PUMPS & SYSTEMS

Published on *Pumps & Systems* (http://www.pumpsandsystems.com)

Liquid-Lubricated Double Seals Increase Stability for PTA Production

One facility's high-speed centrifugal pumps saw improved performance and efficiency after adding custom seals.
by Andreas Pehl (EagleBurgmann Germany GmbH & Co. KG)

The production of purified terephthalic acid (PTA) poses unique challenges for centrifugal pumps. For increased safety and reliability, some facilities with this process have incorporated custom-engineered liquid-lubricated double seals. This new technology meets the ever-increasing product performance requirements of leading PTA producers.

HP reactor feed pumps—in many cases, integrally geared high-speed centrifugal pumps—play a vital role in the purification stage of crude terephthalic acid (TA). These pumps deliver TA slurry, which contains TA powder suspended in demineralized water at a high temperature, into a hydrogenation reactor, where a reaction with hydrogen removes contaminants from the solution. PTA is the predominant raw material for production of high-purity polyester resin, which is widely used in the production of polyester fiber, polyethylene terephthalate (PET) bottle resin, polyester film and engineering plastics.

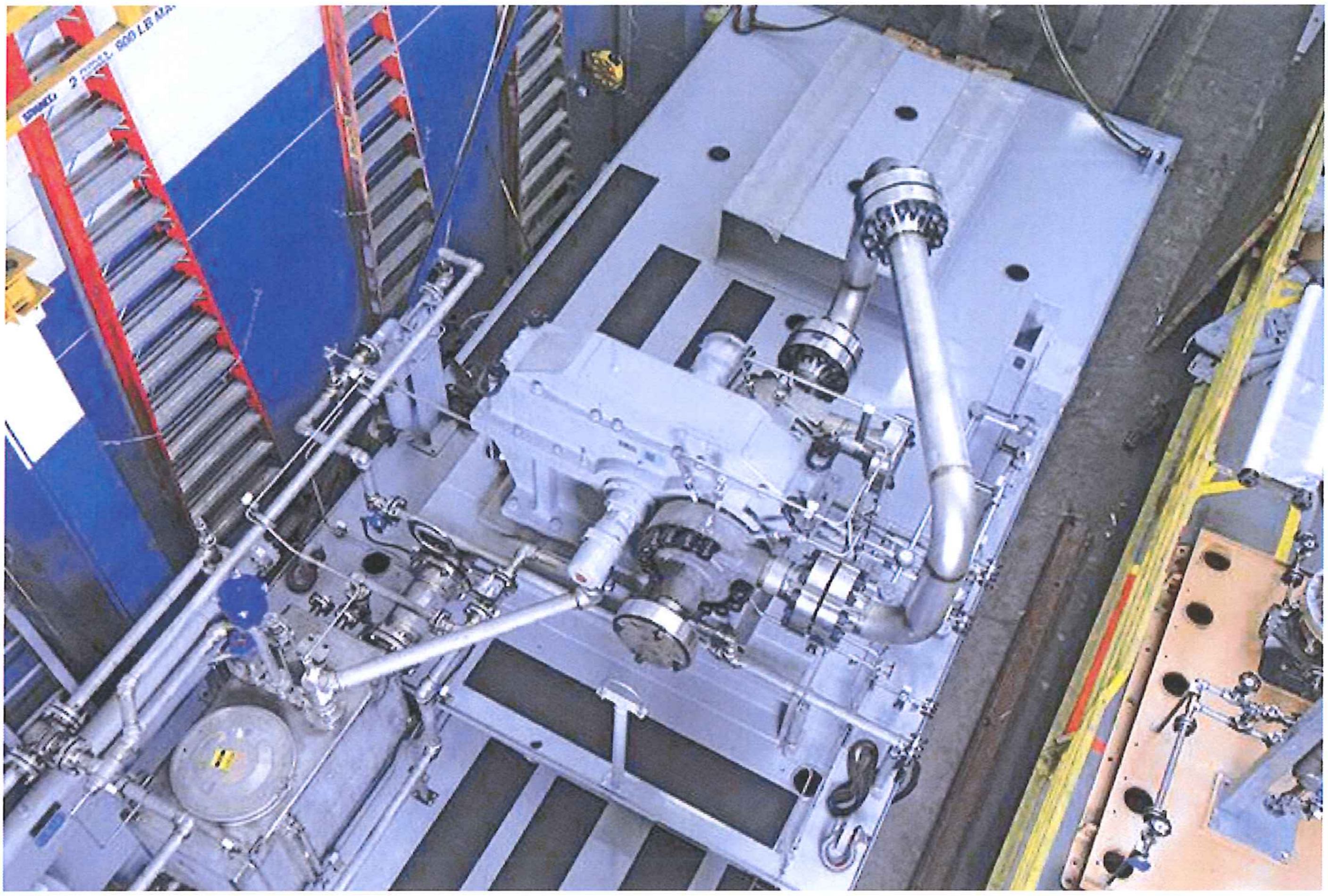

Image 1. Pump in operation *(Image and graphic courtesy of EagleBurgmann)*

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

In one particular application—for one of the world's largest PTA producers—the selected centrifugal pump was configured as a horizontally mounted, integrally geared two-stage pump with a single double-ended output shaft, which operates at a rotational speed of 6,200 revolutions per minute (rpm) 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. This setup boosts the Stage 2 seal chamber pressure to 80 bar, or 1,160 pounds per square inch (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 splits the total differential pressure between two seals and maintains suitable pressure velocity (PV) parameter levels. The seal support system utilizes flush supply to both pump stages, which helps to protect the product side seals from plugging with TA slurry.

Technical Challenges

One of the main technical challenges in this application pertained to the barrier/buffer fluid. Instead of using the more common ambient-temperature demineralized water as a barrier/buffer liquid that is usually supplied from the PTA plant centralized seal-support system, the facility requested to use plant return water at the normal temperature of 70 degrees C (158 F), with a maximum temperature of 80 C (176 F). The potential problem with using plant return water as barrier/buffer liquid under these conditions is an adverse seal environment characterized by inadequate heat dissipation and poor lubrication of seal faces resulting from a loss of fluid film from vaporization.

An additional technical challenge was reverse pressurization of the Stage 2 process side seal during 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 problem occurs in opposite order during pump coast down to shutdown. The original seal design was modified to incorporate new features to overcome seal hang-up associated with the secondary seal.

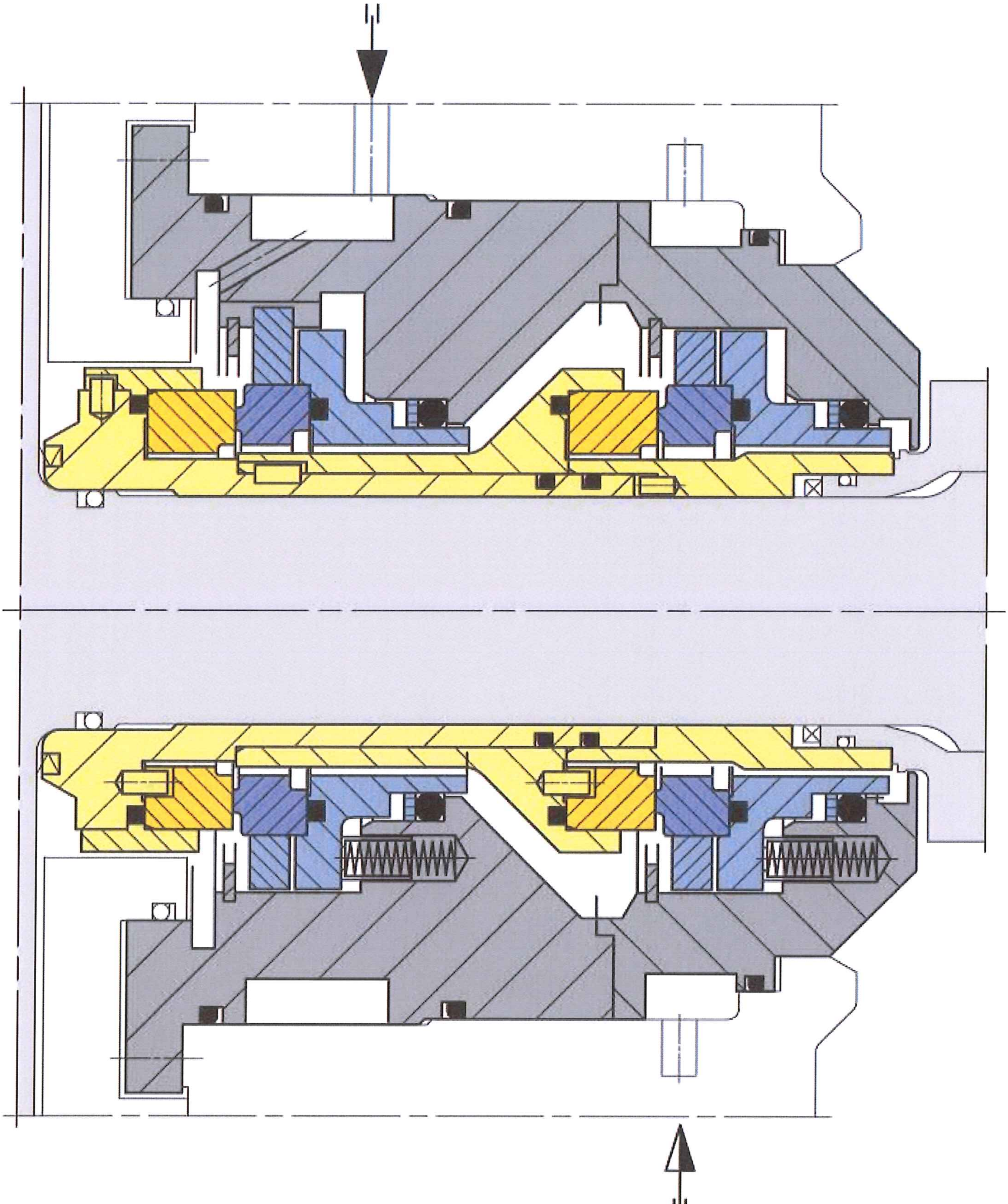

Figure 1. Double seal in tandem arrangement. The yellow parts are rotating, blue are stationary, and gray shows the shaft and housing.

The demanding requirements of this facility required an application-specific solution. Once the performance specification had been drawn up, the development and design stage began. The seal and pump manufacturers' teams met to analyze the operating points in detail. This provided precise performance calculations and a computer-aided design for the sliding elements.

The new double seals were based on a special high-pressure seal from the manufacturer's existing product portfolio. Specifically, the team opted for the efficient high-pressure seal. In contrast to conventional mechanical seals from the standard range, high-pressure seals have one important special feature: 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 meters per second (66 feet per second) or more, the springs should be stationary so they do not absorb vibrations and deform.

Optimized Design

Design improvements to the seal technology, including the use of ultra-high-performance materials, were made to guarantee stable running across the entire operating range. While the regular seals use silicon carbide ceramic material for both seal face and stationary seat, the stationary seal face for this application was based on the silicon carbide variant BuKa 30. This material has a high carbon content, making it an ideal 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. Another technical feature of the high-pressure seal developed for the PTA application is the incorporation of high-precision grooves in the seal faces. The depth and geometry of these grooves were specified with accuracy. At low pressure, the grooves promote lift-off of the seal faces by creating a positive pressure cushion, and they quickly establish a stable operating state. At high pressure, the grooves have a stabilizing effect because they prevent the gap from opening further.

Image 2. Test rig at research and development center

Field Tested

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 rpm and ensure functional reliability. The liquid-lubricated double seals cope with all operating parameters, and constant sealing performance is reliable, even when exposed to considerable pressure, temperature and speed fluctuations.

The seals, which are designed as easy-to-fit cartridge systems, were extensively tested and confirmed in dynamic test runs in the test field. The new double seals have also proven their worth in the many integrally geared pumps that were bought into service in China in 2014 in one of the world's largest PTA facilities.

About the Author
Andreas Pehl is technical sales support for mechanical seal applications at EagleBurgmann Germany in Wolfratshausen. He joined EagleBurgmann in 2010. He has a degree in industrial engineering from the University of Applied Sciences, Munich. For more information, visit eagleburgmann.com.

Source URL: http://www.pumpsandsystems.com/centrifugal-pumps-seals/february-2016-liquid-lubricated-double-seals-increase-stability-pta