Vibration Analysis Of Vane Pass Frequency Vibrations In Single Stage Single Volutebetween Bearing Type Pumps

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Abstract**—***This Paper represents study work carried out on a single stage volute type centrifugal Pump. The flow induced pressure pulsations, mechanical vibrations and noise has been monitored. Overall vibrations levels, frequency spectra, in a wide frequency range, have been examined. Vibrations and noise both are predominantly due to hydraulic effects. Impeller vane pass component has generally dominated the spectra. Frequency analysis revealed a good correlation in the overall vibration level and overall noise level. In the frequency analysis, pressure pulsations are dominating at fundamental frequency and impeller vane pass frequency. Experimental results show that by increasing the radial clearance between impeller and volute tongue, lower pulsations, vibrations and noise levels have been achieved.*

Key words:Centrifugal pump, Mechanical vibrations,pressure pulsations, Radial clearance, Volute tongue

Introduction

Condition Based maintenance proved to be one of the efficient maintenance philosophy for avoiding unpredicted failures as well as optimizing the maintenance expenditure.

Both fatigue and rubbing wear in pump components is caused by excessive rotor vibrations, typical causes for which include the rotor being out of balance, the presence of misalignment between pump and driver shaft centerline, excessive hydraulic force such as from suction recirculation stall or vane pass pulsations or natural frequency resonance.

A case study is discussed on analysis of the vane pass frequency vibrations in single stage single volute pumps and cost effective remedial measures are presented for mitigation of super synchronous vibrations.

VANE PASS FREQUENCY :

Pressure pulsation are fluctuations in the basic pressure /head developed by the pump. The pulsations can sometimes be very severe and cause damage to the Pumps. In centrifugal pumps a pressure pulse is developed as each rotating vane passes the cut water or diffuser vane reaching a maximum value when the vane tip passes this point. When vane tip is adjacent to cut water, the maximum amount of energy in the form of liquid in motion is directed towards the discharge nozzle. At any other point between vane tips and cut water, the distance is large and consequently some of the liquid slipsby under the cutwater and is recirculated through pump. The change from minimum to maximum transfer of energy to the discharge nozzle results in corresponding change or variations in the discharge pressure which constitute pressure pulsation. Pressure pulsations have two important characteristics: Frequency and amplitude.

FREQUENCY:

Frequency is defined as the number of recurrences of periodic phenomenon in unit of time. The vane frequency is the basic frequency generated by a centrifugal pump. There is a pulse generated each time as vane tip passes the cut water. If there are seven rotating vanes in the impeller and one cutwater, for complete revolution of the impeller seven vane tips pass the cut water or there would be seven pulses per revolution.

$$f = N(S/60)$$

f = Impeller vane passing frequency (Hz)

N = No. of vanes of impeller

S = Speed of the Impeller

AMPLITUDE:

The amplitude of pressure pulse is measure of the maximum amount by which the pressure varies from the average or steady state value. Unit for measurement is Root-Mean-Square (RMS).

Another unit used in measuring the magnitude of pressure pulsations is pressure decibel (pdB). The decibel is as dimensionless units expressing a logarithmic ratio between two quantities, one the measured quantity, the other reference quantity.

Pressure Level (pdB) = 20 Log10 Measured pressure/ Reference pressure

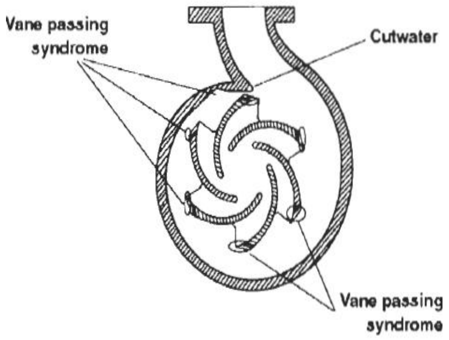

Fig 1: Locations for generation of Vane passing frequency.

FACTORS EFFECTING FREQUENCIES

In perfect centrifugal pump, the vane frequency and most probably harmonics of it are the only discrete frequencies that would be generated. It is the imperfections in thePump that generate additional discrete frequencies

Vane pass frequency can be changed/ reduced by following ways

1. Changing the number of impeller vanes
2. Speed of Impeller
3. Increasing vane tip clearance.

III : Case Study

Equipment No: 295PM1B

Service	: Seawater cooling pump
Make	: M/s KBL
Capacity	: 3500 m3/hr
RPM	: 960
Type	: Single stage single volute

History :

Casing of the Pump was refurbished by welding and metallic putty application due to erosion. After refurbishment, Pump was taken into service and abnormal noise was observed from the pump while in service.

After 7 days of continuous service, shaft of the pump sheared off into two pieces at impeller area. Shaft was replaced with new shaft and pump was again taken into service. The same noise which was heard before shaft failure was again heard and equipment was stopped.

Observations for Analysis

1. Abnormal cavitation noise observed from pump
2. Dominant vibration peak observed at 5X RPMi.e. vane pass frequency of the Pump.
3. Magnitude of 1X is less than 1mm/s
4. Below is the spectrum and time wave form

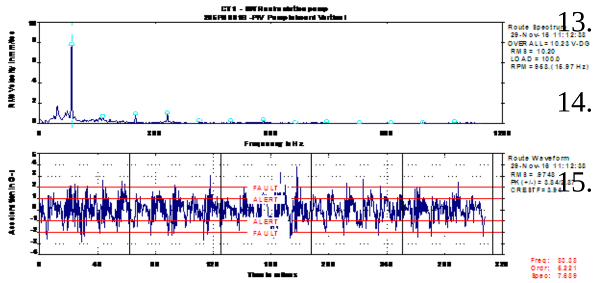

Fig No.2 : Vibration spectrum and time wave form

IV : Analysis of the problem

1. Dominant peak at 5X eliminates possibility of unbalance and misalignment
2. No raised noise floor observed in the spectrum. Hence, possibility of flow problem is eliminated
3. As no dominant peak observed at 1X, no stable phase observed in the phase analysis.
4. Pump is single stage single volute pump.
5. Suspecting fault with flow restriction, suction strainer of the pump was cleaned but no improvement was obtained.
6. In view of dominant Vane pass freq, attempts were made to reduce amplitude of vane pass frequency.
7. Neither impeller vanes can be changed nor speed of the equipment can be reduced as it shall have effect on downstream of the equipment,
8. Impeller vane tip clearance was measured and found to be 19.8 mm
9. As per standards, impeller vane tip clearance can be upto 10% of the impeller diameter without having any effect on performance of the Pump.
10. Impeller vane tip clearance was increased from 19.8 mm to 30 mm.
11. Vane tip clearance was increased by grinding.
12. Pump was placed in service.
13. Vibrations of the equipment reduced to 5 mm/s from 13 mm/s
14. Cavitation noise from the Pump reduced to allowable limits.
15. Below is vibration spectrum after change in impeller vane tip clearance.

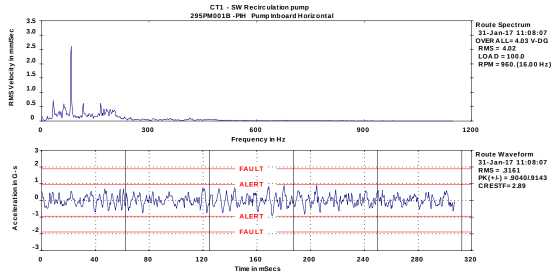

Fig-1 : Top view of the pump

Fig-2: Cut water area of the pump after modification

References

[1] Practical Centrifugal Pumps by M/s Paresh Giridhar