Nat. Volatiles & Essent. Oils, 2021; 8(5): 3394 - 3403

Defect Diagnosis Of Bearing In An Induction Motor By Vibration Monitoring

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Abstract

Induction motors are commonly utilized in both industry and the home. It's popular because of its durability and efficiency. In order to preserve its efficiency, every machine must be examined on a regular basis. and avoid unanticipated breakdowns that would result in a loss of productivity. As a result, fault diagnostics must be used to regularly monitor the motor in order to discover pump failures and, if necessary, replace it. Motor dismantling and reassembling during defect diagnostics is a time-consuming process. Vibration analysis is a time-consuming procedure that can be useful in monitoring the motor system's functionality without the need for disassembling induction motors were employed in this study for testing purposes. Utilizing the Lab VIEW software and a DAQ card as an interface, an accelerometer is employed to determine the amplitude and frequency of vibration at different axes of the pump. After that, the vibration spectrum is analyzed, and faults are detected by determining the frequency at which the vibration amplitude exceeds the danger threshold. Vibration data is used to diagnose faults such as impeller unbalance, bent shaft, shaft misalignment, cavitations, and bearing defects. The frequency with which various issues arise has been assessed employing induction motor experimentation. As a consequence, using vibration data to diagnose induction motors reduces the cost and time necessary for routine maintenance.

Keywords—efficiency, vibration, frequency

I. INTRODUCTION

The electric motor uses electromagnetic phenomena where the energy is transformed from electrical to mechanical. The many types of it differ in how the conductors and field are organized, as well as the control that may be applied over mechanical output torque, speed, and position.

When any physical apparatus is pushed out of equilibrium and allowed to respond to external stimuli seeking to restore, vibration occurs owing to back and forth motion of particles in an elastic body or medium. Vibrations are classified into two types: free and forced. They are the two forms of vibrations. Free vibrations arise when a system is briefly perturbed initially and then permitted to move without any disturbances [7], [8]. An ideal example is a mass hanging from a spring. When it is at equilibrium, it has the least energy and the mass is at rest. If the same mass is pressed down and then released, the mechanism will react by oscillating laterally [9]. Because of its nature, the vibrations of a spring are referred to as simple harmonic motion (SHM).

When a restoring force proportionate to the magnitude of the disturbance counteracts the system's disturbance, this is what happens. Spring's displacement defines the amount of restoring force that which is the tensile nature or compressive. (according to Hooke's law, they are proportional too). Sinusoidal oscillations are the mathematical form of periodic oscillations in simple harmonic motion.

II. NEED FOR THE STUDY

Induction motor vibration monitoring and analysis were performed in the industry as a result of rising maintenance costs and downtime. The use of vibration monitoring and analysis on a rotor-dynamic mechanical component was carried out in this case study (i.e. an induction motor). Bearing characteristic frequencies were difficult to come by, and the cause of vibration was unclear. Every machine must be inspected on a consistent basis for its efficiency and avoid unanticipated breakdowns that cause efficiency loss. It takes a long time to dismantle and reassemble a motor during a defect diagnostic. This work aims to determine fault diagnosis of bearing in a motor by vibration monitoring, Reduce the cost of maintenance and downtime, monitor the performance.

III. LITERATURE SURVEY

B.P. Graney [1] recognizes indicators of irregular or excessive in-service movement. Vibration analysis detects mechanical problems such as core/winding loosening by measuring amplitude, intensity, and frequency. One of the most common approaches used in PdM systems is vibration analysis. As part of condition evaluations, MISTRAS monitors the vibrations of machinery and spinning equipment, allowing us to more precisely forecast breakdowns before they cause more costly losses.

A. Suhane [2] presented the results of an experimental research on a single-staged non-positive pump. Flow-stimulated pressure pulses, mechanical vibrations, and noise of it were looked after during the tests at many flow rates by altering the clearance radial direction. For each example of it and flow conditions, all levels and frequency spectrum throughout the range were studied. Vibration is mostly caused by hydraulic collisions [10]. The impeller vane pass component has dominated the spectrum in general. The entire vibration level and the overall noise level have a substantial connection, according to frequency analysis. Pressure pulsations dominate the frequency analysis at fundamental frequency and impeller vane passage frequency [11], [12]. In frequency analysis, the first mode dominates the vibration spectra, whereas the blade moving frequency dominates the noise spectra. According to test results, increasing the clearance between the impeller and diffuser gives reduced pulsation levels.

Farokhzad et al. [3] conducted research to mimic each fault situation and get vibration data as a consequence. A data gathering device collects the information from the pump, which has an accelerometer on bearing housing (DAQ). The FFT is used to determine if different types of faults produce stationary or non-stationary signals. However, it has been determined that the detection accuracy for non-stationary signals must be improved, and several approaches have been proposed as a result.

Albraik et al. [4] explores the connections between pump performance metrics such as head, flow rate, and energy usage, as well as surface vibration for both pump condition checking and performance evaluation. A series of experiments were conducted on a non positive pump system using an in-house pump system, with several impellers in which one in good condition and others were with many defects, and at different flow rates for comparative study.

Yuvaraja et al. [5] presents about the reasons for the occurrence of vibrations in a motor and in centrifugal pump and presents about the methods of vibration monitoring in a motor by the use of LABVIEW software and DAQ card and explains about the vibration control using shape memory alloys

M. Senthilkumar [6] describes how to identify and find electrical drive issues, especially those using induction devices. Following that, the modelling approach is demonstrated using erroneous parameters, and machine diagnosis techniques are developed. The recommended diagnosis technique makes use of relatively little trial data and incorporates powerful modelling capabilities for detecting erroneous behaviours . The project is part of the monitoring and fault diagnostics subject for squirrel cage three-phase induction machines. Advanced technologies are required to keep track of the state of rolling element bearings effectively and efficiently. In simulation, the offered signal-based detection approaches have been confirmed.

IV. METHODOLOGY

Identification of suitable rotor dynamic mechanical component. Choosing the suitable location for detecting the vibrations in the motor. Study of sub components like accelerometer, DAQ card. Encoding the program for vibration monitoring in LABVIEW software. Vibration monitoring carried on the motor with the ideal bearings. Replacing the ideal bearings with faulty bearings. Vibration monitoring carried on the motor with faulty bearings. Exporting the graph obtained in LabVIEW software to excel to obtain the numerical data. Comparison of the numerical data (vibrations with safe bearings vs. vibrations with faulty bearings).

V. EXPERIMENTATION

A) Identification of suitable rotor dynamic mechanical component

Figure 1. Induction motor chosen for vibration monitoring

Specifications:

Table 1. Specifications of induction motor

RATED POWER	2 HP
MOUNTING TYPE	FOOT MOUNT
IP RATING	IP55
SPEED	2800 RPM
VOLTAGE	220 V
FREQUENCY	50Hz

Initially an induction motor as depicted in Figure 1 is chosen, which has ideal bearings Figure 2 shows, produce less amount of vibrations

Figure 2. Ideal bearings in the motor

b) Trial on accelerometer and DAQ card

Accelerometer: A device that monitors correct acceleration. The piezoelectric effect is employed, which originates when certain types of crystals are stretched and a voltage is generated across them. Figure 3 shows the accelerometer that was used to detect damping vibrations in the ruler

DAQ card: Data collection systems are composed of the following components: A sensor, analog to digital converter circuit. Analog-to-digital converters convert a conditioned sensor signals to digital values. The DAQ card is provided in Figure 4.

Figure 3. Accelerometer used in detecting damping vibrations in a ruler

Figure 4. DAQ card

VI. LABVIEW SOFTWARE

The Laboratory Virtual Instrument Engineering Workbench (LabVIEW) of National Instruments is a system designed to describe for their visual programming language. There are several uses for lab view software. Some of them are component/sub-system/system-automated manufacturing tests. Validation of equipment product design using automation. A machine or piece of industrial equipment is being monitored for its condition. Figure 5 depicts the VI block diagram done using LabVIEW software

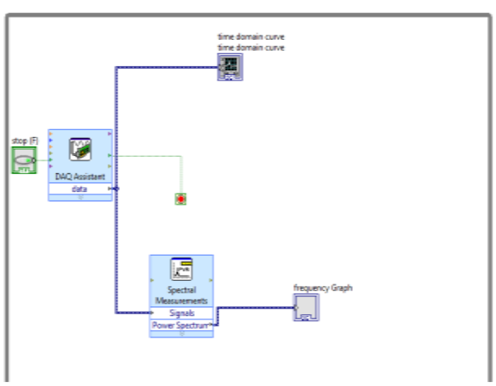

Figure 5. VI block diagram in LabVIEW

A) Encoding the program for vibration monitoring

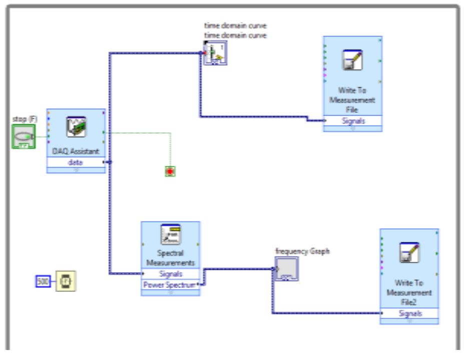

Figure 6. VI block diagram with the program

The following block diagram as depicted in Figure 6 consists of the program for vibration monitoring. Some of the elements present in the block diagram are discussed below

a) DAQ Assistant: Converts the voltage signal into binary signals. b) Time domain curve: Provides time vs. amplitude of acceleration graph. c) Spectral measurements: Time signals are transformed to frequency signals d) Write to measurement file: Used to save the output in a desired folder

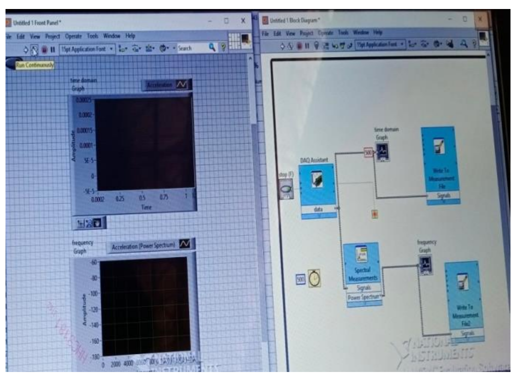

Figure 6. VI block diagram with graph

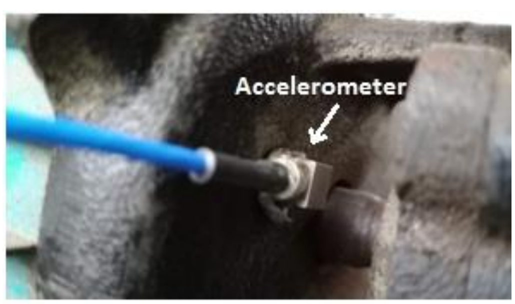

Figure 7. Accelerometer placed in the induction motor for detecting the vibrations

B) Factors that contribute vibration in motor

Vibration caused by unbalance: An imbalance during the motion in the mono-block impeller or shaft can generate considerable oscillations and convey it to the piping system, which can be remedied by adjusting the fan with the shaft on a balancing machine. The following characteristics may be used to locate a simple imbalance that is not compounded by additional issues: a) at normal speed of the shaft, amplitude occurs. b) The radial oscillation is rather homogeneous and not excessively directed. c) If a particular component, such as an impeller, is the source of imbalance, it will have a large amplitude at normal speed.

Misalignment causes vibrational effect in motor. The most prevalent source of equipment vibration is misalignment of directly connected machinery. Although self aligning bearings, flexible couplings are used, aligning two shafts and their bearings is challenging, resulting in vibration. Although these machines may tend to be perfectly aligned at first glance, a variety of factors such as operation temperature, base configuration, and grounding damage can all affect alignment. The following features can clearly identify misalignment.

a) 2 x RPM is the most frequent.

b) When compared to the horizontal direction, the axial direction has a higher amplitude.

Hydraulic pulsation causes mechanical vibration. They cause difficulties that are simple to spot since the resulting vibration occurs at a frequency that is in proportion to impeller vanes and speed of the machine (rpm). Owing to the pump's operation, the magnitude of excitation caused by hydraulic impulse in a pipe line is unavoidable. On virtually every pump, some vibration may be seen at the vane passage occurrence. It would be difficult to build a device without considering hydro-dynamic forces.

When the raceways of a rolling element bearing deteriorate, a variety of vibration might emerge, depends on the amount of the degradation. Identifying them can thus assist in not only confirming that a bearing is degrading, but also in estimating the extent of deterioration. The following features may be used to locate bearing defects: The vibration is only detectable at the bearing location. As the day continues, the haystack of vibration will increase and propagate.

C) Vibration monitoring in a motor with ideal bearings

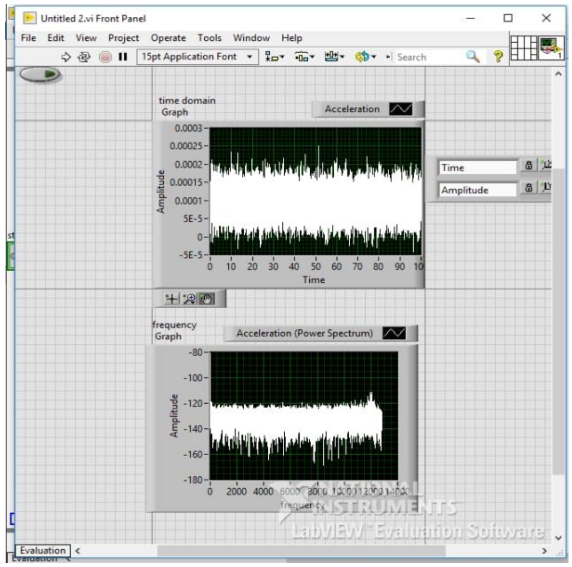

Figure 8. Output obtained while running the motor

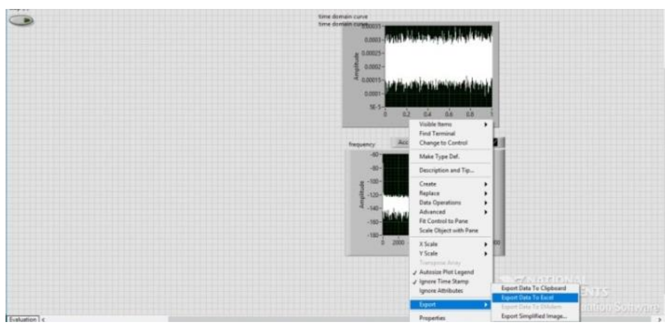

Figure 9. Exporting the obtained output to excel to obtain numerical values

	A	B	C
1	frequency - Acceleration (Power Spectrum)	Amplitude - Acceleration (Power Spectrum)	
2	0	-76.8354	
3	1	-79.8641	
4	12057	-110.575	
5	11957	-110.898	
6	12056	-111.479	
7	11956	-112.266	
8	12257	-115.403	
9	63	-116.483	
10	12007	-116.736	
11	10662	-117.426	
12	10963	-117.43	
13	9060	-117.456	
14	12020	-117.561	
15	8760	-118.087	
16	11906	-118.154	
17	10782	-118.17	
18	11756	-118.256	
19	9961	-118.276	
20	9061	-118.371	
21	11806	-118.46	
22	10781	-118.476	
23	11907	-118.87	
24	9661	-119.018	
25	10962	-119.127	

Figure 10. Frequency vs amplitude-acceleration values

D) Replacement of ideal bearings with fault bearings

Figure 12 a) Ideal bearing Figure 11 b) Fault bearing

E) Vibration monitoring in a motor with fault bearings

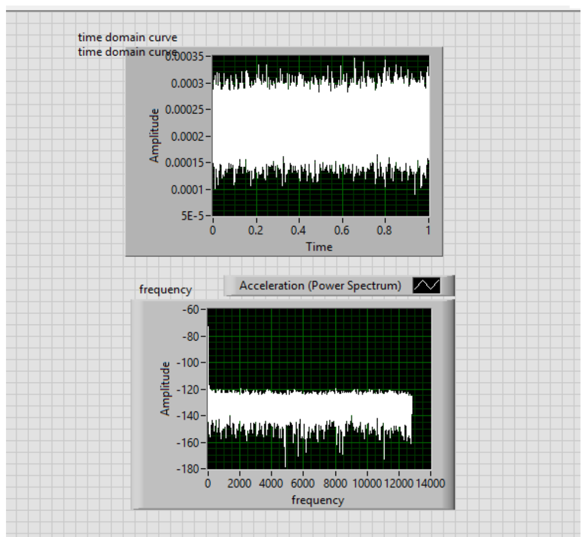

Figure 12. Output obtained while running the motor with fault bearing

	A	B
12777	834	-156.323
12778	7100	-156.386
12779	4771	-156.618
12780	11996	-156.719
12781	12501	-156.976
12782	11151	-157.069
12783	6461	-157.606
12784	11260	-157.782
12785	2093	-157.839
12786	3709	-158.608
12787	10189	-158.874
12788	8203	-158.924
12789	12400	-159.167
12790	4842	-160.027
12791	3459	-160.903
12792	3587	-161.046
12793	11967	-161.674
12794	6071	-161.825
12795	9560	-162.17
12796	9951	-162.765
12797	9446	-163.115
12798	3920	-163.819
12799	465	-164.212
12800	8526	-166.578
12801	11728	-172.369

Figure 13. Frequency Vs amplitude-acceleration (fault bearing)

VII. CONCLUSION

Output values (Frequency vs amplitude-acceleration) can be extracted from LabVIEW software as seen in Figure 10. On obtaining the numerical values for case-1 (motor with ideal bearing) from Figure 11 - Frequency Vs Amplitude-acceleration , it was found that the maximum amplitude of acceleration (-166.327) is obtained at a frequency of 4502 Hz . Repeated trials were carried on and it was concluded that the maximum amplitude of acceleration occurs between 4502 Hz and 4603 Hz. Hence this is set as the limit below which the motor is safe.

When the ideal bearings are replaced by fault bearings as shown in Figure 12, because of it the vibrations in the motor increases which leads to increased amplitude of acceleration (179.8) which occurs at 11205 Hz obtained from Figure 14- Frequency Vs Amplitude - acceleration, which are above the limit set by the motor with ideal bearing and hence the motor is not safe

Vibration monitoring is very useful in determining the performance of the motor and also acts as an indicator by indicating defects which helps us to rework on the areas which are identified as defects

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