Solution for improved reliability through increased stability

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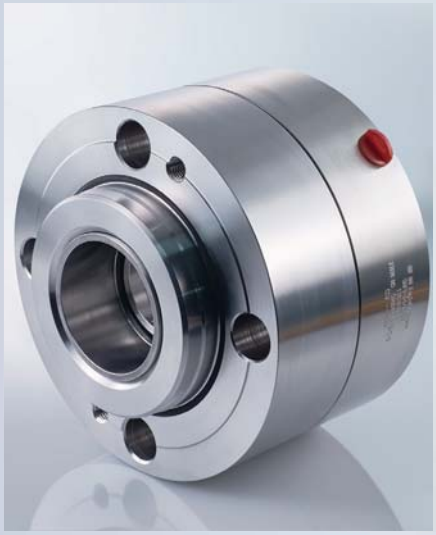
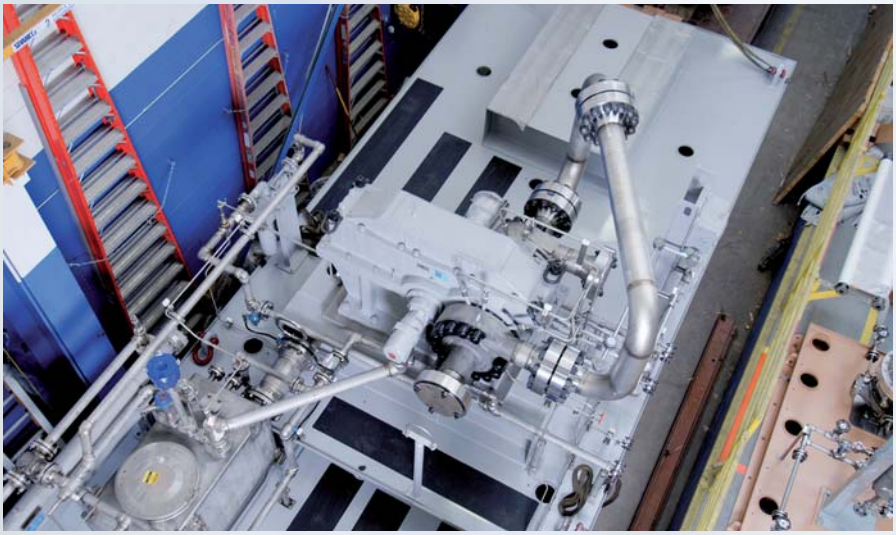
Rely on excellence

SH(V) mechanical seals for high-speed pumps in PTA facilities



EagleBurgmann SH(V)



Sundyne pump in operation

EagleBurgmann delivers increased safety and reliability with custom engineered liquid-lubricated double seals designed for high-speed centrifugal pumps that are used in purified terephthalic acid (PTA) production. These sealing solutions were developed in close collaboration with Sundyne, global pump manufacturer headquartered in Arvada, Colorado, USA. Based on the proven original EagleBurgmann design, the new double seals meet the ever increasing product performance requirements dictated by leading PTA producers.

Sundyne HMP-series centrifugal pumps have been the preferred choice for HP reactor feed pumps at PTA purification plants all over the world for many years. These integrally geared high-speed centrifugal pumps are used during the purification stage of crude terephthalic acid (TA). Sundyne pumps deliver TA slurry, containing TA powder suspended in demineralized water at a high temperature, into a hydrogenation reactor, where contaminants are removed from the solution via reaction with hydrogen. PTA is the predominant raw material for production of high-purity polyester resin which is widely used in production of polyester fiber, polyethylene terephthalate (PET) bottle resin, polyester film, and engineering plastics.

Operational reliability of the HP reactor feed pump is critical for maintaining stable operation of the PTA purification plant, and mechanical seals are among the most critical pump components due to high-speed and high-pressure service requirements.

The selected for this application centrifugal pump, configured as horizontally mounted integrally geared two-stage pump that has a single double-ended output shaft at rotational speed of 6,200 min^{-1} with impellers attached on each end. The two stages are piped up to operate in series to develop the required head rise, and the first stage discharge feeds the second stage pump suction boosting the stage 2 seal chamber pressure up to 80 bar (1.160 PSI).

The seals for the application were engineered as a cartridge design double seal face-to-face arrangement for stage 1 and as a tandem oriented face-to-back dual seal arrangement for stage 2 which allows to split the total diff erential pressure between two seals and maintain suitable pressure velocity (PV) parameter levels. The seal support system utilizes flush supply to both pump stages protecting the product side seals from plugging with TA slurry.

Particular technical challenges

One of the main technical challenges pertained to the barrier/buffer fluid was presented by the end user, one of the world's largest PTA producer, which takes the initiative on maximizing the efficiency of the PTA process technology. Instead of using the more common ambient temperature demineralized water as barrier/buffer liquid that is usually supplied from the PTA plant centralized seal support system, it was requested to utilize a water source at a temperature range of 65 °C (149 °F) to 85 °C (185 °F). The potential problem with water under these conditions as barrier/buffer liquid is an adverse seal environment such as inadequate heat dissipation and poor lubrication of the seal faces due to loss of fluid film caused by vaporization.

eagleburgmann.com
info@eagleburgmann.com

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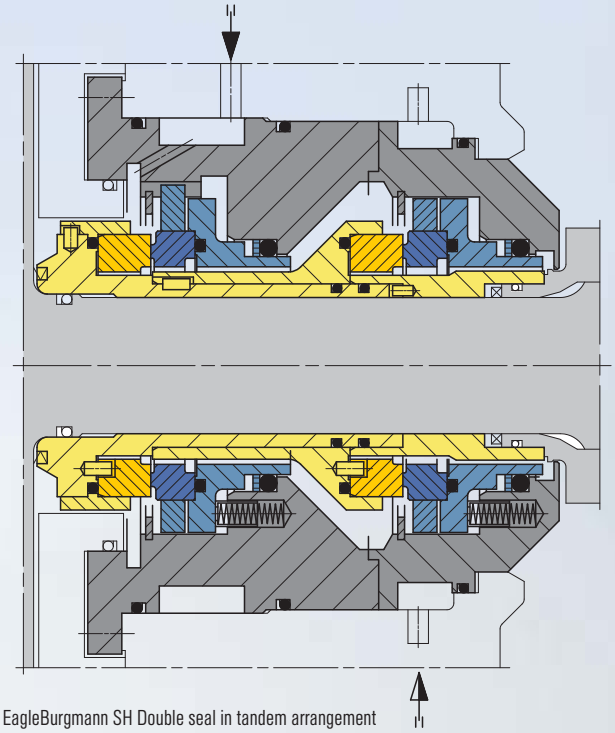

EagleBurgmann SH Double seal in tandem arrangement
Yellow parts are rotating, blue are stationary, gray parts show pump shaft and housing.

Test rig at EagleBurgmann R&D center in Wolfratshausen/Germany.

An additional technical challenge was reverse pressurization of the stage 2 process side seal during the pump startup and shutdown. During the startup sequence, this seal is reverse pressurized by the buffer fluid introduced into the seal support system before the pump main driver is turned on. Under transient conditions, while the pump is ramping up to full speed and reaching full discharge pressure, the pressure applied to the seal is reversed causing the seal to hang-up. The same occurred in opposite order during pump coastdown to shutdown event. The original seal design was modified to incorporate new features to overcome seal hang-up associated with the secondary seal.

End-to-end expertise required

"In view of this demanding specification, we could clearly see at an early stage that in-depth know-how was needed - and that we would have to design a special application-specific solution," said Eric Vanhie, project leader at EagleBurgmann's US subsidiary in Houston.

Once the performance specification had been drawn up at a kick-off meeting between Sundyne and EagleBurgmann's US subsidiary, the development and design stage started at the company's headquarters in Wolfratshausen, Germany. The operating points were analyzed in detail with the R&D department. This provided precise performance calculations and a computer-aided design for the sliding elements.

The new double seals were based on a proven special high pressure seal from the existing product portfolio. Specifically, the team opted for the highly efficient high pressure seal SH(V), which has been used in high pressure applications for years. In contrast to conventional mechanical seals from the standard range, high pressure seals have one important special feature: in these seals, the seat rotates on the shaft while the seal face - with its spring backing - is stationary in the housing. This seal concept provides additional stability at high speeds. At sliding velocities of 20 m/s (66 ft/s) or more, the springs should be stationary so that they do not absorb vibrations and thus deform.

Optimized design

The design of the proven SH(V) seal was also optimized for the specific application. Specific design improvements were made to guarantee stable running across the entire operating range. These included the use of ultra-high performance materials. While the regular SH(V) seal uses the proven silicon carbide ceramic material for both seal face and stationary seat, the stationary seal face for the Sundyne solution was based on the silicon carbide variant BuKa 30. This ultra-high performance material from EagleBurgmann has a high carbon content, making it the perfect solution for media with poor lubricating properties, such as water. BuKa 30 impresses with its effective emergency running properties and tolerance to dry running.

The seal was further optimized to guarantee functional reliability, even in the marginal ranges. a loosely-fitted seal face provides additional safety against tipping and tilting. One of the special technical features of the high pressure seal developed for the PTA application is the incorporation in the seal faces of high-precision grooves calculated by R&D. The depth and geometry are specified with incredible accuracy. The grooves that EagleBurgmann has been using for years in the dry gas seal field also support safe operation of liquid-lubricated double seals in critical phases. At low pressure, the grooves promote lift-off of the seal faces by creating a positive pressure cushion - and thus very quickly establish a stable operating state. At high pressure, the grooves have a stabilizing effect as they prevent the gap opening further.

Proven in the test field and in practice

Combining all these measures resulted in sophisticated sealing systems in both tandem and back-to-back versions. These cover the range of applications up to 100 bar (1,450 PSI) and 9,000 min^{-1} and guarantee the functional reliability that Sundyne required. The liquid-lubricated double seals easily cope with all operating parameters – and their constant sealing performance is impressive, even when exposed to considerable pressure, temperature and speed fluctuations. This was tested and confirmed in dynamic test runs in the test field in Wolfratshausen, where the seals, which are designed as easy-to-fit cartridge systems, were extensively tested and then accepted by the Sundyne engineering team.

The new double seals have proved their worth in the many Sundyne HMP model integrally geared pumps that were bought into service in China in 2014 in one of the world's largest PTA facilities.