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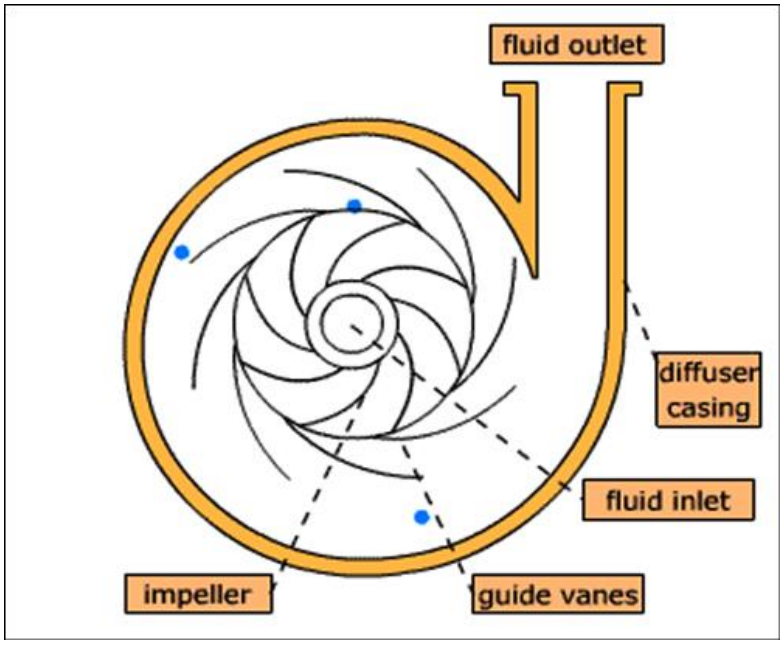
Pump Cavitation: Damage and Causes

Pump Cavitation

A centrifugal pump is designed as a hydraulic machine to move liquids. Cavitation (or entrained gas) causes problems in pump performance. Experiments claim that a volume of only one per-cent air will cause a loss of head and efficiency. Pump cavitation can severely damage the pump impeller blades and frequent dry running of pumps can damage other pump parts.

Pump cavitation is the formation and subsequent collapse or implosion of vapor bubbles in a pump. It occurs when gas bubbles are formed in the pump due to drop in absolute pressure of the liquid below vapor pressure. These gas bubbles occupy space inside the pump and affect the pump's operating pressure and flow. With vapor bubbles in the *low-pressure* zones of the pump, the motor's energy is wasted *expanding* the bubbles instead of bringing more liquid into the pump. As the bubbles pass into the pump's *high-pressure* zones, the motor's energy is wasted *compressing* the bubbles instead of expelling the liquid from the pump. The bubbles can collapse as they pass from low- to high-pressure zones in the pump. When vapor bubbles collapse inside the pump, the liquid strikes the metal parts at the speed of sound. The noise generated from these collisions of gas bubbles into the metal parts of pump sounds like pumping marbles and stones.



Damage to Pumps Caused by Cavitation

DAMAGE TO THE PUMP MECHANICAL SEAL

Mechanical seals are very important in any pumps as they prevent any foreign materials from entering into the pump casing which may cause the pumped liquid to escape into the environment. Any damages that may occur to the mechanical seal may increase operating cost and consumption of natural resources. Cavitation can badly affect the performance of the mechanical seal as it will cause damage to the seal faces and if the cavitation phenomena continues, the seal may run dry without continued cooling or lubrication.

DAMAGE TO PUMP SHAFT ALIGNMENT

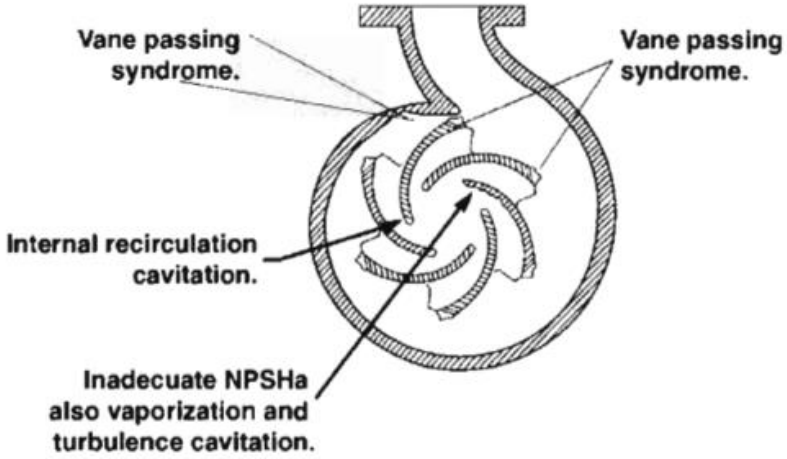
Shaft misalignment can occur after pump operation due to many reasons, but the most important one is vibration and expansion of the pump shaft due to heat generated in the pump as a result of cavitation.

DAMAGE TO BEARINGS

The bearing life will decrease significantly due to the vibration of the pump shaft which will be transmitted from the pump casing to the bearing housing. The vibration cause the balls and rollers to jam into the raceways causing very small bents. The raceways will begin to look like a corduroy cloth.

DAMAGE TO THE PUMP IMPELLER

When pressure in the eye of the impeller falls below the vapor pressure of the fluid, then cavitation can begin and gas bubbles are formed. The bubbles can collapse (implode) as they pass from low- to high-pressure zones in the pump. When vapor bubbles collapse inside the pump, the liquid strikes the metal parts at the speed of sound. The noise heard from outside the pump will sound marbles or rocks rattling inside (also called “water hammer”). The force of these shockwaves can indent or “pit” the impeller over time.



Causes of Pump Cavitation

DROP IN PRESSURE AT THE SUCTION NOZZLE DUE TO LOW $NPSH_A$

If the fluid at the pump suction is not available sufficiently above the vapor pressure of the 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

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

INCREASE IN THE FLUID VELOCITY AT PUMP SUCTION

An increase in fluid velocity at the pump suction can typically be caused by higher liquid flowrates than the design case. As per Bernoulli's principle, higher liquid velocity means lower pressure head. Frictional pressure drop in the pump suction also rises with the rise in the flowrate, 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 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 the 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 ($NPSH_R$). If the pump is not selected properly, $NPSH_A$ might fall below this $NPSH_R$ limit, causing cavitation.

Credit

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