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# Electro-pump Fault Diagnosis of Marine Ship by Vibration Condition Monitoring

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**Abstract:** The objective of this research is to investigate the correlation between vibration analysis and fault diagnosis. This was achieved by vibration analysis of an electro-pump of marine ship. The vibration analysis was initially run under regular interval during electro-pump life. Some series of tests were then conducted under the operating hours of stone crasher. Vibration data was regularly collected. The overall vibration data produced by vibration analysis was compared with previous data, in order to quantify the effectiveness of the results of vibration condition monitoring technique. Numerical data produced by vibration analysis were compared with vibration spectra in standard condition of healthy machine, in order to quantify the effectiveness of the vibration condition monitoring technique. The results of this paper have given more understanding on the dependent roles of vibration analysis in predicting and diagnosing machine faults.

**Key words:** Bearing, condition monitoring, electro-pump, predicting and diagnosing machine faults, pump, vibration analysis

## INTRODUCTION

Condition based maintenance is a preventive maintenance type that utilizes condition monitoring technologies in order to determine the current condition of an item, such as a machine, and thereby plan the maintenance schedule. The current condition and thus condition monitoring can be decided through highly complex equipment with objective measurements, such as vibration, temperature, shock pulse measurements, etc., or by humans subjective senses, such as sight, smell, hearing, and touch (Johansson, 1993).

The need of condition based maintenance with the use of proper condition monitoring technologies was revealed as early as in the 1960's through a study performed during the development of the preventive maintenance program for the Boeing 747. The study's purpose was to determine the failure characteristics of aircraft components (Overman, 2004).

Condition monitoring of critical machinery depends on observation of some symptoms, (like amplitudes of vibration, the temperature, etc), and comparing them with their limit values, usually determined by some long term experience (Czeslaw, 2004).

Recently, rotary machines with rolling bearings have become highly advanced and the environments in which the machines are being used have diversified. The improvement of the reliability of the rolling bearings for special environments such as corrosive, high temperature, high speed, or high vacuums environments, has become very important (Rokkaku, 1992; Matsunaga, 1999). Over the past few years several studies have been made on the performance of all-ceramic ball bearings with regard to fatigue life and temperature rise (Swab and Sweeney, 1995).

It has been known for many years that the mechanical integrity of a machine can be evaluated by detailed analysis of the vibratory motion (Eisenmann, 1998). Many mechanical problems are initially recognized by a change in machinery vibration amplitudes. In addition, the frequency of vibration, plus the location and direction of the vibratory motion are indicators of problem type and severity. Vibration characteristics can be distinctively divided into two types: forced vibration and free vibration. Typical forced vibration relates to problems such as mass unbalance, misalignment, and excitation of electrical or mechanical nature. Free vibration is a self-excited phenomenon that is dependent on the geometry, mass, and damping of the system, and typically caused by structural, acoustic resonance, and by aerodynamic or hydrodynamic excitation. Byrne and his co-worker showed that condition monitoring had a good application in industrials (Byrne *et al*., 1995). Vibration analysis in particular has for some time been used as a predictive maintenance procedure and as a support for machinery maintenance decisions (Mathew and Stecki, 1987).

The purpose of this study was to explain vibration characteristics of electro-pump in marine ship. Also another objective of this research was to investigate the correlation between vibration analysis and fault diagnosis.

This was achieved by vibration analysis of electro-pump. The vibration analysis was initially run under

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regular interval during electro-pump life. Some series of tests were then conducted under the operating hours of stone crasher. Vibration data was regularly collected. The overall vibration data produced by vibration analysis was compared with previous data, in order to quantify the effectiveness of the results of vibration condition monitoring technique. Numerical data produced by vibration analysis were compared with vibration spectra in standard condition of healthy machine, in order to quantify the effectiveness of the vibration condition monitoring technique. The results of this paper have given more understanding on the dependent roles of vibration analysis in predicting and diagnosing machine faults.

## MATERIALS AND METHODS

None Driven End (NDE) and Driven End (DE) bearings of electro-pump were SKF 6317, and the electro-pump speed was 1450 rpm. The radial and axial vibrations of none driven end and driven end of electro-pump were detected by using accelerometers VMI X-Viber, while the electro-pump was rotating at 1450 rpm. The overall vibratory velocity levels of electro-pump were measured by a measuring amplifier VMI X-Viber. Moreover, frequency analysis was done by using an FFT analyzer. In the vibration measurement, the rotational velocity of electro-pump was 1450 rpm. Vibration data was collected on a regular basis after the running period.

The experimental procedure for the vibration analysis consisted of taking vibration readings at two select locations over the housing of electro-pump. Vibration measurements were taken on the DE and NDE of electro-pump using an X-Viber (VMI is the manufacturer). Its accelerometer is very suitable for use in dirty field or high temperature environments with little degradation of the signal. The signals from the accelerometers were recorded in a portable condition monitoring signal analyzer. In general, electro-pump can be quite difficult to analyze. The wear mechanisms, primarily sliding and rubbing, for the elements of the bearing such as inner race, outer race, or wear balls, can be represented by an increase in vibration amplitudes, and a narrowband region of increasing energy content in the frequency spectrum. An evident offset of the spectrum from the baseline or zero amplitude may also provide an indication of wear of the bearing elements.

A number of standards and guides have been developed to explain what levels are acceptable for various machine types. In the field of machinery vibration monitoring and analysis, a variety of relevant standards are developed and published by ISO (International Organization for Standardization).

Standards for evaluation of vibration severity are considered one of the most important activities of ISO/TC108 and ISO/10816 series (6 parts) “Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts”.

## RESULTS AND DISCUSSION

Ahmadi and Mollazade (2008) explained that vibration condition monitoring technique has detected fault diagnosis of transmission storage bines electromotor. Vibration analysis has provided quick and reliable information on the condition of the bearings. Integration of this condition monitoring technique with another condition technique resulted in a comprehensive diagnosis of the machinery condition (Ahmadi and Mollazade, 2008).

The experimental results of the overall vibratory velocity level of DE of electro-pump have shown in Fig. 1. The vertical ax in this figure was expressed in mm/s. The warning and critical reference value is 2.8 and 4.5 mm/s, respectively. It's obvious from figure 1 that the overall vibratory velocity level of the DE of electro-pump was on critical level at several measurements. Bearing condition of DE of electro-pump was also in critical status in these measurements. The overall vibration of none driven end of electro-pump has shown in Fig. 2. Also the results showed that the overall vibratory velocity levels of none driven ends of electro-pump were on warning level at several first measurements too.

The results showed that the RMS values were on warning and critical status in several measurements and bearing condition value was on critical condition on those measurements. Results showed that RMS and BC values of several first measurements before repair were higher than standards and it could be showed that the bearings were on bad status.

The typical vibration spectrum of the DE of electro-pump has shown in Fig. 3 that shows the measured vibration spectra and the arrows show main vibration peaks. The velocity frequency spectrum of the DE of electro-pump showed a ball pass frequency.

The experimental result of overall vibratory velocity level of NDE of electro-pump has shown in Fig. 4. The velocity frequency spectrum of NDE of electro-pump showed both ball pass frequency and ball pass frequency outer race. Results showed that both bearings of DE and NDE of electro-pump were on bad situation.

According to spectrum analysis we found that both bearings of DE and NDE of electro-pump were faulty. We replaced them and after that the overall vibrations were reduced.

**Correlation of vibration and fault diagnosis:** Vibration analysis technique has been used to assess the condition of the electromotor and diagnose its problems. The results from vibration analysis of this applied test indicate some defaults in our electromotor.

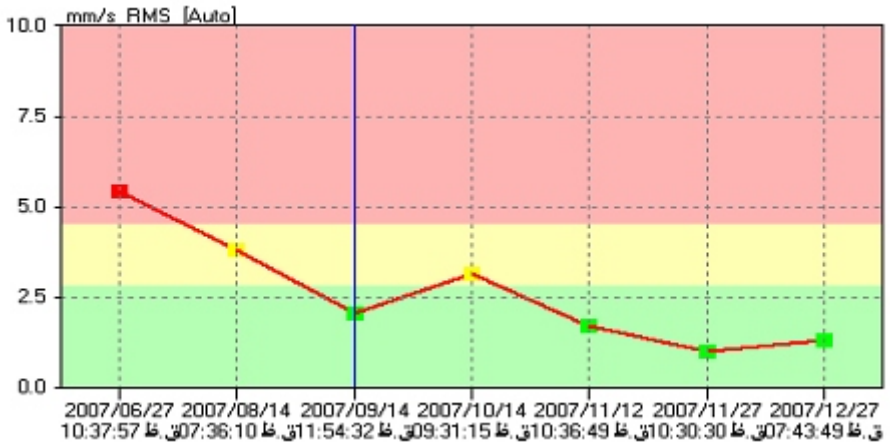


Fig 1: Overall vibrations of DE of electro-pump

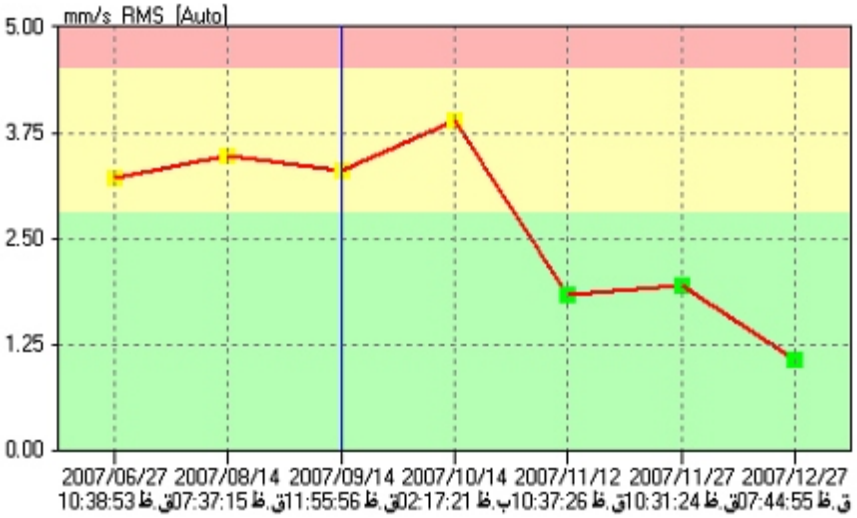


Fig 2: Bearing Condition of NDE of electro-pump

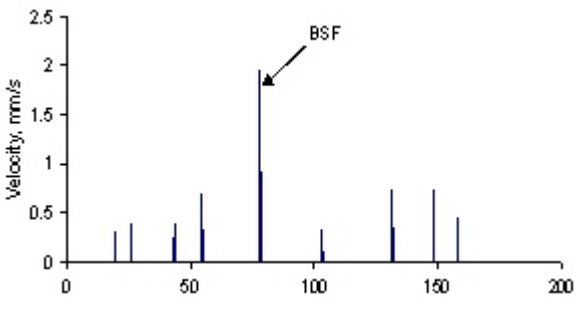


Fig 3: Frequency spectrum result of DE of electro-pump

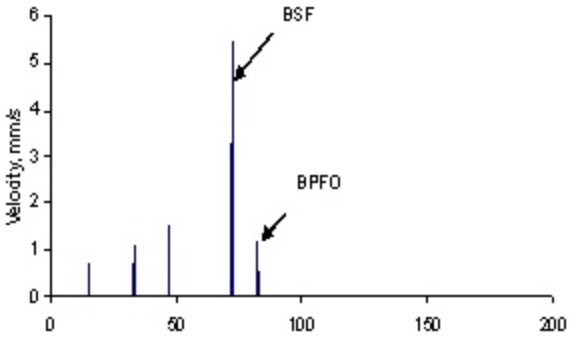


Fig 4: Frequency spectrum result of NDE of electro-pump

Vibration analysis of NDE of electromotor discovered the imbalance and defects on bearing of that side. From the vibration analysis of DE and NDE of electro-pump, it was determined that bearings had been used in bad condition.

The correlation between the vibration analysis and fault diagnosis was excellent as vibration technique was able to pick up on different issues, thus presenting a broader picture of the machine condition. The vibration analysis confirmed that a three-body rolling action took place, and significant life remained in the bearings of stone crasher. Vibration analysis technique was capable in covering a wider range of machine diagnostics and faults within the bearings.

Ahmadi and Mollazade (2009) illustrated that the vibration condition monitoring technique could detect faults in an electro-pump. The results have shown that early failure of machinery can often be detected using condition monitoring techniques (Ahmadi and Mollazade, 2009).

## CONCLUSION

By applying maintenance methods suggested for critical equipment parts of electro-pump, they allow to plan the shutdown before severe damage occurs and reduce reactive maintenance practices. The failure can be analyzed that cause benefits in critical equipment parts availability, optimized use of resources, reduced downtime, which increased availability of the sea company. For applying these methods for critical equipment parts of the sea company, it will require a substantial investment. The return on this investment will be dependent on the effectiveness of its implementation and the commitment of all personnel.

In this study, vibration condition monitoring technique, namely vibration analysis, has been used to identify fault diagnosis in bearing of electro-pump in a sea company. Results have shown that this independent condition monitoring technique has detected fault diagnosis of bearing of electro-pump.

By comparing the results of this technique, a more reliable assessment of the condition of the test rig can be made. Meanwhile, the vibration technique has its individual advantages. Vibration analysis has provided quick and reliable information on the condition of the bearings. Integration of this condition monitoring technique with another condition technique results a comprehensive diagnosis of the machinery condition.

Future research is planned, further to examine the relationship among the vibration techniques during active machine faults, and examples from other machinery and components that are commonly encountered in industry.

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