Optimizing MTBM and MTBF in unloading stations through the use of magnetic drive pumps

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Simplified unloading stations with specialized sealless magnetic drive centrifugal pumps to increase reliability, ruggedness against wrong operation and thus vastly improve Mean Time Between Maintenance (MTBM) and Mean Time Between Failure (MTBF).

More and more customers use Klaus Union Magnetic Drive Pumps for applications, where traditionally mechanical sealed pumps have been used. This is driven by an effort to improve MTBF and MTBM of existing installations.

Typically unloading stations offer a variety of challenges to the lifetime of the installed pumps. Most of these challenges result from the attempt to empty the tanks as much as possible (ideally completely or almost completely stripping the tanks) and from using the same pumps for a wide variety of products. The first objective – emptying out the tanks as quickly and as completely as possible – can lead to the pumps operating in cavitation during the end of the process and potentially even dry running conditions, if the pumps are not shut off in time. The second objective to have as flexible an installation as possible can be an issue for any elastomers present in the pump, if a change of product results in the formerly perfectly suitable elastomers no longer being resistant to the product or some of its components. A final desire of the operators is of course to have as little unplanned – or even planned – downtimes as possible, so the unloading station is available whenever needed.

This final desire for a reliable and maintenance free installation as possible is challenged by the previously mentioned priorities. Product changes can potentially endanger any elastomers present in the pump. This can be addressed by using a high grade FFKM for any elastomers potentially in touch with the product; however this is an expensive solution, both in initial installation and in the continuous maintenance costs when these elastomers need to be replaced.

Operating at low NPSH(A) conditions when the tank is empty or almost empty can lead to cavitation which causes direct erosion of the impeller and can cause additional secondary damage due to vibration. Both these vibrations and the partial dry run condition caused by evaporating fluid in the stuffing box area of the pump can substantially reduce the overall lifetime of the shaft sealing.

Dry running at the end of the process can naturally spell an early end for the mechanical seals and may be an additional fire or explosion hazard if the pumps are installed in hazardous areas.

Careful pump design can address all these points. Yet a careful selection and application of technologies is required to give the desired results. Utilizing a sealless magnetic drive pump eliminates already a lot of the typical wear parts in a pump with mechanical seals. A pump with a magnetic coupling eliminates the dynamic shaft seal which is typically the part with the lowest MTBF in a conventional pump. A magnetic coupling transmits the torque slip free using attracting and repelling forces through a stationary containment shell. Accordingly there are no dynamic seals in a magnetic drive pump – that way there is zero leakage risk from a magnetic drive pump. The forces generated inside the pump are supported by prod-

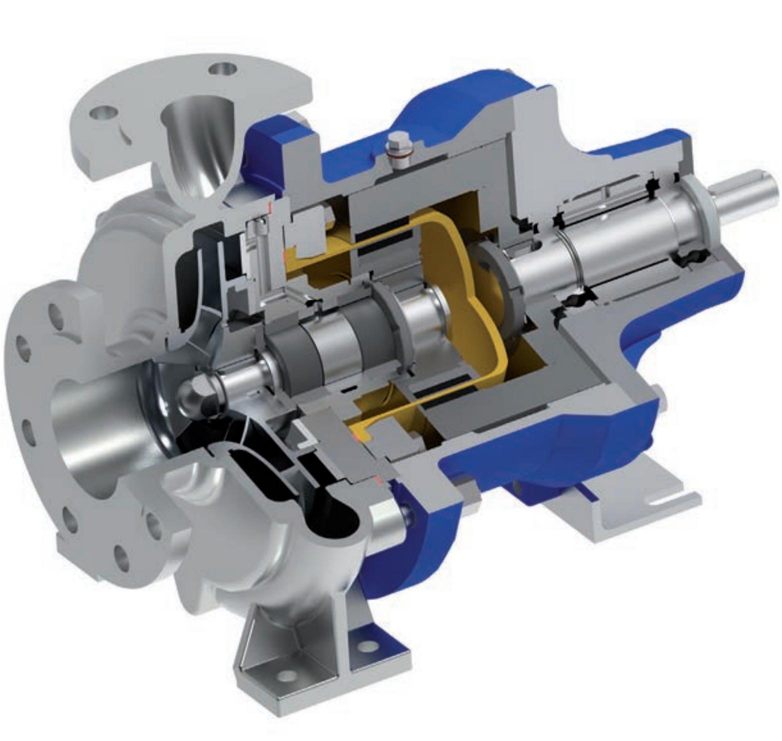

Fig. 1: Magnet Drive Centrifugal Pump in Dry Running Design

uct lubricated maintenance free axial and radial journal bearings.

Conventional magnetic drive pumps use metallic isolation shells. The rotating magnetic field of the inner and outer magnet carrier induce eddy currents in the metallic containment shells. These eddy current losses reduce pump efficiency and the generated heat needs to be cooled by a partial flow, taken from the discharge flange, further reducing pump efficiency.

Ceramic isolation shells are able to eliminate these disadvantages. For decades isolation shells made from technical ceramics such as Zirconium Oxide are used in the most demanding applications. As ceramics are non-conducting there are no eddy current losses associated with them, increasing pump efficiency both directly and indirectly as there is no longer any partial flow required for cooling. Even during running conditions no longer pose danger to an isolation shell made of ceramic.

The journal bearing is typically lubricated and cooled by the pumped liquid, using a partial flow taken from discharge pressure of the pump. During dry running conditions in normal pumps it is likely that these bearings would not be sufficiently lubricated anymore. Special journal bearing designs allow however for a pump to operate without continuous partial flow. Heavy duty solutions are in use for more than two decades in the chemical and petrochemical industry, where the journal bearing is not flushed with the pumped product, but is supplied via an external flush source. There are two ways to do this, depending on the operating profile of the pump. The first one supplies the journal bearing with a constant, low volume flow (typically in the range of one to ten liters per hour) for lubrication and/or cooling. The other option is to not have a constant injection but only a static supply that is periodically exchanged or topped off. This protects the pump bearing from damage during dry run operation and considerably increases the resilience of the pump against particles.

For most unloading applications this additional step is not required however. Instead a considerably reduced partial flow is taken from the pump discharge as in a standard pump and the isolation shell area is used as a high volume reservoir. Due to this design the pump can accommodate periodic dry running conditions without the need for an external fluid injection or any other utility consumption. As soon as the pump suction is flooded again, the liquid reservoir will be automatically refilled. A magnetic drive pump with properly designed reservoir and product lubricated journal bearings can overcome a dry running condition without additional protection for a predetermined amount of time.

A typical cycle would for example be 10 minutes dry running every hour, although more frequent dry running conditions can be achieved as well. This design is suitable for operation in hazardous areas (ATEX Zone 1 and 2), without requiring additional instrumentation.

A typical application where this system came in handy was with a customer in France, where it was discovered that the pump was kept running for 90 minutes after the truck departed the unloading station. The pump did not suffer any damage or degradation in its performance although it continued to operate for an extended period of time. While certainly an extreme example, it confirms the reliability of the system.

In case the pumped liquid contains solids another advantage of the reduced partial flow is reduced erosion of the journal bearing material. Since only a small partial flow is required to top off the reservoir, the inlet port near the pumps discharge acts as an internal partial flow filter, reducing the amount of solids in the partial flow that is used to top off the reservoir. This further improves the lifetime of the journal bearing arrangement.

The final aspect to address is the desire to empty out tank trucks as quickly and as much as possible. For this type of application an inducer can be installed. An Inducer is essentially an axial impeller suction stage which is installed on the pump shaft directly

Fig. 2: Inducer to improve observed NPSH(R) of the pump

in front of the regular impeller. It has only a small number of vanes and provides a small head increase. This results in a significant improvement of observed NPSH(R) of the pump. While many inducers on the market limit the permissible operating range of the pumps, sometimes considerably, carefully designed and customized inducers are available, that do not inhibit the permissible or preferred operating range of the pump. By changing the design of the inducer, the point of best NPSH on the pump performance curve can be further optimized, so it better aligns with the required operating point of the pump. The inducer design can be further optimized for each radial impeller to ensure the overall permissible operating range of the pump is not reduced compared to pumps without inducers. It can be retrofitted on existing pumps, in most cases with only a minimum amount of pump modification.

Additional environmental protection can be achieved by adding a backup mechanical seal to operate as secondary control device according API 685. Even in case of a containment shell breach the backup mechanical seal prevents product from leaking uncontrolled to the atmosphere and the unloading batch can still be completed.

The smart combination of a high performance magnetic coupling, imploying a non-metallic isolation shell and a low flow journal bearing cartridge along with a customized suction inducer provides a flexible, reliable and highly robust zero leakage pumping solution for unloading applications. One less source of trouble and peace of mind for operators!

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