Troublesome mechanical seal problem solved

A centrifugal shear screen mixer had been a source of trouble since its installation in 1996. The main source of trouble appeared to have been associated with failure of the environmental controls of the mechanical seals. Classic signs of failure included heat checking of the seal faces, extruded PTFE “elastomer” wedges and worn drive slots and dogs in the carrier and seal face.

Various fixes had been attempted or advised by the mixer manufacturer, the original seal vendor, consultants, and alternative seal manufacturers. These fixes had included modifying the original seal environmental control, from a quench-to-drain seal plan supplying double, component type unbalanced seals, to a pressurised thermo-syphon system.

The seals in turn were modified to a silicon carbide/carbon face combination. A low-pressure alarm had also been installed to detect early pressure failure of the thermo-syphon system. Feed and return lines to the thermo-syphon were also replaced with smooth bore hoses in an attempt to improve the flow-rate and thermo-syphon effect.

Some site observations were:

The mixer was pressure fed from a constant displacement progressive cavity Mono pump.

The PRV of this pump was set to lift at 80psi, the PRV was originally believed set at 30psi.

When observed, the product pressure at the mixer showed a gauge reading of 20psi, a product temperature of around 20-30 degree C and the thermo-syphon tank had a temperature of between 50-60 degree C. There was a visible level in its sight glass.

No temperature differential had been detected across the feed and return lines of the thermo-syphon system, both legs of the system were at the same temperature as the tank. The barrier pressure in the thermo-syphon tank appeared to be approximately 45psi.

After investigating the system and stripping the mixer and seal assemblies down, the conclusions reached were that the pusher seals of the generic type fitted to the mixer (T109/MO1/59U) generated significant amounts of heat (partially due to the seals being hydraulically un-balanced).

This was especially when used in a double configuration in a seal chamber with a restricted radial clearance. The silicon carbide/carbon face combination also generated more heat than a ceramic/carbon combination. The spring pressure acting on each seal was found to be around 1.37bar (20psi). This was in addition to the barrier pressure of around 3.1bar (45psi) giving a force acting on each seal face of 30kg (68lb), however the inner seal pressure was eased slightly by the product pressure attempting to lift the inner seal faces.

It could be seen that a face combination with a higher coefficient of friction and an increased face loading due to high barrier pressure would generate significant amounts of heat. This heat should in theory, and commonly in practice, have been able to be dissipated by an efficient thermo-syphon system.

The thermo-syphon tank appeared to hold around 4-5 litres and as such would probably have heated up fairly quickly. It would follow therefore that the surface area of the tank was also relatively small and would thus radiate less heat than a larger tank. The lack of temperature differential across feed and return lines indicated that no flow was actually taking place, and that heat was travelling up both lines by conduction into the tank.

As the feed and return lines had been changed for smooth bore versions and the lines had no horizontal legs, bends or kinks and travelled in a constant vertical manner it was not likely that the lines were restricting the flow. Examination of the ports at the seal chamber showed a tortuous route from the seal chamber to the upper connection, and a tangential lower connection to the seal chamber.

It would seem that the reasons for failure were that the operators ignored the low-pressure alarm of the pressurised thermo-syphon tank. This was because there was no remote stop/start at the control room, or any automatic safety trip. At alarm condition an operator would have to make a journey to the machine to switch it off.

What the operators did to defeat the alarm was to leave the regulated air supply to the thermo-syphon tank permanently on. Unfortunately what subsequently happened was that the liquid level in the tank dropped through normal use, the mechanical seals then failed due to high face loading and temperature (dry running) and of course the alarm didn't sound. The first any one knew of a problem was a large leak of sticky black product all over the factory floor.

I decided that it was necessary to get back to basics and look at the sealing system from the original specification. I found that a double mechanical seal was specified because it was felt undesirable to have a leak to the floor. It being more preferable to have any leak going into the product, hence the pressurised system. However because of the frequent failures it was obvious that they were putting up with external leakage anyway. Further investigation showed that this specification was purely for aesthetic reasons.

The system was designed to have a duty and standby mixer, the standby was available but had never been installed.

My recommendations were:

To remove the pressurised thermo-syphon system and install a larger capacity atmospheric-pressure thermo-syphon system holding approximately 20 litres. Discard the thermo-syphon pressure alarm as redundant.

Manufacture a new mechanical seal chamber to accept a 1.5" modular double mechanical seal. This is hydraulically balanced, and the seal faces will see little more than spring pressure loading. Revise the routing of the feed and return line connections through the seal chamber to improve the flow characteristics

Connect the thermo-syphon tank via a float-operated valve to a water supply to enable automatic topping up.

Re-set the PRV of the progressive cavity supply pump to 30psi

Removing the unbalanced mechanical seals and replacing them with a hydraulically balanced cartridge system removed the source of loading and heat.

This enabled the small pressurised thermo-syphon system to be removed and a larger atmospheric pressure tank to be fitted. Heat generation at the seal faces was drastically reduced and the tank temperature has dropped to approximately 30 degree C.

Mechanical seals have remained in service for 8 months, previous MTBF being 10 weeks. Operator intervention other than initial start-up and shutdown after batch production is not now required.

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