Journal of Scientific Research in Allied Sciences (JUSRES)

Original Research Article

INCREASE PRODUCTIVITY OF CENTRIFUGAL PUMP BY DETECTION OF CAVITATION PHENOMENA

Shraddha Soni, Sharda Pratap Shrivas

ME Scholar, Assistant Professor
Chouksey engineering college, Bilaspur

Article history:
Submitted on: January 2016
Accepted on: February 2016
Email: info@jusres.com

ABSTRACT

Centrifugal pumps are widely used in a variety of applications. In many applications the role of centrifugal pump is critical and condition monitoring is essential. Cavitation within the pump can cause undesirable effects, such as damage of the impeller by pitting and erosion and deterioration of the hydraulic performance. Cavitation can appear within the entire range of operating conditions, therefore it must by all means be prevented. To prevent cavitation in a pump it has to know the beginning and development of the cavitation in the pump. For this purpose, the vibration and noise must be kept within certain limits. If the mechanical state of the pump and its drive are good, the inflow conditions are in order and the duty point is admissible, these limits can be observed without difficulty. Higher vibrations ultimately results in decreased component life due to Pitting in impeller, cyclic loads, bearing failure, distortion to foundation etc. Vibration spectrum analysis technique is a most effective approach to maintain the safe and reliable operation of centrifugal pumps.

Key words:- Cavitation, Vibration, Centrifugal pump.

INTRODUCTION

Centrifugal pumps are a sub-class of dynamic axisymmetric work-absorbing turbo machinery. Centrifugal pumps are used to transport fluids by the conversion of rotational kinetic energy to the hydrodynamic energy of the fluid flow. The rotational energy typically comes from an engine or electric motor. The fluid enters the pump impeller along or near to the rotating axis and is accelerated by the impeller, flowing radially outward into a diffuser or volute chamber (casing), from where it exits. Cavitation is defined as the phenomena of formation and consequent implosion of vapor bubbles in a region where the pressure of the liquid falls below its vapor pressure. Cavitation can occur in any fluid handling equipment, especially in pumps. Technological advances in industrial protective coatings and repair composite materials have made it possible to repair pumps suffering from cavitation rather than simply replacing them. Cavitation Resistant (CR) elastomers have the ability to retain adhesion under long-term immersion, dissipate energy created under high intensity cavitation and provide resistance to corrosion and other forms of erosion.

Cavitation is a serious problem for pumps. In simple terms, a pump moves a fluid from one location to another by means of mechanical actions that can be extreme and damage the internal working parts of the pump. The main area of damage can be pinpointed to the pump impeller vane. During operation, the impeller is subject to pressure gradients, which cause bubbles to form, implode and strike the surface underneath. Common uses include water, sewage, petroleum and petrochemical pumping. The reverse function of the centrifugal pump is a water turbine converting potential energy of water pressure into mechanical rotational energy.

WORKING OF A CENTRIFUGAL PUMP

1. Impeller rotates exerting centrifugal force on the liquid
2. Kinetic energy is created
3. Centrifugal force throws the liquid out
4. Creating low pressure at the suction eye
5. This forces new liquid into the impeller inlet
6. Liquid thrown out of the impeller is met with resistance to flow
7. The first resistance is created by the volute
8. As the liquid moves in the volute towards the outlet it slows down due to increasing cross sectional area
9. As the liquid slows down its velocity (kinetic energy) is converted into pressure
10. The impeller is offset in the volute to create a close clearance between the impeller and the volute at the cut water

11. The kinetic energy given to the liquid is proportional to the velocity at the edge of the impeller vane tip
12. Faster the impeller rotates or bigger the impeller is, higher will be the liquid velocity at the vane tip.

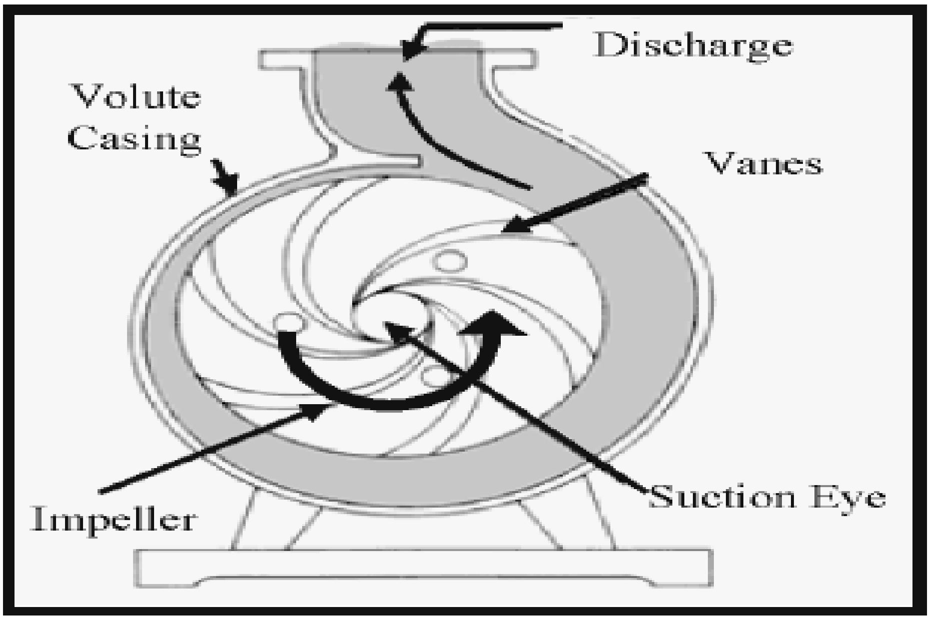

Figure 1 Centrifugal Pump

OBJECTIVE

Determination of the net positive suction head (NPSH), at constant speed and flow rate, is the most popular engineering method. According to ISO 3555 standards, the NPSH value is determined by a 3% drop in the total delivery head which represents the required or critical value at which cavitation is fully developed. This method needs a special test stand prescribed by the standards and a set of measurement results to determine the NPSH required value at different flow rate. It is also used to guarantee tests, but it is not suitable for cavitation monitoring in onsite operations. Visualization of the flow by an in-pump impeller eye is the second most popular engineering method. A transparent model casing and stroboscopic light is used to calm down the Cavitation flow & to get the visualization and photographic evidence of cavitation. The procedure for testing is similar to the one before, but measuring is based on NPSH (4mm) data or 4 mm long vapors cavities, which correspond to the 3% drop in total delivery head or the state of fully developed cavitation (NPSH required). This method is suitable for a single bubble and for high powered pumps, as well as for localization of the cavitation vortex cores within the pump or water turbine. However, it is less appropriate for small pumps and for the flow rates far from the BEP, i.e. at low flow rates and at the free delivery. Instead of stroboscopic light, computer-aided camera visualization and digitalization of the pictures can be used. It can also be used to guarantee tests.

1. CAUSES OF PUMP CAVITATION

- Drop in pressure at the suction nozzle due to low NPSHa

If the fluid at pump suction is not available sufficiently above the vapor pressure of liquid at operating conditions, then vaporization of liquid and formation of gas bubbles is very likely, leading to cavitation.

- Increase of the temperature of the pumped liquid

Increase in liquid temperature at the pump suction point increases the vapor pressure of the liquid. Thus it becomes more likely for operating pressure to fall below this vapor pressure limit, hence leading to bubbles and cavitation.

- Increase in the fluid velocity at pump suction

Increase in fluid velocity at pump suction can typically be caused by higher liquid flow rates than the design case. As per Bernoulli's principle, higher liquid velocity means higher velocity and lower pressure head. Frictional pressure drop in the pump suction also rises with rise in the flow rate, making low pressure and cavitation at pump suction more likely to occur.

- Reduction of the flow at pump suction

Certain minimum flow is required by the centrifugal pumps to keep them from running dry, as indicated by the pump performance curves. If liquid flow falls below this limit, possibility of developing vapor in pumps and cavitation increases.

- Undesirable flow conditions caused by obstructions or sharp elbows in the suction piping

Sharp elbows, valves, other fittings and obstructions cause more frictional pressure loss in the pump suction, thus increasing possibility of low pump suction pressure leading to cavitation.

- The pump is not selected correctly.

Every centrifugal pump has a certain requirement of positive suction head (NPSHR). If the pump is not selected properly NPSHA might fall below this NPSHR limit, causing cavitation.

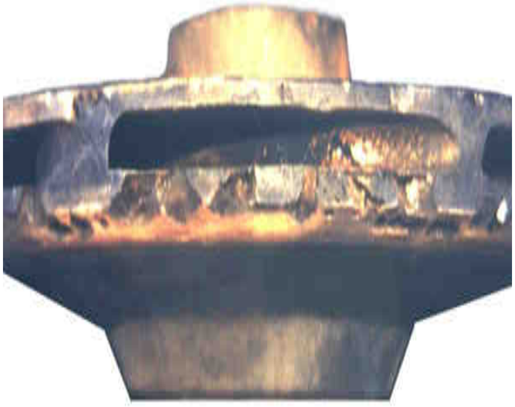

Fig. 2 Cavity Produce in parts.

Table 1 Performance of Pump

Location	**Velocity (RMS)**			**Acceleration(RMS)**		
	Horizontal	**Vertical**	**Axial**	**Horizontal**	**Vertical**	**Axial**
MOTOR NDE	2.17	2.13	1.87	1.13	1.18	1.74
MOTOR DE	2.23	1.80	2.30	1.45	0.49	0.48
PUMP DE	14.1	10.3	7.2	10.87	8.87	6.82
PUMP NDE	12.3	9.5	6.1	9.96	7.72	5.9

Table 2 Performance after Cavitation

Location	Velocity (RMS)			Acceleration(RMS)		
	Horizontal	Vertical	Axial	Horizontal	Vertical	Axial
MOTOR NDE	1.78	2.32	1.69	1.91	1.28	1.42
MOTOR DE	2.97	2.83	1.57	1.32	1.42	1.34
PUMP DE	20.13	14.74	9.76	18.42	20.17	14.56
PUMP NDE	16.72	9.87	10.31	16.45	17.32	11.31

DISCUSSIONS

Generally, if all pumps and fans will have blade/ vane pass frequency (VPF) Peaks that is (no. of impeller vanes * running rpm). The analysis pattern will be carried by considering flow Parameters, suction and discharge pipe lines for clogging of foreign materials or any bed/patch formation in Vanes that cause obstruction to pump to carry out its performance. This phenomenon includes severe side Bands having hump/raised in noise (like rattling/churning at discharge side, growing type at suction) at VPF due to non-uniform function/rotation of impeller. Best Efficiency Point of Impeller has not maintained caused cavitation in the Impeller vane which tends to change the Natural frequency of impeller, which may cause to amplify the signal with natural frequency of the pump Casing/ Pump causing resonance and Vane Pass Frequency Vibration Caused by movement of each blade in the Pump. Each time blade passed an arbitrary Point on pump generating vibration at vane passes frequency (Damaging the impeller Blades). Load on pump directly changed the amplitude of Vane Pass Frequency can Block suction or discharge. By Generating raise in noise floor which lead to catastrophic failure.

Effect on Production

Production before cavitation when pump is running condition. No Stoppage -Before Cavitation

Table 3 Production Description

Description	**Unit**	**#**
Production	TPH	330
Pump Running	Hrs	24
Pump Down Time	Hrs	0
Total Production	Ton	7920

Total production is 7920 ton.

Estimated Planned Stoppage -After Cavitation

Table 4 Production after cavitation

Description	**Unit**	**#**
Production	TPH	330
Pump Running	Hrs	4
Pump Down Time	Hrs	20
Total Production	Ton	1320

Total Estimated Production loss –66%

In order to prevent major breakdown we have to take planned stoppage to rectify cavitaion problem. In case will not take planned stoppage, will have direct production loss around 2 days and also very unsafe from safety point of view.

CONCLUSIONS

Therefore, cavitation must by all means be prevented. To prevent cavitation in a pump we have to know the beginning and development of the cavitation process in the pump. For this purpose cavitation can be detected by visual examine, noise (Crackling or sizzling sound in pump) and through vibration measurement. With the appropriate implementation of vibration and noise diagnosis techniques, pump scan operate with higher liability and efficiency. Vibration analyzer meter is used to measure the vibration in pump. In comparison with the other methods, this vibration analysis method using spectrum in the detection of cavitation phenomena are very fruitful, economical, easy and user-friendly.

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