CAVITATION OR NOT....?

by Ross Mackay

To Cavitate or Not to Cavitate, that is the question!

In a previous article where we discussed NPSH, we left you with a question;

> ".....is this really cavitation I am dealing with,
> or is it air entrainment or recirculation?"

The reason for that question is that all three conditions have almost identical symptoms. Air entrainment and recirculation will also cause the same rumbling/rattling noise and high vibration as cavitation, as well as the recognizable impeller pitting damage.

The major difference is that cavitation is an NPSH problem, while the other conditions have nothing to do with the suction pressure or NPSH.

Consequently, the supply of additional NPSH to the inlet of the pump will make no difference to the symptoms, thus causing considerable confusion for the unwary.

Let's Get Practical! What are these confusing issues, how do we recognize them, and how do we fix them?

Air Entrainment

Air entrainment defines a variety of conditions where the vapor bubbles are already in the liquid before it reaches the pump. When they arrive in the eye of the impeller, exactly the same thing happens as if they were created at that point. In other words, they are subjected to the increasing pressure at the start of the vanes and are then imploded, causing the identical damage as cavitation, and at the same location.

This condition can often be a result of pumping fermenting liquids or foaming agents found in a wide variety of industries. It can also be a result of pumping a liquid, such as condensate, that is close to it's boiling point.

However, air entrainment is most frequently caused by turbulence in the suction line, or even at the suction source. For example, the kind of conditions identified in Fig. 1, will cause turbulence in the suction tank that will entrain vapor bubbles into the line leading from that tank to the pump suction.

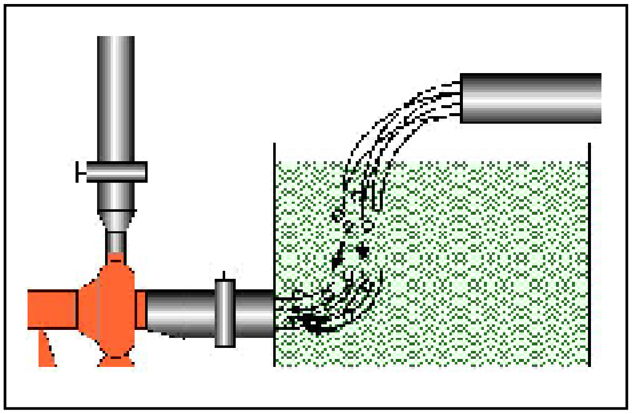

Figure 1

A similar condition can occur if the pump is drawing suction from a tank in which an agitator or fluid mixer is operating.

These problems can frequently be minimized by the use of appropriate baffles in the tanks, if such a condition is feasible.

Turbulence in the suction lines to a pump can also be created by using too many twists and turns in the line. Even one elbow located directly onto the suction flange of the pump can create enough turbulence to cause air entrainment. If there are two elbows close to each other in the suction piping, and they are in different planes, the liquid will exit the second elbow in a swirling fashion that will cause considerable turbulence. This, in turn, will create an air entrainment problem for the pump.

To cure this problem, refer to Rule No. 1 from our earlier article on "The Pitfalls of Pump Piping" which identified that the inlet piping should.....

> ".....provide the suction side with a straight run of pipe, in a length equivalent to 5 to 10 times the diameter of that pipe, between the suction reducer and the first obstruction in the line."

This will ensure the delivery of a uniform flow of liquid to the eye of the impeller and avoid any turbulence and air entrainment.

As air entrainment causes the same pitting damage to the impeller in precisely the same location as cavitation, it can be a little confusing, particularly as both can occur simultaneously in the same service. However, a quick comparison of the NPSHA and NPSHR, combined with a visual review of the piping characteristics will usually help identify the root cause of the so-called "cavitation" and solve the air entrainment problem.

Suction Recirculation

This condition causes pitting damage about halfway along the vanes, and results from a variety of hydraulic conditions that manifest themselves when operating the pump at a flow rate that is too low.

Unfortunately, the flow rate at which this occurs is imprecise as some investigations have identified frequent occurrences at flows lower than 30% of the B.E.P., while others have it tagged as high as 80%. Without delving into the theoretical models involved, the practical result appears to be that the flow patterns double back on themselves. It is also worthwhile to note that it seems to happen independently of the pump suction pressure.

In a nutshell, suction recirculation happens when the pump is operating at low flows, and the pitting damage takes place about halfway along the vanes.

Discharge Recirculation

Discharge Recirculation is a very similar occurrence that results in pitting damage at the tip of the vanes and sometimes at the cut-water of the casing. It too seems to be caused at low flow rates.

Similarities and Differences

Cavitation, Air Entrainment and Recirculation all result in pitting damage on the impeller caused by the formation and subsequent collapse of vapor bubbles. The difference between them lies in the method by which the bubbles are formed and the location of their resultant implosions as shown in Figure 2.

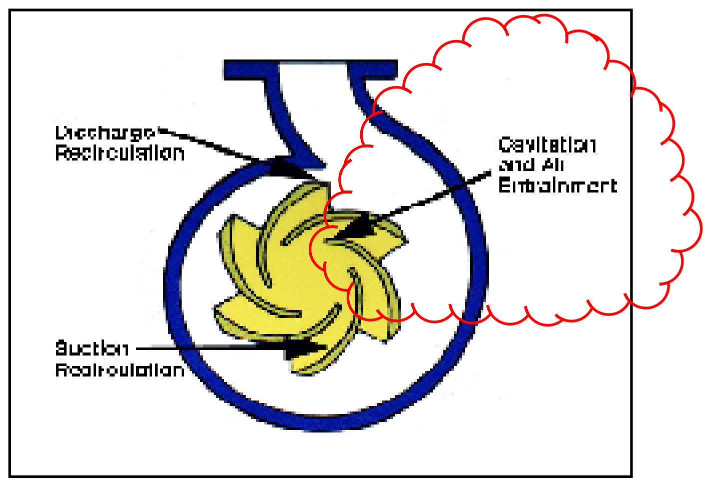

Figure 2.

As the severity of all these conditions increases, the noise, vibration and impeller damage will also increase. Under severe conditions, the pitting damage will spread throughout the impeller and may also extend to the casing.

Cavitation, Air Entrainment and Recirculation - although they share some similar symptoms - are completely unrelated and are caused by three separate conditions. As a consequence, they can easily be diagnosed incorrectly.

Cavitation is caused by low suction pressure, and can be cured by increasing the net positive suction head available.

Air entrainment is most frequently caused by a poor suction design arrangement and can be cured by correcting that layout.

Recirculation is caused by running the pump at too low a flow rate, and can be cured by increasing that flow.

Logically, we can recognize that, in some cases, financial or process conditions are such that none of the cures for these conditions are possible. When this happens, the final option is to live with the problem and minimize the effect of the symptoms. This means limiting the damage to the impeller and reducing the effect of the vibration.

But the biggest problem in all this is to identify which of the three conditions we are faced with when the common symptoms of noise and vibration are experienced. To accomplish this, the throttling of the discharge valve reduces the flow and creates three possible scenarios.

1. The noise and vibration will grow quieter and perhaps even die away completely.

2. The noise and vibration will get worse.

3. Little or no difference is experienced.

With the first result, the pump is now operating at a lower flow that requires a lower level of NPSH, and the quieter, smoother operation identifies that Cavitation is being eliminated.

If the noise and vibration gets worse, it tells us that the pump is moving into a worsening condition of low flow which demonstrates a problem with Recirculation.

When little difference is experienced, that indicates an Air Entrainment problem that is not immediately susceptible to changes in flow rate.

In conclusion, just because the symptoms are familiar, does not mean that we are experiencing Cavitation, it could easily be one of the other similar conditions. All we have to do is identify which of the three are showing up, and the cure becomes more evident.

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