Analysis of vibration due to misalignment in the clutch cluster installation of centrifugal pump

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Abstract. Knowledge of vibration and the resulting data is very important for maintenance and troubleshooting where this ability can help companies reduce the occurrence of downtime and can increase profits both in terms of production and for a longer engine life. One of the causes of high vibrations is a misalignment in a centrifugal pump installation that is driven by an electric motor and connected by a fixed clutch. The method used is to do differences in height in the horizontal, vertical and angular directions by providing variations in the rotation of the electric motor and pump, then checking at four bearing positions on the electric motor and pump. The results showed an increase in vibration at each addition of the small on the electric motor fastener bolts, the greatest vibration occurred in the MOV (indoor motor axially) with the addition of a 1.5mm sim of 3.01 mm / sec an average increase of 29% and at the largest pump vibration in POA (outdoor axial pump) with the addition of a 1.5mm sim of 9.88mm / sec, increased by an average of 58%.

1. Introduction

Vibration is widely used as a tool for analyzing damage to industrial machines [1]. Knowledge of vibration and the resulting data is very important for maintenance and troubleshooting. This capability can help companies reduce downtime and can increase profits both in terms of production and longer engine life. The vibrations that arise due to cyclic force through the elements of the machine, where these elements act with each other and energy is determined through the structure in the form of vibrations. The impact of vibration is a noise, a decrease in performance and pump performance and can damage components at the pump, especially on the shaft and bearings [2].

The purpose of this study is to modify the practicum for centrifugal pump installation that can be used to test the characteristics of machine vibrations caused by the presence of misalignment. So from the results of the analysis of vibration characteristics that can be predicted damage to its components. In this study want to prove that one of the causes of vibration is the occurrence of misalignment on the shaft connected with a fixed coupling in a centrifugal pump installation.

The outline of disability (misalignment) is divided into two conditions including:
Angular misalignment where the position of the two axes of both shafts forms an angle, as in figure 1 below this. Shows that the difference between the shaft of the motor shaft and the axis of the pump shaft forms an angle where the clutch gap has a difference, the axial vibration shows the amplitude 1x rotation per minute in the axial direction, and will decrease at 2x revolutions per minute, also 3x revolutions per minute.

Figure 1. Angular misalignment [3].

Parallel misalignment in which the position of the axes of the two shafts are parallel but have different height which is shown on the surface of the two parallel couplings but the height is different. The axial plane that occurs shows 2x revolutions per minute in the radial direction. Parallel misalignment has the same vibration symptoms compared to angular misalignment, but shows higher radial vibrations approaching 180 phases. When angular or parallel misalignment becomes severe, it can produce a much higher harmonic amplitude 8 times or even the whole series of high frequency harmonics.

Figure 2. Parallel misalignment.

Based on ISO 10816 standard table classification machine vibrations in general are taken based on empirical experience with testing various machines and equipment in the industry shown in figure 3 below.
2. Research methods
The methodology in this study follows the research flow diagram as can be explained as follows:

The first stage in this research is planning a centrifugal pump installation as one of the machines that are widely used in industry, by planning laboratory-scale pump installations. In this plan considered in determining the method of testing pump vibrations with the condition of the equipment and materials available in the maintenance and repair laboratory.

The second stage in this research is to make a vibration characteristic test device due to misalignment of the pump installation using materials according to plan and using existing equipment in the maintenance and repair laboratory.

The third step in this research is to test the vibration of the centrifugal pump under conditions of shaft misalignment with several variables such as the relationship between the pump coupling and the motor during Unfault, the position of the bolts on the prototype of the pump base and the motor, all the motor base bolts and all the pump base bolts in loose / loose state, all motor base bolts are loose / loose, while all pump base bolts are firmly mounted. From the data of the test results then the vibration characteristics are analyzed as a basis for determining damage predictions for centrifugal pump components.

3. Results and discussion
The results of the modification of the vibration test equipment on the pump installation with the following data:

1). IRD 808 Vibration meter vibration test equipment
2). 3 Phase electric motor, 3 HP
3). Centrifugal pump type
   • Brand: Torisma Pump
- Head: 70 m
- Capacity: 30 liters/sec
- Power: 3700 watts
- Voltage: 380 volts
- Rotation: 2950 rpm

**Figure 4.** Centrifugal pump installation.

Determination of the vibration measurement point is used to obtain optimal results, in this study vibration signal retrieval is done both at the motor and at the pump, as in Figure 5. While in table 1 and table 2 displayed the results of vibration measurements in the pump section and on the motor part, the value of vibration increase uniformly occurs in the pump area.

**Figure 5.** Vibration measurement point [4].
Table 1. Results of vibration measurements on the motor.

| Thickness shim (mm) | MOH | MOV | MOA | MIH | MIV | MIA |
|---------------------|-----|-----|-----|-----|-----|-----|
| 0.5                 | 1480| 0,9 | 0,86| 1,18| 1,11| 0,97| 1,43|
|                     | 1200| 0,7 | 0,66| 0,98| 0,91| 0,77| 1,23|
|                     | 1000| 0,5 | 0,46| 0,78| 0,71| 0,57| 1,03|
| 0.75                | 1480| 1,24| 1,51| 1,62| 1,67| 1,43| 2,04|
|                     | 1200| 1,54| 1,91| 2,02| 2,07| 1,83| 2,44|
|                     | 1000| 1,84| 2,31| 2,42| 2,47| 2,23| 2,84|
| 1                   | 1480| 1,45| 2,65| 1,98| 1,05| 1,81| 2,48|
|                     | 1200| 1,2  | 1,4  | 1,73| 0,8  | 1,56| 2,23|
|                     | 1000| 0,95 | 1,15 | 1,48| 0,55 | 1,31| 1,98|
| 1,5                 | 1480| 1,75 | 1,75| 2,09| 1,19| 1,63| 3,01|
|                     | 1200| 1,55 | 1,55| 1,89| 0,99 | 1,43| 2,81|
|                     | 1000| 1,35 | 1,35| 1,69| 0,79 | 1,23| 2,61|

Table 2. Results of vibration measurements at the pump.

| Thickness shim (mm) | POH | POV | POA | PIH | PIV | PIA |
|---------------------|-----|-----|-----|-----|-----|-----|
| 0.5                 | 1480| 0,93| 1,02| 2,57| 1,08| 0,98| 1,58|
|                     | 1200| 0,73| 0,82| 2,37| 0,88| 0,78| 1,38|
|                     | 1000| 0,53| 0,62| 2,17| 0,68| 0,58| 1,18|
| 0.75                | 1480| 1,56| 1,03| 3,5  | 1,74| 1,69| 2,44|
|                     | 1200| 1,96| 1,43| 3,9  | 2,14| 2,09| 2,84|
|                     | 1000| 2,36| 1,83| 4,3  | 2,54| 2,24| 3,24|
| 1                   | 1480| 1,42| 1,84| 6,44| 1,24| 1,65| 3,22|
|                     | 1200| 1,17| 1,59| 6,19| 1   | 1,4 | 2,97|
|                     | 1000| 0,92| 1,34| 5,94| 0,75| 1,15| 2,72|
| 1,5                 | 1480| 1,92| 1,97| 9,88| 1,92| 1,41| 5,04|
|                     | 1200| 1,72| 1,77| 9,68| 1,72| 1,21| 4,84|
|                     | 1000| 1,52| 1,57| 9,48| 1,52| 1,01| 4,64|
From the results of the above vibration tests can be made in the form of figure below.

**Figure 6.** Graph Vibration test for misalignment conditions.

**Figure 7.** Graph of vibration test on an electric motor.
From the results of the discussion above it is known that the vibration test with a variety of misalignment shows that the greater the misalignment on both shafts the greater the vibration and causes damage to the indoor axial motor bearings and outdoor axial pumps, the greatest vibrations occur in axial indoor motors (MIA) at 5.04mm / sec at 1.5mm shim thickness and at outdoor axial (POA) pumps at 9.66mm/sec at 1.5mm shim thickness.

**Figure 8.** Graph of Vibration test vs rotation on an electric motor bearing.

**Figure 9.** Graph of vibration test vs rotation on pump bearing.
4. Conclusions

- One method to see the performance of the pump is to check the vibration test on the electric motor bearings and pump bearings. The test results show the misalignment with a difference in shim height of 0.5 mm of vibration at the MIA point shows a magnitude of 1.43 mm/sec with a difference of shim height of 1.5 mm of vibration increased by 5.02 mm/sec. Whereas at the pump changes occur at the POA point to the depth of 0.5 mm of vibration at 2.57 mm/sec., At the depth of the 1.5 mm shim the vibration becomes 9.88 mm/sec.
- One of the causes of high vibrations in pump installations is the occurrence of impulse on both the pump shaft and the motor (misalignment) which can damage the bearings.
- Vibration checks on pumps and motors can be done every 4-5 hours to prevent damage to the pump and to maintain pump readiness.

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Reference

[1] Aji K 2007 Deteksi Kerusakan Bantalan Gelinding Pada Pompa Sentrifugal Dengan Analisa Sinyal Getaran (Doctoral dissertation, Universitas Sebelas Maret)
[2] Suwandi A, Wahono D R and Hermawanto D 2009 Analisis karakteristik getaran pada kereta api rel listrik dan kereta api rel diesel Jurnal Standardisasi 11(2) 98-105
[3] Scheffer C 2005 Associate Professor "Pump Condition Monitoring Through Vibration Analysis" Department of Mechanical and Mechatronic Engineering: Stellenbosch University
[4] Marscher W D, Olson E J, Onari M M and Boyadjis P A 2016 Vibration Problems & Solutions for Pumps and Other Turbomachines In Proceedings of the 32nd International Pump Users Symposium, Turbomachinery Laboratories, Texas A&M Engineering Experiment Station