Detecting Pump Cavitation with a Vibration Sensor

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Cavitation is a destructive condition that can destroy the inside of a pump before you even realize it is occurring. Early detection can minimize damage, reduce downtime, and save money. Cavitation involves the creation of bubbles formed when the fluid being pumped vaporizes due to a decrease in pressure as the fluid enters the pump. These bubbles are then acted on by the pump impeller, causing them to implode.

As these bubbles (also referred to as *holes in the fluid*) collapse, a noise similar to a ball peen hammer hitting sheet metal can be heard. This action begins to erode the inside of the pump. Left unchecked, the pump will eventually fail. Cavitation can be prevented if the head at the suction end is higher than the vapor pressure head of the fluid. While this is the design goal, process variables can cause a loss of head which, in turn, causes cavitation to occur.

The collapse of the bubbles is a violent process that creates an impacting action inside the pump. This impact excites high frequency resonances in the pump structure. Since these high frequencies are outside the normal range of pump operating frequencies, a special sensor was developed, tuned to these higher frequencies.

This acceleration, true peak detection, frequency banded vibration sensor is sensitive only to those frequencies normally excited during cavitation. Motor and pump 1X and vane pass frequencies are excluded from its measurement. This loop powered sensor provides a 4-mA to 20-mA output signal proportional to the sensed vibration level. A 4-mA to 20-mA output sensor was selected because process control systems, such as a PLC or DCS, readily accept this type of input, and alarm limits can be set.

To prove its effectiveness, a pump manufacturer set up a controlled test by mounting the sensor on a positive displacement pump. The pump was brought up to speed at 359-rpm. A vacuum pump attached to this pump's input provided the means of controlling the input head of the test pump.

As the pump started, the sensor monitored the high frequency vibration signals, represented in Figure 1 by the section of the graph where the vibration level is just above the 4-mA level.

The input pressure was then decreased. The pump began cavitating. An immediate rise is seen in the graph because the sensor recognized the "ball peen hammer effects" generated inside the pump as head pressure decreased and cavitation started. Since high frequency signals tend to attenuate

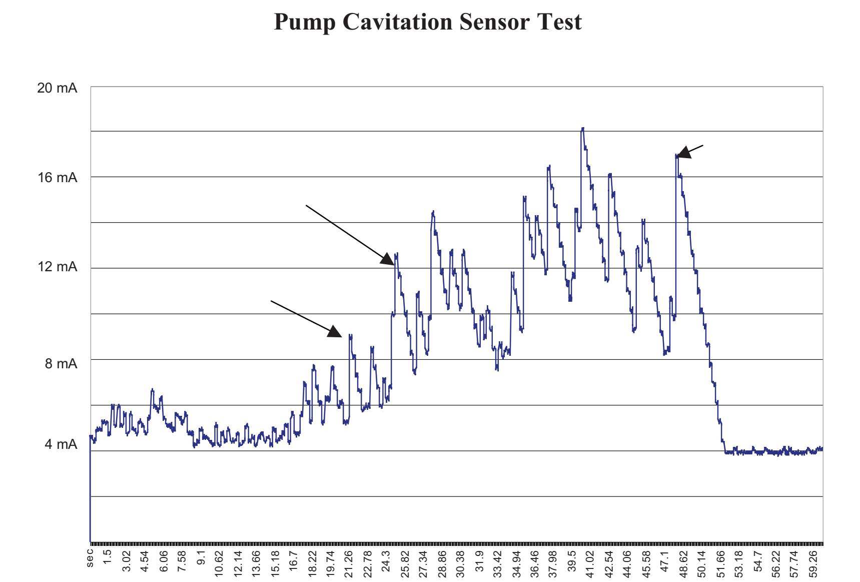

Figure 1. Pump cavitation sensor test results.

after short distances in mechanical structures, there is very little influence from nearby machinery. Thus, there is little concern that the signal is being generated from another piece of equipment.

The peak detection circuit inside the sensor aids in rapidly responding to an increase in the vibration amplitudes in the frequency region associated with cavitation. Using a long time constant on this peak detection circuit helps to hold these peak levels long enough to be recorded.

Had a normal vibration transducer been used, Figure 1 would not show any changes in amplitude as cavitation began because the running speed of the pump would dominate the vibration signal, effectively masking the change in the high frequency signal.

Since many pumps are located in remote locations or in locations not regularly frequented by plant personnel, the ability to accurately, quickly, and remotely sense a cavitation condition is important. If the 4-mA to 20-mA signal is output from the sensor and fed to a DCS or PLC, the loop powered sensor can be used to alarm an operator about an errant pump so corrective action can be taken before irreversible damage occurs.

Even if it is not possible to shut the pump down once cavitation is detected, the knowledge that it is occurring can be used by plant personnel. In some applications, such as food processing, this knowledge could affect the overall quality of the final product.

Another concern may relate to cooling requirements. Since pumping capacity reduces once cavitation begins, a plant operator armed with this knowledge may have to bring more pumps on-line in order to maintain minimum needs. The bottom line here is minimal cost; the operator can keep his equipment running efficiently, prevent costly repairs and possibly improve his overall process performance.

The complete data plot in Figure 1 shows the 4-mA to 20-mA loop signal output during the test run. Cavitation begins to appear at 21.26-sec. The pump is in full cavitation by 24.98-sec, before being manually shut down at 48.12-sec. The data indicates that the sensor detected initial evidence of cavitation at around 21-sec, when the vibration level first went above 8-mA, while easily detecting the presence of full cavitation at 25-sec. Normal pump running produced only a small increase in the vibration signal (0-sec to18-sec) and the sensor output returned to the quiescent 4-mA after the pump shut down.

It is interesting to note that had a normal vibration transducer been used, Figure 1 would not show any changes in amplitude as cavitation began because the running speed of the pump would dominate the vibration signal, effectively masking the change in the high frequency signal represented above.

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