Predictive Monitoring of Seal-less Pumps

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Abstract

In the past, spared critical machinery was automatically designed into plant expansions. With today's advancing technologies, it is becoming more economical to install unspared critical machinery.

To do so, a reliable method of condition monitoring must be implemented that is capable of accurately and consistently detecting conditions that lead to machinery failure.

Variances in process conditions can cause premature machine failure. In many cases, these failures are sudden and catastrophic. Conventional methods of periodic monitoring are sometimes not adequate to catch the sudden failure, and continuous monitoring protection systems are often difficult to justify due to their cost. A method must be used that is both economically implemented and that provides advanced signal processing and continuous monitoring.

Background

A major producer of petrochemicals required an effective method to monitor a large number of unspared magnetic drive ANSI pumps, on a plant-wide basis. They looked to SKF Condition Monitoring for a solution that could be applied in their facilities worldwide.

A test stand was available to reproduce the operating conditions most commonly found to cause damage and subsequent failures in these pumps. SKF Condition Monitoring's Mechanical Condition Monitors (MCM) were installed and tested on a Magnatex MAXP Model AA8 pump running at 3 600 RPM. The Mechanical Condition Monitor is a compact, single-point continuous monitor that measures ISO velocity and enveloped acceleration.

Previous industry experience suggested a high frequency detection method works best to detect the most common problems in these pumps. Based on this experience, two CMSS 672-ENV MCM acceleration enveloped modules with different filter options were tested.

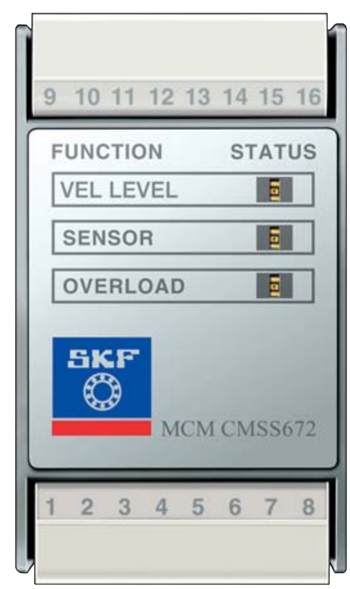

Fig. 1. SKF's CMSS 672 Mechanical Condition Monitors (MCM).

Seal-less pump theory

Seal-less pumps use a containment shell that completely isolates the internal shaft and impeller from the remainder of the pump and the environment. This allows the process fluid to be worked without the risk of seal failures. This is critical, since these pumps are typically used in applications where the fluid being worked is hazardous and requires containment.

There are two basic types of seal-less pumps: magnetic drive and canned motor. A magnetic drive pump uses a set of rotating magnets outside the containment shell to drive the impeller. A canned motor uses an electromagnetic field on the outside of the containment shell and a torque ring on the inside to drive the impeller. In both cases, the internal shaft runs on journal bearings that are lubricated and cooled by the process fluid itself, as this fluid completely fills the containment shell. This characteristic leads to the two most common root cause problems found on these pumps: cavitation and dry running. Both of these conditions affect the environment within the containment shell and can lead to damage to the internal bearings. Internal bearing damage typically results in pump failure.

The focus for monitoring these pumps should be the predictive detection of these operating conditions that can lead to pump damage, not simply detecting the damage once it has occurred.

Explanation of root cause problems

Dry running is the condition in which insufficient process fluid is available to the pump. This results in inadequate cooling and lubrication of the pump's internal bearings, and may cause catastrophic failure of the pump. If this condition is left unchecked, the time to failure may vary from as little as a matter of minutes to a number of hours.

Cavitation is the condition in which low pressure bubbles form and collapse within the process fluid due to mechanical forces and operating conditions. This condition also results in inadequate lubrication and cooling of the internal bearings and may cause catastrophic failure of the pump. Time to failure for seal-less pumps running with cavitation tends to be longer than that of dry running.

Test results

The MCM units were using two different filter options, the E66 filter option and the E88 (the F4 filter in the SKF Microlog, 5 to 40 k) filter option. Two series of tests were run to verify their effectiveness for this application. The first test involved varying pump flow rate to determine if this affected the enveloped acceleration level. **Fig. 2** illustrates the results of this test.

This test illustrated there is very little variation in the enveloped acceleration readings when flow rate is varied. Statistical analysis of this data reveals a variance equal to 11% of the mean for the E88 unit, and a variance equal to 6% of the mean for the E66 unit. This indicates an acceptably small variation in detection level when flow rate is varied.

Table 1 illustrates the results of the second test that involved a series of condition simulations at a fixed flow rate. This test was conducted to determine if the MCM would detect a change in the pump's operating condition. The E88 filter option showed a decrease to 35% of normal operation value under dry running conditions and an increase to 165% during cavitation. The E66 filter option showed a decrease to 41% of normal operation value under dry running conditions and an increase to 238% during cavitation. The simulations were of normal operation, dry running and cavitation. The values are averages based on repeated test runs and linear estimations of plotted data.

Fig. 2. Test results.

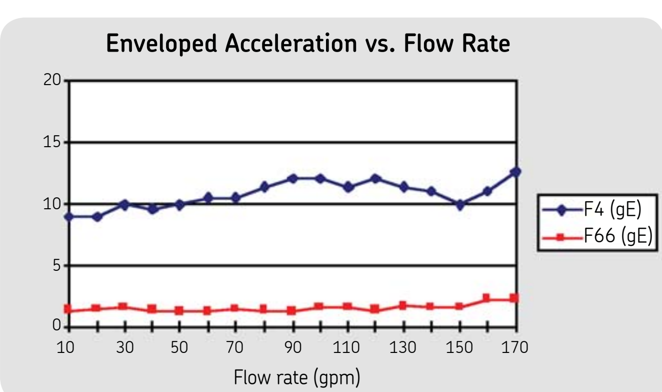

Table 1

Test results

Condition*	**MCM E88 (gE) (peak) Level**	**%**	**MCM E66 (gE) (peak) Level**	**%**
Normal operation	10,00	100	1,60	100
Dry running	3,40	34	0,65	41
Cavitation	16,50	165	3,80	238

* Normal operation and cavitation values are linear estimations based on plotted data. Dry running values are averaged values from repeated runs.

Summary

Effective predictive monitoring of seal-less pumps requires a method of continuous monitoring that detects the most common operating conditions that cause pump damage and failure: cavitation and dry running. Both tested MCM units were effective at detecting these two conditions and did not show any appreciable variation of output level with a varying pump flow rate. The ability of these units to interface with a plant's process control system adds to their versatility. MCMs may easily be implemented on a plant-wide basis for relatively low cost compared to other continuous monitoring/protection systems. Output signals of either 0 to 10 V DC or 4 to 20 mA DC proportional to the peak or average value of the enveloped acceleration signal can be directly interfaced to the process control system. Alarm setting and annunciation may be performed with the process control system.

It is recommended that a baseline be established for normal operating conditions prior to setting alarm levels. After baseline levels are established, a 50% increase from normal running conditions should be used to indicate cavitation. A 50% decrease from normal running conditions should be used to detect dry running. The analog/recorder output from the MCM is tied to the process control system for trending and alarming.

These units should be installed in field mounted junction boxes that include a 24 V power supply and pre-wired connections to a BNC panel for both a buffered acceleration output and an enveloped acceleration output. This enables periodic data collection with a portable FFT analyzer.

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