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The Effectiveness of Centrifugal Pump Shaft Alignment Process Against Vibration Reduction

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ABSTRACT

High vibration in the pump is something that should be anticipated because it can cause damage to the bearings, seals, and shafts. If the pump continues to operate in this condition, it will also cause damage to other pump components and cause the pump to stop operating. Therefore, the condition of the pump must be monitored regularly to ensure that the pump can operate properly. One of the most frequently used methods to find out where high vibrations come from is to use the aptitude analyst application that will produce a unique vibrational spectrum. Vibration analysis is done by observing the amplitude and frequency of the vibration signal. Vibration spectrum analysis can detect pump damage without having to disassemble the equipment and can provide early warning before major damage occurs and takes a large repair cost. The results showed that the existence of high vibration at the 11-PA-7131A pump was caused by the parallel misalignment that occurred at the pump shaft and motor. This is indicated by the high amplitude of vibration on orders 1x, 2x and followed by the presence of amplitude on orders 3x. Vibration data retrieval after the alignment process on the pump shaft and motor also proves that there is a very significant change in vibration amplitude on orders 1x, 2x, and on order 3x. Overall vibration also experienced a very significant decrease so that the pump can be operated normally.

Keywords: Pump, Vibration, Misaligment, Overall Vibration

ABSTRAK

Getaran yang tinggi pada pompa merupakan hal yang harus diantisipasi karena dapat mengakibatkan kerusakan pada bantalan, seal dan poros. Apabila pompa tetap beroperasi dalam keadaan seperti ini maka juga akan mengakibatkan terjadinya kerusakan pada komponen pompa lainnya dan mengakibatkan pompa berhenti beroperasi. Oleh sebab itu kondisi pompa harus terus dipantau secara teratur untuk memastikan pompa dapat beroperasi dengan baik. Salah satu metode yang paling sering digunakan untuk mengetahui dari mana getaran yang tinggi berasal adalah dengan menggunakan aplikasi aptitude analyst yang akan menghasilkan spektrum getaran yang unik. Analisis Getaran dilakukan dengan mengamati amplitudo dan frekuensi sinyal getaran. Analisis spektrum Getaran dapat mendeteksi kerusakan pompa tanpa harus membongkar peralatan serta dapat memberikan peringatan dini sebelum kerusakan besar terjadi dan memakan biaya perbaikan yang besar. Hasil penelitian menunjukkan bahwa adanya getaran yang tinggi pada pompa diakibatkan oleh adanya parallel misalignment yang terjadi pada poros pompa dan motor. Hal ini ditunjukkan dengan tingginya amplitudo getaran pada order 1x, 2x dan diikuti oleh adanya amplitudo pada order 3x. Pengambilan data getaran setelah dilakukan proses alignment pada poros pompa dan motor juga membuktikan bahwa terjadi perubahan yang sangat signifikan pada amplitudo Getaran pada order 1x, 2x dan order 3x. Overall getaran juga mengalami penurunan yang sangat signifikan sehingga pompa dapat dioperasikan secara normal.

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Kata Kunci: Pompa, Getaran, Misaligment, *Overall* Getaran

1. Introduction

In the oil and gas industry, pumps play a very important role where pumps are used to drain liquids such as condensate and water. Various types of pumps are used for various purposes according to their functions, one of which is the 11-PA-7131A pump which is used in producing water in PT. Pertamina Hulu Mahakam

The pump itself generally uses an element in the form of a bearing which functions to withstand the load acting on the pump shaft and motor. The load that must be borne by these bearings over time will make their reliability decrease. One of the initial impacts of this decrease in reliability is the increase in the magnitude of the vibration before the failure occurs. Problems High vibration often occurs in pump 11-PA-7131A and causes this unit to stop operating due to damage to the bearings on the pump. According to data maintenance maintenance PT. Pertamina Hulu Mahakam, this bearing failure has occurred three times in the past year. If the bearings on this pump are damaged, damage to other pump components will occur and this pump will automatically stop producing. This will cause financial losses due to production delays. On the other hand, the need to provide material is also not easy to do. In addition to relatively expensive material prices, the availability of the necessary material stocks is also not necessarily available. For this reason, Vibration analysis is very important to be used for early detection of the condition of an equipment so that development problems can be identified before they become more serious and can cause unscheduled downtime.

Vibration analysis is very important to do because it is one of the supporting factors for detecting mechanical problems for rotating equipment including the 11-PA-7131A pump. Vibration analysis can detect problems early on such as bent shaft, worn gear, misalignment, bearing damage, imbalance, and so on so that greater damage and fatal consequences to the pump can be avoided. For machines designed with long operating hours /long then operational vibration limits are given, namely alarms and trips. An alarm is a limit value of vibration that is determined to provide an early warning that vibration has reached or there has been a significant change. If an alarm limit occurs, machine operation can be continued temporarily while an investigation is carried out to identify the cause of the change in Vibration and determine the corrective action.

2. Methodology of Research

This research began with receiving reports from operators regarding the condition of the vibrating pumps and then carrying out field visits/observations to find out the current conditions for taking vibrations using the GX microlog analyzer.

According to the review that has been carried out and the vibration data that has been taken, we will enter the data into the software which will later get vibration spectrum data. From these data we will analyze what problems occur with the pump and motor. Vibration data collection is carried out in two parts, namely the motor side and the pump side. Vibration data collection point as shown in the following figure

Figure 1. Vibration point

The results obtained in the Vibration inspection are in the form of values for the magnitude of the vibrations that occur, but the data must be processed first, along with an overview of the vibration data processing.

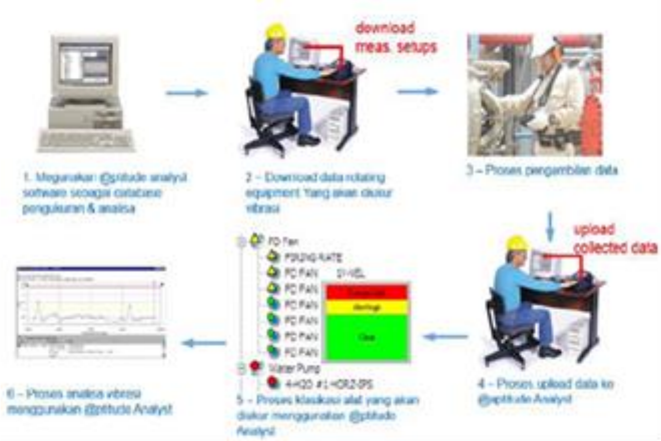

Figure 2. Vibration data processing

The parameters being compared are amplitude and frequency. Because the amplitude is proportional to the excitation force that occurs in the pump and motor components. So according to theory, if there is damage to the pump and motor components, a high amplitude will occur at a certain frequency.

3. Result and Discussion

Vibration spectrum data on pumps and motors are shown in the following table.

Table 1. Vibration spectrum data of motors and pumps

Frequency (cpm)	Order (times)	Amplitude (mm/s)	
		Motor	Pump
2880	1x	4.55	5.48
5760	2x	5.28	6.42
8640	3x	0.55	0.52
11520	4x	0.45	0.64

3.1 High vibration spectrum analysis

Based on the vibration analysis chart listed below, we will analyze the vibration spectrum that has been taken on the pump unit 11-PA-7131A. The analysis will be carried out by looking at the vibration spectrum that has been taken on the motor and also the vibration spectrum on the pump.

Figure 3. Vibration analysis chart

In the motor vibration spectrum it can be seen that the dominant amplitude is at a frequency of 5760 cpm (2X) of 5.28 mm/s and followed by a frequency of 2880 cpm (1X) of 4.55 mm/s. Based on the spectrum signal data above, it shows that the shaft on the motor experiences parallel misalignment due to a high amplitude at order 2X which is also followed by a high amplitude at order 1X.

3.2 Vibration spectrum analysis on the motor

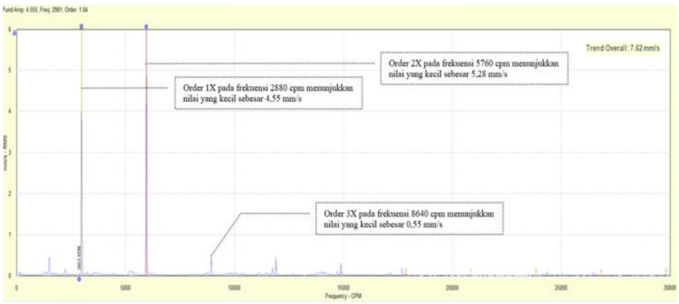

Figure 4. Motor vibration spectrum (misalignment)

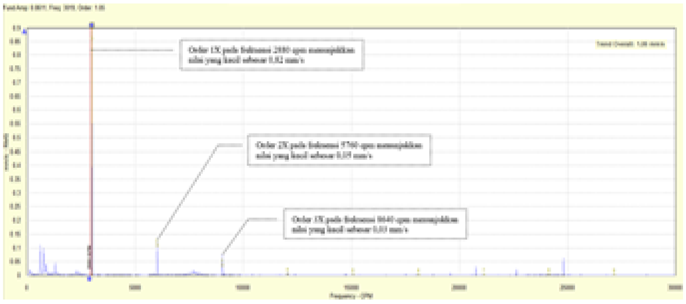

Figure 5. Motor vibration spectrum (alignment)

In the motor vibration spectrum signals in shaft alignment conditions, the amplitude values for each order are not high and only within normal limits. If we look at the amplitude at a frequency of 2880 cpm (1X) it is 0.82 mm/s and the amplitude at 5760 cpm (2X) is 0.05 mm/s. The amplitude of vibration at a frequency of 8640 cpm (3X) is 0.03 mm/s.

3.3 Vibration spectrum analysis on the pump

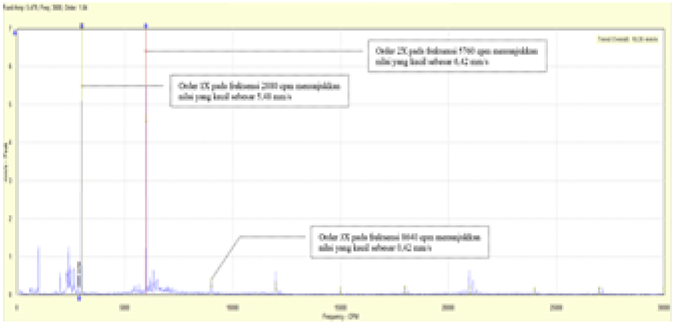

Figure 6. Pump vibration spectrum (misalignment)

The vibration spectrum of the pump as shown in the figure above shows that the spectrum signal generated at the pump also has the same characteristics as the motor. If we observe that the pump vibration spectrum shows that the dominant amplitude is also at a frequency of 5760 cpm (2X) of 6.42 mm/s, followed by a frequency of 2880 cpm (1X) of 5.48 mm/s. Based on the spectrum signal data above, it shows that the shaft at the pump also experiences parallel misalignment due to a high amplitude at order 2X which is also followed by a high amplitude at order 1X.

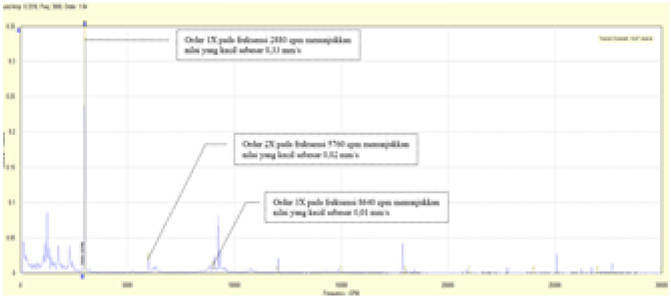

Figure 7. Pump vibration spectrum (alignment)

In the vibration spectrum signal on the pump which is in shaft alignment condition, the amplitude value in each order is also not high and only within normal limits. If we look at the amplitude at a frequency of 2880 cpm (1X) it is only 0.33 mm/s and the amplitude at 5760 cpm (2X) is 0.02 mm/s. The amplitude of vibration at a frequency of 8640 cpm (3X) is 0.01 mm/s.

3.4 Overall analysis of vibration on pumps and motors

The standard of severity for the pump unit 11-PA-7131A refers to ISO Standard 10816-3. It is known that the pump unit 11-PA-7131A has a power of 3 kw with a flexible coupling type and integrated driver, then in accordance with ISO 10816-3, the limits for each category are as follows:

a) 1st safety limit (Good) = 0.1 mm/s - 2.3 mm/s

b) 2nd safety limit (Permitted to operate) = 2.3 mm/s - 4.5 mm/s

c) Alarm limit = 4.5 mm/s - 7.1 mm/s

d) Dangerous limit = >7.1 mm/s

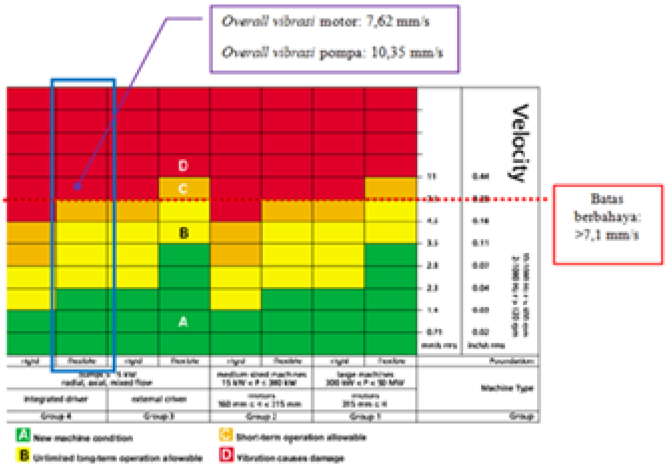

Figure 8. Overall vibration (misalignment)

After shaft alignment, the overall vibration on the motor is 1.06 mm/s and the overall vibration on the pump is 0.57 mm/s included in the 1st safe limit category, which means the pump can be operated continuously safely.

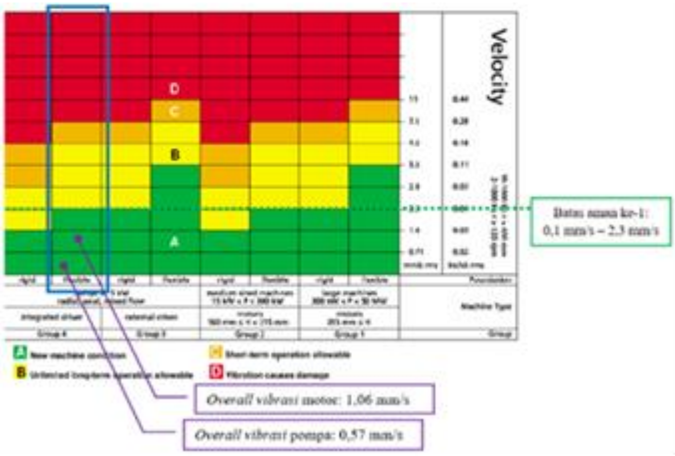

Figure 9. Overall vibration (alignment)

3.5 Shaft misalignment calculation

Based on the analysis that has been obtained that the pump unit 11-PA-7131A has a parallel misalignment, the pump unit 11-PA-7131A needs to do shaft alignment. This is done to avoid damage that will occur to the pump bearings and other components.

Figure 10. Shaft misalignment calculation

The technical data obtained from the measurement conditions are as follows:

1. The circumference diameter of the dial indicator = 50 mm.
2. The distance from the dial indicator rim to the foot of the front of the motor = 120 mm.
3. The distance from the front foot to the rear foot of the motor = 140 mm

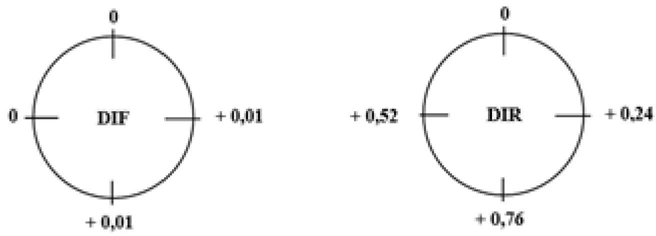

Figure 11. Dial indicator reading

- *Rim Dial Vertical (DIR)*
  Tir = Total indicator reading rim = 0,76 - 0 = 0,76 mm
  Face Dial Vertical (DIF)
  Tir = Total indicator reading face = 0,01- 0 = 0,01 mm
- *Rim Dial Horizontal (DIR)*
  Tir = Total indicator reading rim = 0,24 – 0,52 = -0,28 mm
- *Face Dial Horizontal (DIF)*
  Tir = Total indicator reading face = 0,01- 0 = 0,01 mm

3.6 Calculation of vertical misalignment data

$$Coupling\ offset = \frac{(DIR)\ Tir\ Vertical}{2}$$
$$= 0{,}76/2$$
$$= 0{,}38 \text{ mm}$$

$$\text{Shaft tilt} = \frac{(DIF)\ Tir\ Vertical}{A\ Dimension}$$
$$= 0{,}01/50$$
$$= 0{,}002 \text{ mm}$$

Calculating the addition or reduction of movement on the forefoot of the motor.

$$Front\ feet = \frac{[\,(\text{DIF}\ Tir)\ B\,] + 1/2\ \text{DIR}\ Tir}{A}$$
$$= \frac{[\,(0{,}01)\ 120\,] + 1/2\ (0{,}76)}{50}$$
$$= (0{,}024) + (0{,}38)$$
$$= 0{,}404 \text{ mm}$$

With this result, the shim on the front leg of the motorbike must be reduced by 0.404 mm.

Calculating the addition or reduction of movement on the hind legs of the motor

$$Rear\ feet = \frac{[\,(\text{DIF}\ Tir)\ B + C\,] + 1/2\ \text{DIR}\ Tir}{A}$$
$$= \frac{[\,(0{,}01)\ (120 + 140)\,] + 1/2\ (0{,}76)}{50}$$
$$= (2{,}6 / 50) + 0{,}38$$
$$= 0{,}052 + 0{,}38 = 0{,}432 \text{ mm}$$

With this result, the shim on the rear leg of the motorbike must be reduced by 0.432 mm.

3.7 Calculation of horizontal misalignment data

$$Coupling offset = \frac{(DIR)\ Tir\ Horizontal}{2}$$
$$= -0,28/2$$
$$= -0,14\ mm$$

$$Shaft\ tilt = \frac{(DIF)\ Tir\ Horizontal}{A\ Dimension}$$
$$= 0,01/50$$
$$= 0,002mm$$

Calculating the addition or reduction of movement on the forefoot of the motor.

$$Front feet = \frac{[\ (DIFTir)\ B\ ] + 1/2\ DIRTir}{A}$$
$$= \frac{[\ (0,01)\ 120\ ] + 1/2\ (-0,14)}{50}$$
$$= (0,024) + (-0,07)$$
$$= -0,046\ mm$$

With this result, the front foot of the motor must be moved to the right by 0.046 mm.

Calculating the addition or reduction of movement on the hind legs of the motor.

$$Rear feet = \frac{[\ (DIFTir)\ B + C\ ] + 1/2\ DIRTir}{A}$$
$$= \frac{[\ (0,01)\ (120 + 140)\ ] + 1/2\ (-0,28)}{50}$$
$$= (2,6 / 50) - 0,14$$
$$= 0,052 - 0,14$$
$$= -0,088\ mm$$

With this result, the rear leg of the motor must be moved to the right by 0.088 mm.

3.8 Comparison of vibration spectrum under conditions of shaft misalignment and alignment

a) The amplitude comparison of the motor vibration spectrum signal data is in the following table

Table 2. Comparison of motor vibration spectrum signal data

Frequency (cpm)	Order (times)	Amplitude (mm/s)	
		Misalignment Condition	***Alignment Condition***
2880	1X	4,55	0,82
5760	2X	5,28	0,05
8640	3X	0,55	0,03
11520	4X	0,45	0,02

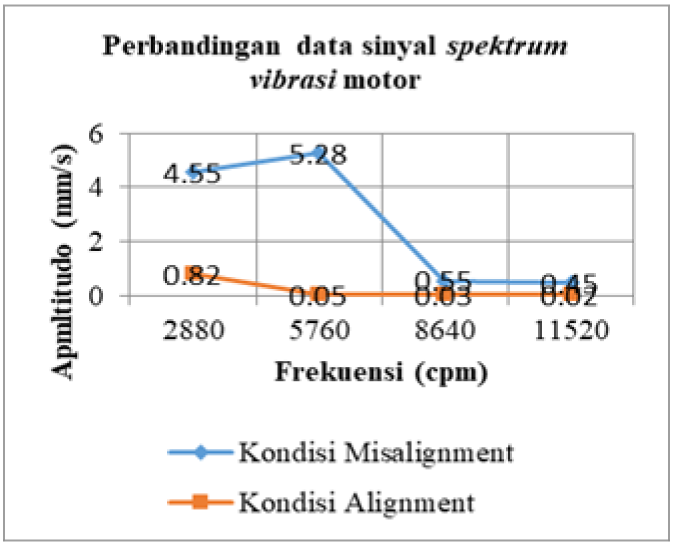

Figure 12. Motor vibration spectrum comparison graph

There was a decrease in the amplitude of the motor vibration spectrum signal after shaft alignment was carried out at order 1X of 3.73 mm/s, at order 2X at 5.23 mm/s, at order 3X at 0.52 mm/s, and at order 4X at 0.43mm/s.

b) The amplitude comparison of the pump vibration spectrum signal data is in the following table:

Table 3 Comparison of pump vibration spectrum signal data

Frequency (cpm)	Order (times)	Amplitude (mm/s)	
		Misalignment Condition	***Alignment Condition***
2880	1X	5,48	1,82
5760	2X	6,42	0,22
8640	3X	0,52	0,12
11520	4X	0,64	0,18

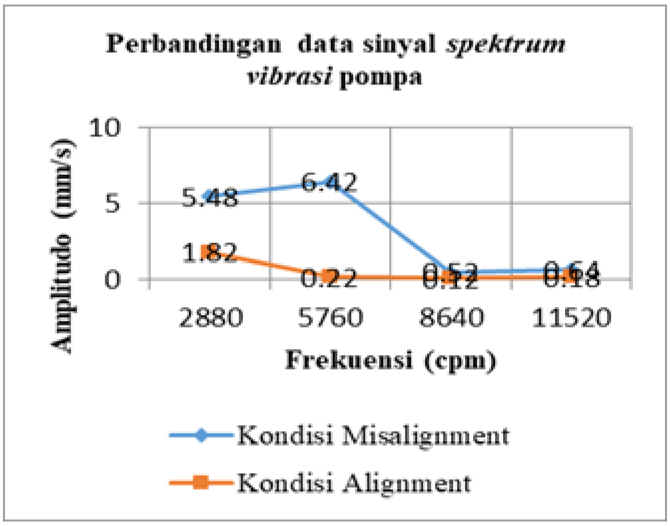

Figure 13 Pump vibration spectrum comparison graph

There was a decrease in the amplitude of the pump vibration spectrum signal after shaft alignment was carried out at order 1X of 3.66 mm/s, at order 2X at 6.2 mm/s, at order 3X at 0.4 mm/s, and at order 4X at 0.46mm/s.

c) The overall comparison of motor and pump vibration is in the following table:

Table 4. Comparison of motor and pump vibration overall data

Pump Unit 11-PA-7131A	*Vibration Overall* (mm/s)	
	Misalignment Condition	*Alignment Condition*
Motor	7,62	1,06
Pump	10,35	0,57

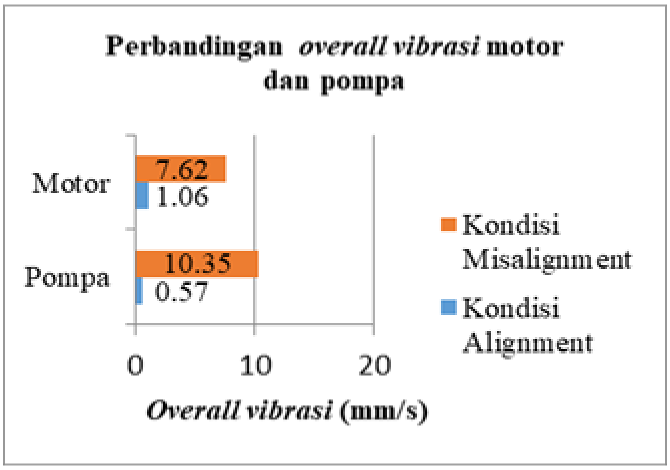

Figure 14 Overall comparison chart Vibration pump and motor

There was a significant decrease in overall motor vibration after shaft alignment was carried out, which was 6.56 mm/s. In overall pump vibration there was also a significant decrease after shaft alignment was carried out which was 9.78 mm/s.

4. Conclusion

The cause of high vibrations in the pump can be detected using vibration analysis using the velocity spectrum method. The velocity spectrum method can show the amplitude peaks that appear at each order/frequency. By paying attention to the dominant high frequency in the spectrum we will be able to find out where the high vibrations in the pump are coming from.

The high vibration of the 11-PA-7131A pump is caused by a parallel misalignment of the pump and motor shafts. This is evidenced by the occurrence of high amplitude peaks, a vibration spectrum at a frequency of 2880 cpm and followed by a high frequency of 5760 cpm on the motor and pump.

Misalignment that occurs in the pump unit is very influential on the overall results of Vibration. Vibration data shows a significant difference in results when the pump is operating in a misalignment condition compared to operating in an alignment condition. The spectrum data also shows that pumps operating in alignment conditions will produce small amplitude peaks at all frequencies.

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