cause is necessary. This project is an approach for fault detection in rotating machines using orbit analysis of shaft and Image processing. Several works have been focused on detecting early mechanical faults before damage appears in the machine. All these techniques such as Motor Current Signature Analysis, Vibration Monitoring, Thermal imaging, Oil particle analysis are very effective their way. In this project a new methodology is proposed for identifying and detecting different faults in motors. Through Image Processing Based on Orbital Analysis, different faults will be studied, generating characteristically different patterns that are used for fault identification.***
Keywords**:** ***Orbit Analysis, Image Processing, Rotating Machines, Fault Detection, Vibrations***

I. INTRODUCTION

For many years (and in many plants till today), philosophy has been to simply run the plant until a machine failed, deal with it and get it back in good condition, running it once again. If machines failed, they were repaired or a spare was used. Little thought was given to equipment reliability or predicting failures. The maintenance department was a huge cost sink and that was considered the standard part of running the business. More recently, the philosophy has changed. Rotating machines have a high capital cost and hence the development of condition monitoring techniques is very important. Now organizations recognize that it is worth the investment of time and money to change the maintenance practices to be more proactive and to work to improve equipment reliability. Great cost savings have been realized because of this. Several works have been focused on detecting early mechanical and electrical faults before damage appears in the motor. All the modern methods that use accelerometer are very effective except the potential problems that may occur at low frequency vibration.

A. The two Disadvantages are

1) Reduced sensitivity at low frequencies especially below 500 rpm due to electrical noise.
2) Instrument integration errors on vibration spectrum.

In this project, a new methodology is proposed for identifying and detecting different faults in motors. Through image processing, presence of faults can be detected, based on orbital analysis, generating characteristically different patterns that can be used for fault identification.

II. BASIC BLOCK DIAGRAM

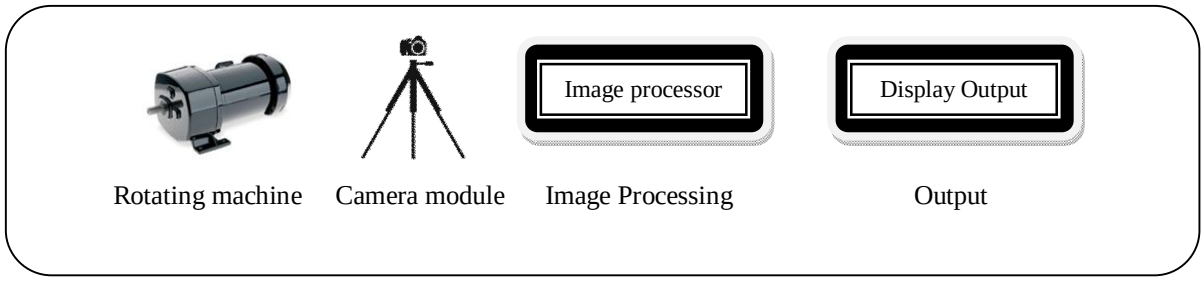

Fig. 1 Block Diagram

Device under test is the rotating machine for e.g. electric motor or pump whose shaft facing is visible with a dot or point (for plotting) on it. A high resolution camera module will capture a slow motion video of the rotating shaft. Image processing section will process the video using matlab. Image processing section includes conversion of video to frames, detecting the dot in the frame, plotting of dots from the frames, classification of plot according to the fault. Output will be displayed on the screen.

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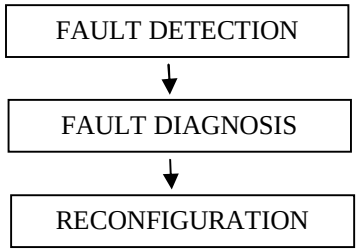
III. ROTATING MACHINE

Electric motors impact almost every aspect of modern living. In addition to running the commonplace appliances that we use every day, electric motors are also responsible for a very large portion of industrial processes. Electric motors are used at some point in the manufacturing process of nearly every conceivable product that is produced in modern factories. Because of the nearly unlimited number of applications for electric motors, it is not hard to imagine that there are over 700 million motors of various sizes in operation across the world.

A. Condition Monitoring

Condition monitoring is the process in which the condition of the machine in working state, is monitored and interpreted to know the machine health.

Condition monitoring has three main steps



This project stress on the first two steps that is whether the machine has a fault or no fault. In case a fault is detected, then fault diagnosis is done in order to find out the possible type of fault.

B. Why Condition Monitoring?

All operating machines vibrate. Machines vibrate due to imperfections. Different imperfections produce Vibrations of different characteristics. So there is a need to analyse the characteristic patterns that different faults represent. Most common defects in rotating machines are: Unbalance, Misalignment, Mechanical looseness.

IV. ORBIT ANALYSIS

Orbit analysis is carried out and more effective for a limited number of rotating speed or rpm. Orbits are Lissajous patterns of time domain signals that are simultaneously plotted in the XY coordinate plane of an oscilloscope or vibration analyser. Orbit plots can efficiently be used in vibration diagnosis where other techniques, such as FFT and time waveform, may not provide sufficient information specially at lower speeds of rotating machines.

A. Significance of Orbit Shape

A more circular orbit usually represents More of an 'unbalance' type vibration force (centrifugal force that is fairly equal all the way around) as can be seen in Fig.2

Flatter, more 'linear' motion indicates problems that affect a specific direction such as looseness, resonance, and (on belt or chain drives) bent shafts or eccentricity as can be seen in Fig. 3

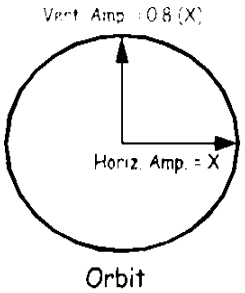


Fig. 1 Unbalance

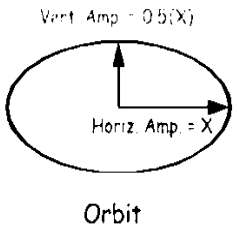


Fig. 3 Other faults

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V. IMAGE PROCESSING

In this section, a stream of video is converted to multiple image frames. The programming language used is matlab. Each image frame consists of the dot on the shaft. The unnecessary part except the dot is again filtered from each frame. After experimenting the above procedure, the frame before and after filter is as shown in the figure:

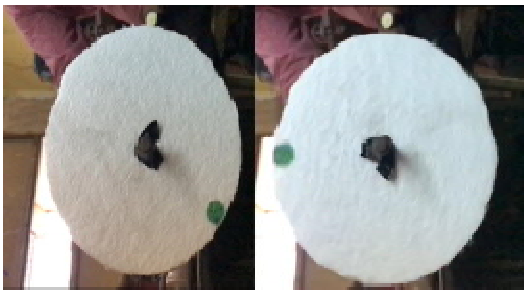


Fig. 4

Fig. 5

Figure 4 is the frame that is converted from the stream of videos. Figure 5 is the frame that is filtered using matlab. After further filtering, these frames will be plotted so as to represent a characteristic pattern. This is shown in Figure 6. The pattern of the plot will be used for recognition of type of fault in rotating machine. From Figure 6, it is seen that the plot is circular. This concludes that there is no fault in the machine. At the same time, figure 7 plot is slightly elliptical. That means there is fault in machine of figure 7 that is unbalance.

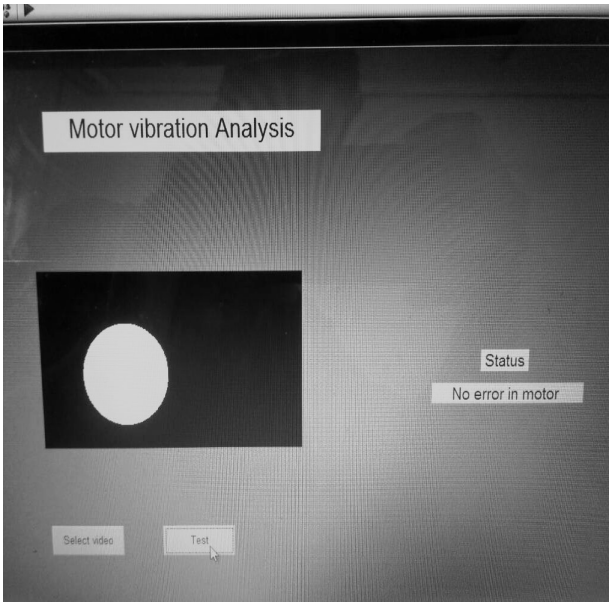


Fig. 6 No fault

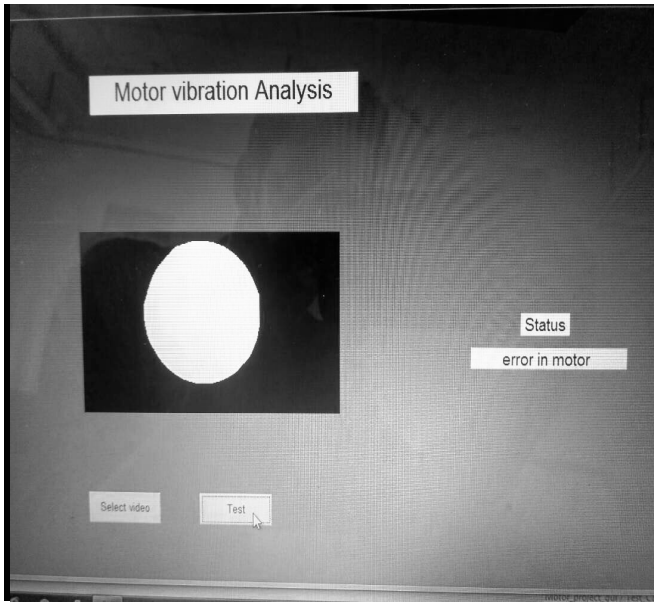
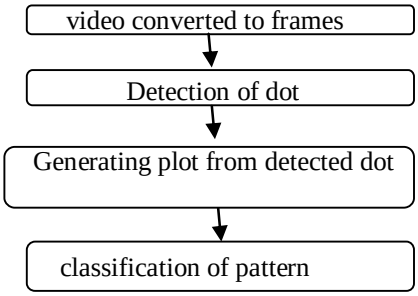


Fig. 7 Fault in machine

A. *Flowchart for Matlab Code*



B. Classification Methodology

After the generation of the plot, the orbits are classified on the basis of eccentricity.

VI. OUTPUT

A. Output

After the classification of the pattern, the output will be displayed on the computer screen. Depending on the type of fault, the output can be as follows:

1) No Fault (when pattern is circular)
2) Unbalance (when pattern is an ellipse)
3) Loose Foundation (when pattern is random or sharply elliptical)

B. Advantages

1) Increases machine RELIABILITY.
2) Gives early warning of potential failure.
3) Cost effective.
4) Less manpower required.
5) New challenging point of view for condition monitoring in the field of mechatronics.
6) More profitable to the company.

VII. CONCLUSION

Condition monitoring in Rotating machines is possible with the new methodology which is proposed in the project using orbit analysis and Image Processing. Use of high resolution camera will add on to the effectiveness of the output.

VIII. ACKNOWLEDGMENT

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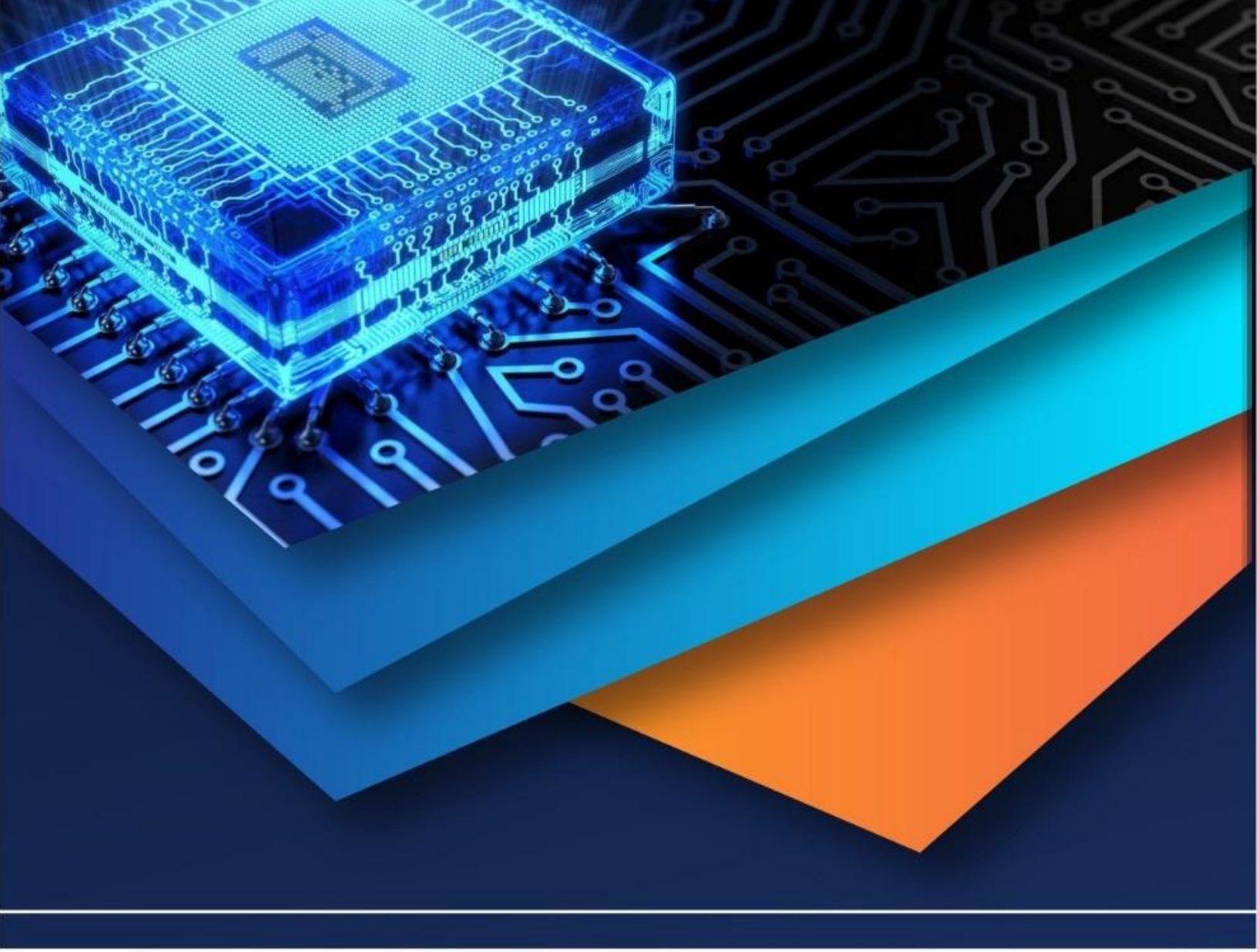

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