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VIBRATION ANALYSIS OF CRITICAL MOTOR

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ABSTRACT

A refinery is a production facility composed of a group of chemical engineering unit processes and unit operations refining certain materials or converting raw material into products of value. To achieving this, all the machineries such as motors, pumps, compressors, fans... etc need to be properly maintained. The underperformance shown by a critical motor has been analysed by the condition monitoring. The major contributors which cause the problem have been identified and solutions were given to overcome the problem and it could be able to run as efficiently.

KEYWORDS: Vibration Spectrum Analysis, Condition Monitoring

INTRODUCTION

While the crude is pumping from the shore tank farm (STF) to CDU1 the pressure of the crude is about 15kg/mm2. This pressure is inadequate for the crude to flow through the distillation column. So there is a need of increasing the pressure to travel through the distillation column, for that a pump is required to increase the pressure of the crude which is coming from the STF. The pump is known as the booster pump and the motor as booster motor. The pump has generated a pressure of 35kg/mm2. Hence the crude could able to travel through the distillation column.

PROBLEM DEFINITION

The CP1B motor has generated severe noise. When it had checked, the abnormal vibration has shown in the spectrum which led to decline of its performance. There are various reasons which cause of decline of its performance. This study is focus on how to reduce the severe noise that affects the performance of the motor.

SPECIFICATION OF THE CP1B

The specification of the defected motor are given below

Construction type of model	: IP55
Electrical motor frame	: KD40028
Motor power rating	: 370 KW
Rpm	: 2976

Volt : 3300

Amps : 80

Motor drive end bearing : NU224J/C3

Motor non drive end bearing : 6221J/C3

DATA COLLECTION

The data which given below are the notifications provided to operators to do the maintenance

Table 1: Data of Motor CP1B

Motor	Date	Time	Maintenance
CP1B	02/20/2012	9:15 AM	CP1B MOTOR DE BRGS TO BE REPLACED
CP1B	03/12/2012	2:05 PM	CP1B MOTOR DE RH LEG BOLT LOOSE
CP1B	03/25/2012	10:01 AM	CP1B MOTOR DE BEARING TO BE GREASED
CP1B	04/10/2012	11:10 AM	CP1B MOTOR DE BEARING TO BE GREASED
CP1B	04/21/2012	3:45 PM	CP 1B MOTOR BRG TO BE REPLACED
CP1B	04/28/2012	1:20 PM	CP 1B MOTOR ALIGNMENT CHECKED
CP1B	05/19/2012	1:50 PM	CP 1B MOTOR BRNG TO BE GREASED

For this study I had collected some data of its maintenance for 4 months. As per the data I had made an analysis and evaluation that each category of the machine has its own velocity. My aim is to bring the machine to its desirable velocity.

MACHINE CLASSIFICATION

In this part of ISO 10816, the vibration severity will be classified according to the following parameters:

- Machine type.
- Rated power or shaft height.
- Support system flexibility.

CLASSIFICATION ACCORDING TO MACHINE TYPE, RATED POWER OR SHAFT HEIGHT

Significant differences in design, type or bearings and support structures require a separation into different machine groups. Machines of these four groups may have horizontal, vertical or inclined shafts and can be mounted on rigid or flexible supports.

Group 1: Large machines with rated power above 300 kW. These machines normally have sleeve bearings. The range of operating or nominal speeds is relatively broad and ranges from 120 r/min to15000 r/min.

Group 2: Medium-size machines with a rated power above 15 kW up to and including 300 kW. These machines normally have rolling element bearings and operating speeds above 600 r/min.

Group 3: Pumps with multivane impeller and with separate driver (centrifugal, mixed flow or axial flow) with rated power above 15 kW. Machines of this group may have sleeve or rolling element bearings.

Group 4: Pumps with multivane impeller and with integrated driver (centrifugal, mixed flow and axial flow) with rated power above 15 kW.

CLASSIFICATION ACCORDING TO SUPPORT FLEXIBILITY

Two conditions are used to classify the support assembly flexibility in specified directions:

- Rigid supports.
- Flexible supports.

Large- and medium-sized electric motors, mainly with low speeds, would normally have rigid supports, whereas turbo-generators or compressors with power greater than 10 MW and vertical machine sets would usually have flexible supports.

EVALUATION

ISO 10816-1 provides a general description of the evaluation zone used to assess vibration severity on various classes of machines.

Evaluation Zones

The following evaluations zones are defined to permit a qualitative assessment of the vibration of a given machine and provide guidelines on possible actions.

Zone A: The vibration of newly commissioned machines would normally fall within this zone.

Zone B: Machines with vibration within this zone are normally considered acceptable for unrestricted long-term operation.

Zone C: Machines with vibration within this zone are normally considered unsatisfactory for long-term continuous operation. Generally, the machine may be operated for a limited period in this condition until a suitable opportunity arises for remedial action.

Zone D: Vibration values within this zone are normally considered to be of sufficient severity to cause damage to the machine.

Here in the Table 2 has shown the vibration severity zone as per the ISO 10816.

Table 2: Classification of Vibration Severity Zones for Machines of Group 1: Large Machines with Rated Power above 300 kW and not More than 50 MW

Sl No	Support Class	Zone Boundary	RMS Velocity (mm/s)
1	Rigid	A/B B/C C/D	2.3 4.5 7.1
2	Flexible	A/B B/C C/D	3.5 7.1 11.0

Since the motor has the power greater than 300kW this motor comes under the category of group 1 and since this motor is medium sized and has low speed it has comes under the rigid support class.

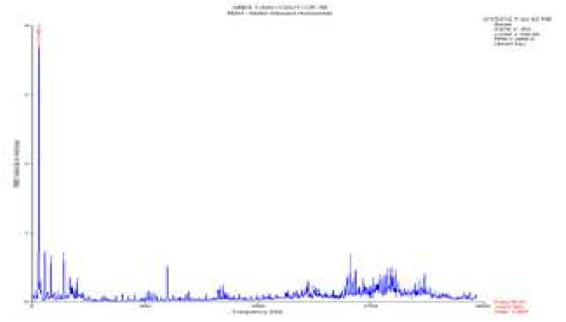

Figure 1: Vibration Spectrum Showing Velocity

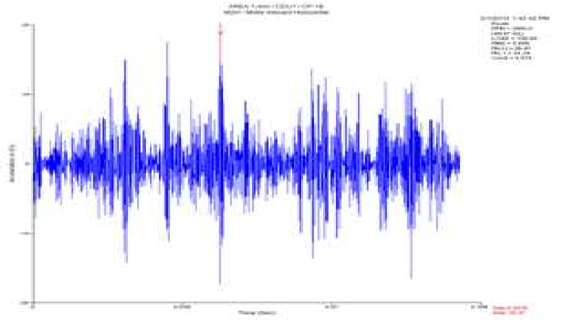

Figure 2: Vibration Spectrum Showing Acceleration

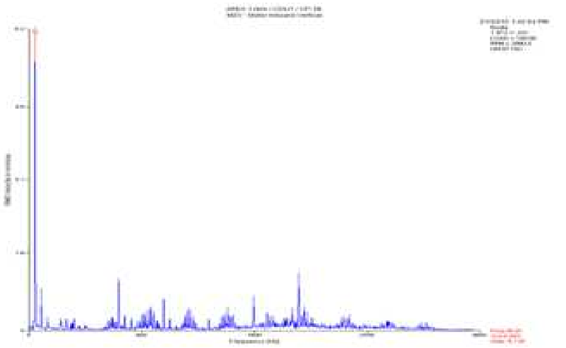

Figure 3: Vibration Spectrum Showing Velocity

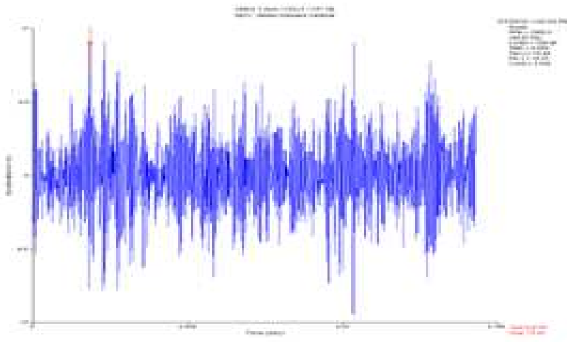

Figure 4: Vibration Spectrum Showing Acceleration

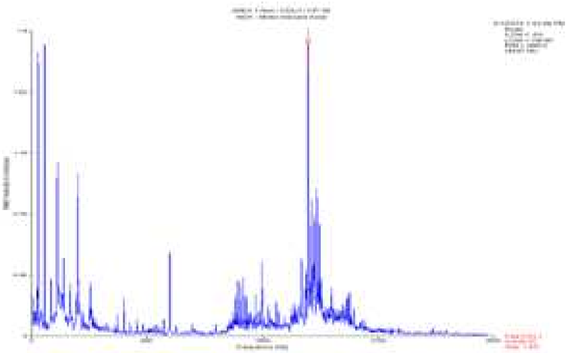

Figure 5: Vibration Spectrum Showing Velocity

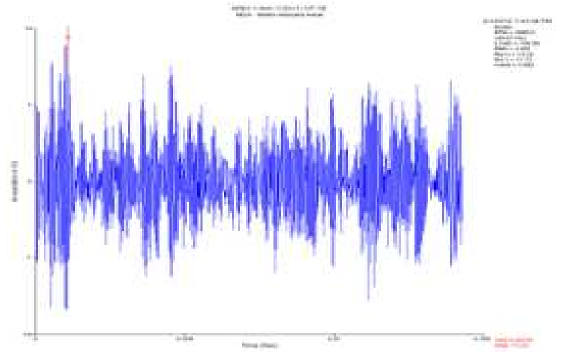

Figure 6: Vibration Spectrum Showing Acceleration

ANALYSIS OF THE MOTOR BEFORE MAINTENANCE

The motor (inboard horizontal vibration) spectrum was showing the velocity around 3.904mm/s and the peak to peak value is +26.47 to -24.29. Normally the limit of the motor vibration rms velocity is about 2.3mm/s and the peak to peak value is about 15. And the both reading is exceeding the limit. So we can infer that motor is not running efficiently.

In the motor (inboard vertical) spectrum the velocity is around 6.129 mm/s and the peak to peak value is around +15.44 to -16.07. Normally the limit of the motor rms velocity is around 2.3mm/s and the peak to peak value is about 15. And the both reading is exceeding the limit. So we can infer that the motor is not efficient.

In the motor (inboard axial) spectrum the rms velocity is around 1.83mm/s and the peak to peak value is around +13.22 to -11.72. Normally the limit of the motor rms velocity is about 2.3mm/s and the peak to peak value is about 15. Here the vibration is in the limit.

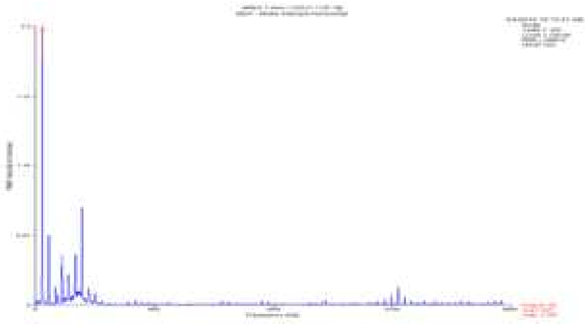

Figure 7: Vibration Spectrum Showing Velocity

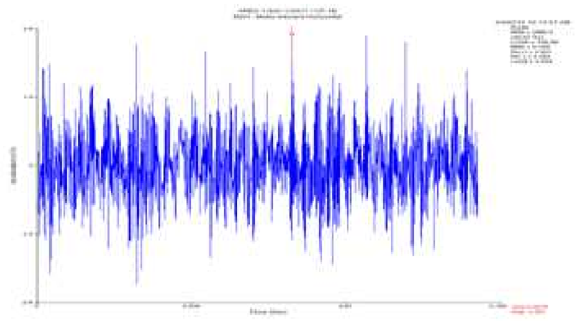

Figure 8: Vibration Spectrum Showing Acceleration

Figure 9: Vibration Spectrum Showing Velocity

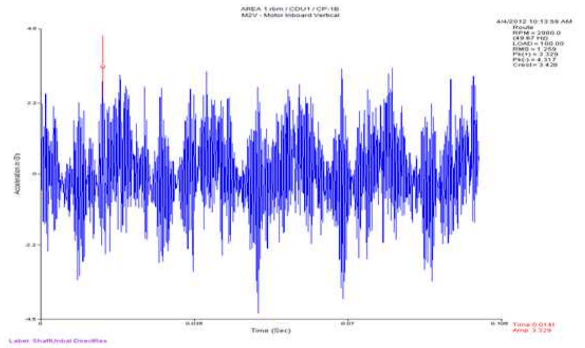

Figure 10: Vibration Spectrum Showing Acceleration

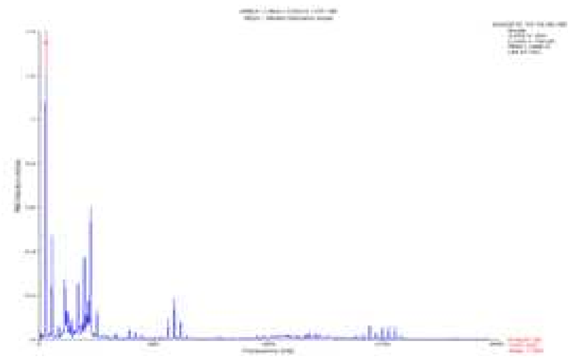

Figure 11: Vibration Spectrum Showing Velocity

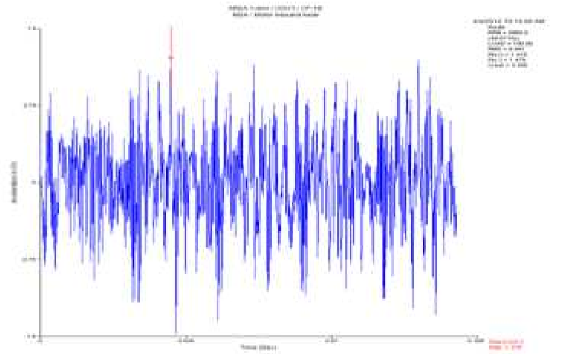

Figure 12: Vibration Spectrum Showing Acceleration

ANALYSIS OF THE MOTOR AFTER MAINTENANCE

In the motor (inboard horizontal) spectrum the rms velocity is about 2.26mm/s and the peak to peak value is about +2.5 to -2.25. Both values are below 2.3mm/s and 10 respectively. In that we can infer that it is up to the performance.

In the motor (inboard vertical) spectrum the rms velocity is about 9.64 mm/s and the peak to peak value is about +3.32 to -4.31. The peak to peak value has reduced. The more concern is about the peak to peak value. So we can infer that it is up to the performance.

In the motor (inboard axial) spectrum the rms velocity is about 1.345 mm/s and the peak to peak value is about +1.21 to -1.47. The rms velocity has reduced and the peak to peak value also has reduced. So we can infer that it is up to the performance.

APPEARANCE OF ABNORMALITY

Non synchronous and vibration peak values were observed at motor drive end bearing on horizontal and vertical side.

DETECTION

Usually for a motor vibration reading are taken at 4 different locations namely,

- Motor non drive end
- Motor drive end
- Pump drive end
- Pump non drive end

VIBRATION SPECTRUM ANALYSIS

Now the increase in vibration could be due to variety of problems like unbalance, misalignment, bearing damage flow problem, electrical fault etc. I have looked through vibration spectrum of the motor and the pump taken at the different locations and followed a process of elimination to zero in or what could possibly be at fault

- There were no peaks corresponding to 1X vibrations. This rule out unbalance as the cause of vibration
- No peaks were present at the 2X position. Also the average sum value of the amplitude at the axial position was same as the averages at the horizontal and vertical direction. Hence we could ascertain the reason was not misalignment.
- Peaks were not observed in random turning speed multiple like 1x, 2x, 3x etc. hence looseness was not the cause for the excessive vibrations.
- While observing the vibration spectrum we found out harmonics of non-synchronous peaks and sideband peaks appearing around the rotating face frequency.
- By analysis the progressive side band peaks on either side of high amplitude peak we can say that this may be due to any damage of bearing.
- Inner race defects and failure occur at much lower amplitudes than outer race defects.
- Early force generates predicted defect frequency and harmonic frequency for one of the races.
- Extended harmonics of the defects frequency may indicate multiple defect size or extended defect size.
- Race defect frequencies are modulated by the shaft speed, which result in the appearance of side band peaks. The number of side band frequency increases as the damage progresses.

POSSIBLE REASONS FOR BEARING TO BE FAILED

Some possible reasons which are causing failure to the motor given below.

- Foreign Matter

- Improper mounting
- Bearing clearance
- Electrical damage
- Improper bearing lubrication
- Bearing fatigue
- Defective sealing
- High temperature

Table 3: Measurement Report

Point Id	Parameter Description	RMS Velocity Value (after) (mm/s)	RMS Velocity Value (before) (mm/s)	Peak to Peak (after)	Peak to Peak (before)
M1H	MOTOR INBOARD HORIZONTAL	2.26	3.904	+2.5 to -2.25	+26.47 to -24.29
M1V	MOTOR INBOARD VERTICAL	3.06	6.129	+3.32 to -4.31	+15.44 to -16.07
M1A	MOTOR INBOARD AXIAL	1.34	1.831	+1.21 to -1.47	+13.22 to -11.72

CORRECTIVE ACTION

The motor was isolated and decoupled from the pump at the site and then it was shifted to maintenance workshop for overhauling. On dismantling the motor, it was observed that unwanted vibration caused due to defect in the bearings. This was the reason for erratic vibration peak values which was observed. This problem was rectified by replacing the faulty carbon alloy steel ball bearing with stainless steel ball bearing which has high corrosive resistant strength.

CONCLUSIONS

The work carried out enabled us to have a detailed study of condition monitoring of rotary equipment through vibration analysis. The unwanted noise generated due to the aberration of the bearing caused due to corrosion. The important suggestion has made to eliminate the noise of the motor and hence prevent failure of the motor. The correction then was made as a result of which the machine life was extended. Thus with the condition monitoring the condition of the machinery is known beforehand and its chances of failure can be eliminated.

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