Run Times

LAWRENCE PUMPS INC.

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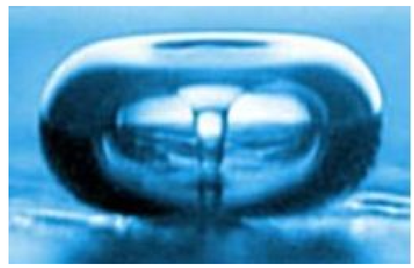
The engineer receives a report that a pump is vibrating and sounds as though it is pumping ball bearings. The discharge pressure and power are both unsteady. The operators believe that the pump is cavitating, – but is it really?



Cavitation is certainly a possibility that would fit all of the symptoms described. Another possible culprit however, is gas entrainment. Because the symptoms are so similar, many use the term cavitation interchangeably for both inadequate NPSHA[1], and the presence of non-condensing gases in the inlet fluid stream. The mechanics of each are quite similar. Cavitation is the rapid formation and collapse of vapor bubbles that occurs whenever the local absolute pressure of a liquid falls below its vapor pressure. Vapor bubbles form in low pressure regions of an impeller inlet when a portion of the pumped liquid vaporizes. Cooling and re-pressurization results in a rapid and violently implosion of the vapor bubble, usually against an adjacent impeller surface. Subsequent noise, vibration, and erosion of material from the impeller surface is the result of these vapor bubble implosions.

Whereas cavitation manifests itself as a function of localized suction pressure at the pump inlet, gas entrainment involves non condensable gas bubbles that are already present within the fluid stream approaching the pump. When gas enters a centrifugal pump, centrifugal force will work to separate the much denser liquids from the entrained gas. If easily separable, as is often the case with free air in water, the liquid will move radially outward leaving the gas to collect at the impeller eye. The gas collecting at the pump inlet will restrict flow onto the impeller and often will cause a sufficient pressure reduction at the impeller blade inlet for cavitation to occur, even though the pump appears to have sufficient suction pressure.

When a gas liquid mixture is able to be pumped by an impeller, a centrifugal pump will usually evidence reduced performance. Any centrifugal pump impeller turning at a given speed will produce a certain amount of head. This is true whether the impeller is handling liquid, gas, or a mixture of the two. Most impellers designed to handle liquids do not make a very useful compressors. The amount of pressure that will be developed is directly related to the density of the media pumped. An impeller that will develop 100 m (325 ft) of head will develop 9.66 bar (140 psi) pressure handling water at 15^{o} C., but will only develop 11.6 kPa (1.7 psi) of air pressure at the same 100 m (325 ft) of head.

[1] Net positive suction head available – The absolute suction pressure minus fluid vapor pressure at the impeller eye.

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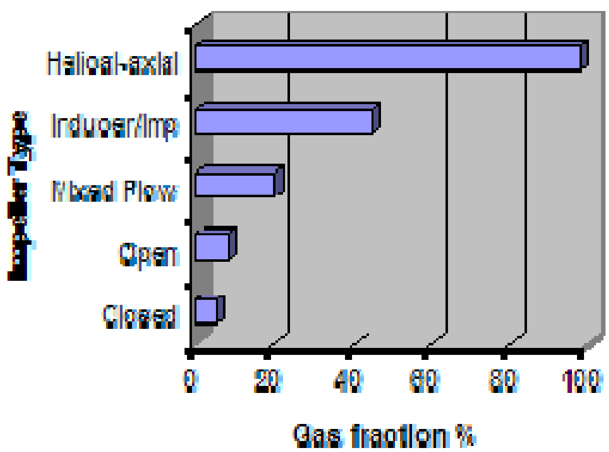
Any gas fraction present in the liquid will immediately manifest itself by a drop in discharge pressure relative to the density ratio and gas fraction present.

The amount of gas that any centrifugal pump can handle is usually limited to about 10% maximum. The performance of centrifugal pumps handling gas/liquid mixtures is not accurately predictable beyond very low gas fractions. The factors that affect a pump's ability to handle gas/liquid mixtures include: relative densities of the gas/liquid mixture, bubble size. bubble distribution, viscosity, pump type, and RPM.

The symptoms of cavitation and gas entrainment are very similar often making them difficult to diagnose properly. If the NPSH required by the pump is reduced at lower flows, restricting the discharge valve may quiet a cavitating pump. Also, injection of a small amount of non-condensable gas such as air or nitrogen near the pump inlet will often quiet a cavitating pump. The compressible gas bubbles act to cushion the shock waves produced by the vapor bubble implosions. Perhaps, the best way to differentiate between cavitation and gas entrainment is a close examination of the system. If the NPSH margin should be significant then gas entrainment should definitely be suspect.



Much work has been done in recent years to develop pumps for handling gas/liquid mixtures. Twenty-five years ago it was not generally thought possible to handle gas fractions much higher than 10-15% with centrifugal pumps. In recent rears some specialized rotodynamic pumps have been designed to handle mixtures approaching 100%. Performance predictability at high gas fractions is still largely derived from empirical data and these products are generally engineered to order.