Conquering cavitation

Axel Jäschke, director, advanced technology, CIRCOR looks at the role of information technology in managing pump cavitation

NPSHa and NPSHr. These acronyms incite confusion and fear in the hearts of storage terminal operators everywhere. Achieving a balance between them is essential to avoiding the problems caused by pump cavitation, and scholarly volumes have been written over many decades about managing this persistent phenomenon. But is cavitation necessary?

THE CULPRIT

Cavitation starts when a fluid's operational pressure drops below its vapour pressure. Vapour bubbles form in the fluid (this is called flashing and no system can prevent it entirely), which is now a two-phase flow and has a higher volume. As the pressure increases inside the pump, the vapour bubbles can implode with destructive high energy pulses in local areas. This is cavitation. For a storage tank terminal, cavitation problems translate into unacceptable process inefficiencies having direct effects on OPEX and, eventually, CAPEX.

The traditional solution to this has been simply to design the system for the worst-case scenario and ensure that NPSHr (net positive suction head required by the pump) is always lower than NPSHa (net positive suction head available) at pump inlet. One approach is to oversize the pump and run it slower, which typically will lead to a lower pressure drop inside the pump and a lower NPSHr, but higher CAPEX and operational cost.

However, today's storage terminal pumping systems must accommodate a wide operating range and many different products. And so – whether it be tank level, fluid temperature, density, viscosity and shear rate, or atmospheric pressure – at certain flow rates and combinations of these variable operating conditions, NPSHa will be less than what it should be to avoid cavitation inside the pump entirely.

Positive displacement two-screw pumps are inherently more flexible when process conditions change compared to centrifugal pumps. They are more reliable and predictable in operation with minimal sensitivity to gas content and fluid properties. Pump flow rate is linear related to the pump speed, and the differential pressure is independent of viscosity, density, gas content and speed. Vapour bubbles are distributed across the fluid volume, travelling into and through the screw chambers towards pump discharge, while the appropriate slip-flow design slowly pressurizes the fluid, causing the flashing bubbles to collapse slowly in a controlled way without harming the pump.

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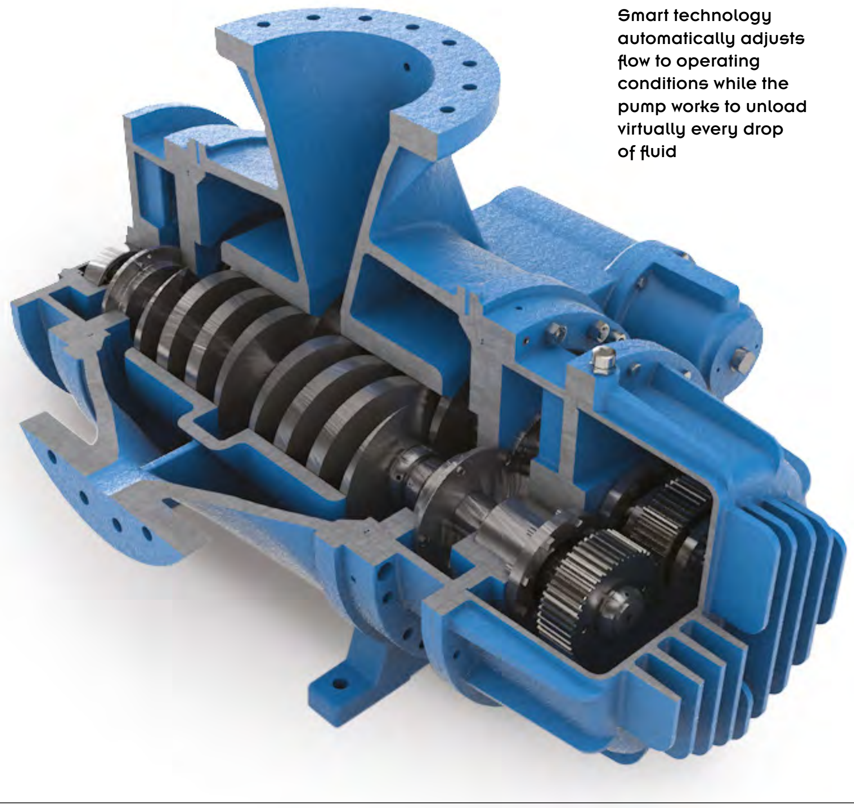

Smart technology automatically adjusts flow to operating conditions while the pump works to unload virtually every drop of fluid

CONVENTIONAL SOLUTIONS

A more flexible and efficient way to manage cavitation is adjusting pump capacity to system conditions. This allows new incoming products with different fluid properties to be handled without risk and average loading/unloading time accelerated, because the pump

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can operate at the highest possible flow rate instead of the one worst-case flow rate. There are several ways of achieving this and depending on the assumptions made, the end result is that the pump can operate at higher speed as long as the liquid level inside the tank is high and the ambient temperature is warm. Otherwise, it must be slowed down when the tank level is lower, the fluid is getting more viscous or the ambient temperature is very low.

Calculating safe operating speed can be done with a pump controller that integrates applicable process parameters (tank level, barometric pressure, fluid temperature), along with pump and pipeline curves and fluid information provided by the customer. The vapour pressure of the fluid is typically known and is the basis of the correct calculation. Additional information like pump inlet and discharge pressures are used to correct the pump speed continuously while in operation. All control systems will protect the pump and slow down or stop the pumps on these standard variables. If, however, any of the supplied values on the standard variables is inaccurate, the solution will not be effective.

Once flow is stabilised, it can stop the pump automatically when detecting gas

ADVANCES IN DETECTION AND AVOIDANCE

What if cavitation was actively controlled, using simple and reliable pressure sensors on the pump inlet, pump discharge and the screw chamber to detect and directly measure cavitation and the increasing presence of gas inside the pump? What if this method required no information about pipelines or fluid properties to do the job and no human attention to tank levels, fluid viscosities and wrong valve settings?

How can this be possible? The reason is that when pumping pure liquid, the pressure build-up along the screw length is linear. Operating with gas content or at increased cavitation will change this pressure build-up profile. This can be measured, analysed and used to change the pump capacity to avoid problematic cavitation – independent of fluid properties, tank level, pipeline setup or ambient conditions.

The pumping industry has innovated smart solutions which, when combined with a twin-screw pump, can go much further, providing information about the pump's exact capacity and fluid viscosity, for example. The smart technology automatically adjusts flow to operating conditions while the pump works to unload virtually every drop of fluid. In real time, the technology is measuring cavitation directly from inside the pump, eliminating the need to collect and calculate external parameters as fluid characteristics change.

Once flow is stabilised, it can stop the pump automatically when detecting gas or after having pumped the requested fluid volume. Any significant pressure reductions at the pump suction during stripping are met with an automatic slowdown of the pump motor. The result: speed, efficiency, predictability and improved pump lifetime – and savings on CAPEX and OPEX by using state-of-the-art cavitation control technologies.

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