CAVITATION

WHEN BUBBLES DON'T BRING CHEER

CAVITATION CAN NOT ONLY RESULT IN SERIOUS MECHANICAL DAMAGE TO BREWERY PUMPING SYSTEMS, THE BUBBLES AND FOAM IT PRODUCES CAN HAVE A SERIOUS IMPACT ON PRODUCT QUALITY. BRITH ISAKSSON, ABB GLOBAL SEGMENT MANAGER FOOD & BEVERAGE, OUTLINES THE CAUSES OF CAVITATION AND EXPLAINS HOW THE LATEST VARIABLE SPEED DRIVES OFFER AN EFFICIENT AND COST-EFFECTIVE METHOD OF PREVENTION.

Cavitation is one of the most potentially troublesome issues that can occur in pumping systems used in the brewing industry to transport raw and finished liquid products, as well as water and cleaning solutions.
Not only does it reduce the life of equipment, requiring expensive maintenance and replacement, it can also damage the beer being pumped, through the formation of bubbles or foam.
It is even possible that a whole batch of beer that has taken weeks or even longer to brew might foam to the point where it has to be discarded.

Cavitation can occur when the pumping system subjects a liquid to rapid local changes in static pressure, creating bubbles or voids.
The point when this liquid-to-bubble transition occurs is when the pumped liquid falls below its vapour pressure. For example, at normal atmospheric temperature, liquid water turns into water vapour (steam) at its 100°C boiling point. But as the pressure is reduced, then so is the temperature at which the vapour point occurs. The transition can even occur at room temperature should the pressure fall to a vacuum.
In addition to water, the same transition applies to other fluids pumped in the brewing process, such as wort, the finished beer and clean-in-place (CIP) solutions.

As the impeller spins in a brewery's typical centrifugal pump, high pressure is created on the front side of the blades. At the same time, there is low pressure on the back of the blades. In some conditions, the liquid vapourises, creating bubbles as shown in Figure 1.
When these vapour bubbles reach areas of high pressure, they collapse. The implosions produce significant shockwaves. This creates a characteristic rumbling or cracking noise that sounds like rocks passing through the pump.

The cumulative effect of many tiny implosions can over time have a significant impact on the pump performance.
Cavitation will eventually damage the pump impeller, housing and other pumping system components through wear and metal surface fatigue.

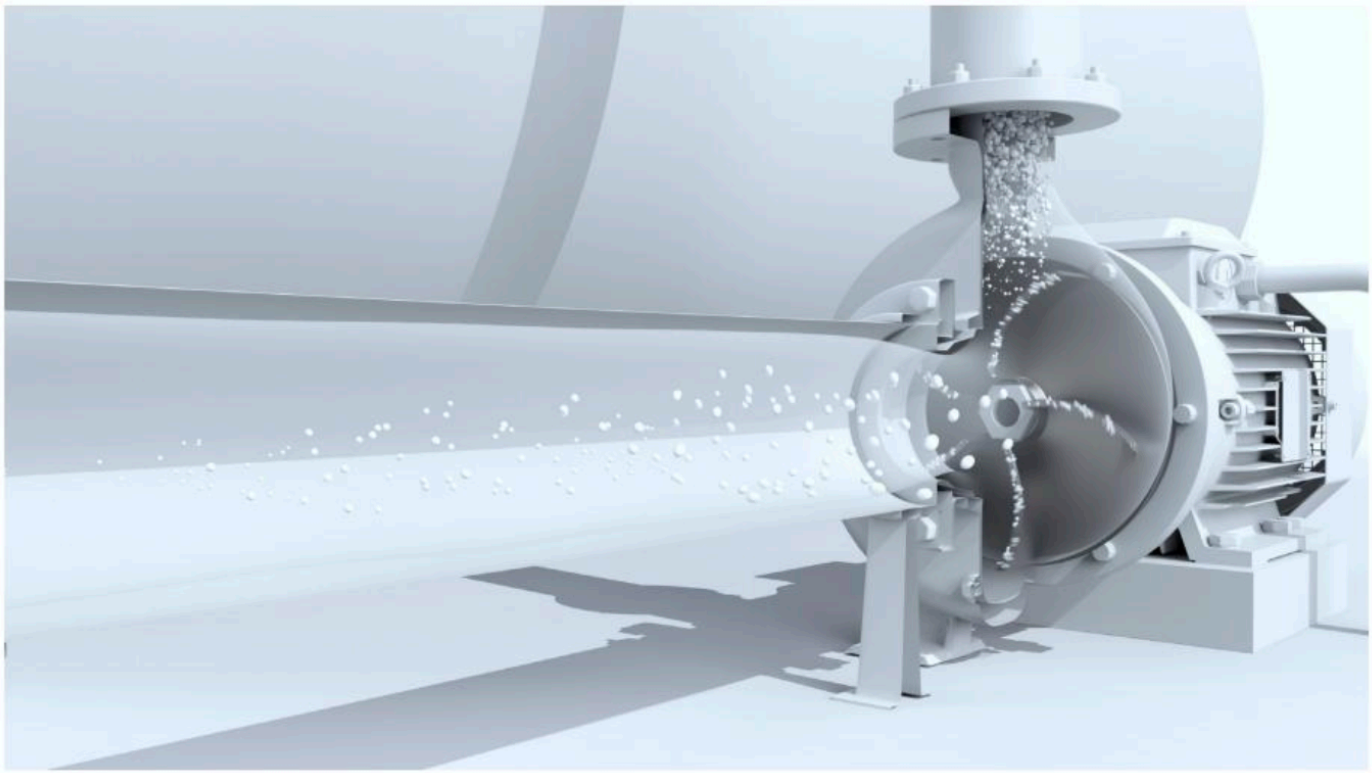
It is known for cavitation to reduce pump life by as much as 50 percent. In the most extreme cases, cavitation can destroy a pump in minutes.
Since surface fatigue causes metal particles to be released from the impeller blades, the beer safety and quality can also be put at stake.

OPEN PUMPING SYSTEMS ARE AT RISK OF CAVITATION

Closed loop pumping systems, such as those used generally to circulate water for heating or cooling, are not normally at risk of cavitation. This is due to their setup that prevents rapid local changes of pressure, unless there is leakage.

In contrast, the open pumping systems that are used to transport liquids around a brewery are subject to cavitation should the inlet pressure drop below the Net Pressure Suction Head (NPSH) – see Figure 2. The NPSH, which is quoted in meters or feet, is a measure of the pressure experienced by the fluid on the suction side of a centrifugal pump. The value of the NPSH is volume dependent and stated by the pump manufacturer as a specific value for each pump.

The inlet pressure to the pump will decrease as the level in the break tank decreases. This could lead to a situation



Above: Figure 1, Cavitation occurs when the liquid in a centrifugal pump starts to vapourise and create bubbles

where the inlet pressure drops below NPSH for the specific pump, and the result will be cavitation. There is generally no risk of cavitation if the inlet pressure stays above the NPSH requirement.

Good design of the pumping system is a first step in avoiding cavitation. It is especially important to ensure that the available NPSH exceeds the required level.
This can be achieved by decreasing the number of elbows and valves in the inlet pipework, shortening the length of the pipework, or increasing its diameter. Reducing the temperature of the fluid or pump can also help, although this may not be desirable or practical in brewing applications.

In some cases, it will not be possible to implement the optimum design, especially when working with existing systems or where space is at a premium. Therefore, designers need to look at ways at detecting the onset of cavitation and modifying the pump operation accordingly.

One possibility is to use discrete sensors such as differential pressure transducers to monitor the changes in pressure that accompany cavitation. However, there is now a more cost-effective and straightforward option.
That is to use the extended capabilities of the new generation of intelligent variable speed drives (VSDs) already used widely in many pumping applications across the food and beverage industry.

In addition to the benefits of energy efficiency, some VSDs, such as ABB's industrial drives, now incorporate anti-cavitation software. This makes it possible to prevent cavitation without the additional cost and complexity of external sensors and controlling with PLCs.

USING AN INTELLIGENT VSD

Algorithms that measure pump torque and speed are incorporated into the dedicated anti-cavitation software. This enables the VSD to monitor the pumping process constantly for the specific patterns that indicate cavitation is taking place.

There is no latency in detection because the measurements are taken directly from the pump shaft. That means the response is virtually instantaneous. When it detects cavitation, the VSD

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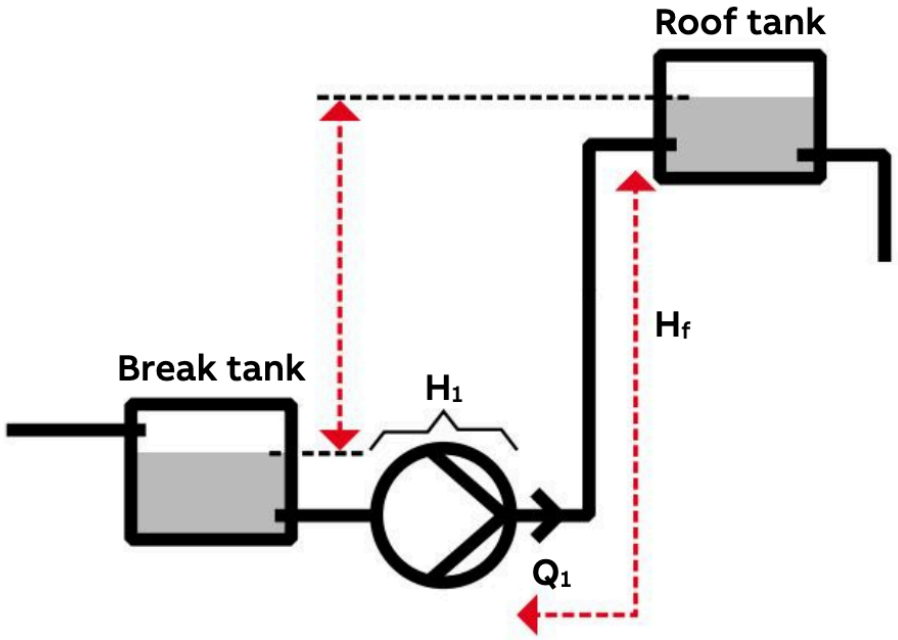

Left: Figure 2, Cavitation can occur in open systems when the inlet pressure drops below NPSH for the specific pump.

Pump cavitation is a significant risk for the brewing industry. If it takes place it can damage the finished product, cause significant disruption to pumping operations and may even require pumps to be repaired and replaced at significant cost.

With the new generation of intelligent VSDs, brewers can solve cavitation issues locally, within the drive, in real time. The built-in anti-cavitation software means no extra components such as sensors and additional PLC controls needed.
The only additional work required is to set the operating parameters. The result is precise, instantaneous control that keeps pumping systems operating with maximum efficiency and reliability while preserving the quality of the finished product.

adjusts the pump speed automatically to react to the change in pressure. It will then resume normal operation as soon as the pump has stopped cavitating. Anti-cavitation operation is especially beneficial for the brewing industry as it enables liquids to be pumped at the optimum flow rate. While at the same time, the pump can adjust automatically and immediately to any change in the flow or draining vortex which might cause cavitation to occur. For example, this enables a tank to be pumped out quickly and efficiently, right to the bottom, without causing bubbles and foam that damage product quality.