Flowserve pushes the envelope of engineering and service, using innovative technology and methods to solve customer problems all over the world.

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Manufacturers of purified terephthalic acid (PTA) use extraordinarily large mixers in their oxidation and crystallization processes, and thus require extraordinarily large mechanical seals to contain the process materials. PTA is a raw material used in polyester-based clothing and plastic bottles, packaging and other products, and it is rapidly growing in demand.

One major petrochemical manufacturer using one of the world’s largest PTA agitators needed a new high-performing 480-millimeter (18.9-inch) PTA shaft seal. The company was dissatisfied with its original supplier’s seal, and it asked Flowserve for help.

Flowserve developed and tested a new seal design that matched the manufacturer’s requirements and exceeded its performance objectives. In the process, Flowserve broke new ground with the unique specifications, enhancing its seal development knowledge and product design tools for the benefit of future clients.

Super-Sized Requirements
Oxidation reactors used in PTA production are subject to highly rigorous temperature and pressure conditions. The shaft driving this manufacturer’s oxidation mixer vessel is 480 millimeters (18.9 inches) in diameter. A PTA mixer seal of the required size and material had never before been built at Flowserve, and the performance specifications were higher than what the company’s current unit in the field could accommodate.

“We needed a seal larger and with greater life than anything we had built before,” says John Whitson, director of sales at Flowserve. “Our client wanted longer-running seals with less leakage in shaft diameters in excess of 18 inches [457 millimeters]. This project pushed the boundaries of the seal materials in the market.”

The seal’s face flatness needed to be controlled across a diameter of roughly 61 centimeters (24 inches). Flowserve engineers had to balance multiple design parameters to provide the necessary full reverse pressure capability and manage thermal cycling conditions. The customer sought extremely low leakage and wear rate characteristics, far in excess of the current supplier’s offerings.

Broadening Experience
The decision to select Flowserve was easy. The petrochemical company already was benefiting from various flow-management products and services from Flowserve. In addition, Flowserve had extensive PTA-specific seal experience. It had delivered more than 100 seals to PTA applications ranging from 38.1 millimeters to 356 millimeters (1.500 inches to 14.000 inches) in size for top-entry mixers, dryers, centrifuges, and supporting pump applications.

“This was a long-time customer of Flowserve that was well aware of our capabilities to solve their request. They already used many different seal types, such as the M-Series and most of the other Flowserve portfolio of seal products,” explains Torsten Bernicke, product manager at Flowserve.

Key representatives from Flowserve Research & Development, Applied Technical Solutions, and Product Management were selected to lead the extensive development and testing program. The global cross-functional product
Development team invested a tremendous number of labor-hours collaborating on the solution and overcoming numerous design, manufacturing, and testing challenges in the process of developing the Flowserve MWC-200 PTA seal and support systems.

Complex analytical models were developed and refined to optimize the design and accurately predict how the seals would perform. Material and design decisions were based on the modeling results. For example, Flowserve selected a robust drive mechanism for the seal. Titanium material was used for wetted parts, silicon carbide was used for the stationary seal face, and antimony carbon was used for the rotating seal face.

Flowserve chose a banded seal face design to increase torque capacity and to reverse pressure capability. The nonwetted band design allows for materials with higher strength and lower costs; the nonsealing band design reduces leak paths and lowers costs; and the centroid loaded band design minimizes seal face deflections while providing stability. The seal face assemblies are supported by a controlled reaction surface that allows for optimization of the seal face deflections.

To accommodate the large scale of this project, Flowserve developed an innovative process to lap extremely large seal faces on standard lapping tables with the flexibility to achieve the required seal face flatness.

The project also included the fabrication of a state-of-the-art test stand with fully automated controls and advanced data acquisition to accurately replicate the application’s conditions and monitor the health of the seal.

The test specifications were finalized in November 2012, and the first tests ran in March 2013. The testing performed at the Flowserve Research & Development test facility in Kalamazoo, Michigan, was extensive, and included hydrostatic pressure, performance, endurance, pressure reversal, and leakage optimization testing.

Finite element analysis was performed for all of the test conditions with excellent correlation between the predicted and actual seal performance. Conditions beyond the standard application parameters also were tested with successful results.

Lastly, customer witness testing, including monitoring the seal under test and post-test inspection of critical components, was performed with positive feedback.

**Mutual Benefits**

The Flowserve MWC-200 PTA mixer seal met or exceeded the petrochemical company’s objectives the first time out, for both seal wear and seal leakage, thanks to the successful efforts of the team and the analytical modeling and testing processes. As a result, the customer approved the Flowserve MWC-200 seal design for its PTA process, including both internal projects and its PTA process licenses.

Flowserve benefited from the project because it made significant improvements to its computer modeling tools, which now can predictably determine seal performance at a much higher accuracy rate. The tools are used internally to further optimize existing seal designs and to accurately predict performance in future applications.

“The knowledge acquired throughout this product development project can be leveraged across several other industries and PTA applications, providing even more benefit to Flowserve — and therefore, our customers — than originally projected,” says Corey Case, senior research and development engineer at Flowserve.

Visit www.flowserve.com/Products/Seals for more information about Flowserve seal technology.
Uniquely Engineered Solution Surpasses Expectations

Innovative technology uses diamond-coated seals to improve mean time between repair of an alumina refinery’s slurry pumps and seals operating in a harsh environment.

When a long-time customer needed Flowserve to raise the mean time between repair (MTBR) of its slurry pumps and seals, Flowserve was up to the challenge. Years of research and development already had laid the groundwork, and successful on-site trials would prove its case.

The harsh and demanding industrial environment of the South Pacific minerals refinery customer required a uniquely engineered solution. Its slurry processes are challenged daily by abrasion, corrosion, temperature and pressure extremes, and off pump-curve running. Flowserve had been testing diamond film technology, and adding the coating to its SLC seal faces would provide the extreme hardness, strength, and wear resistance that the refinery desperately needed.

Improving the MTBR would reduce seal maintenance and pump downtime, and it would further the customer’s corporate goals to increase production capacity, reduce costs, and become more efficient.

Above and Beyond for Improved Performance

Flowserve and its heritage products have been used at the refinery for 25 years. Flowserve supplies 90% of the mechanical seals used on the site and is the supplier of choice when any new rotating equipment is introduced there. Of the approximately 1,300 pump seals installed, about 1,100 are Flowserve SLC Series slurry seals.

When the refinery targeted about 20 seals with a MTBR of less than six months for improvement, Flowserve quickly leveraged its close association with Advanced Diamond Technologies, Inc. (ADT). They had been working together on a solution that would outperform the existing SLC seals.

Ultrananocrystalline Advantage

ADT and Flowserve have long collaborated on improving diamond coatings for mechanical seal faces. ADT’s ultrananocrystalline diamond (UNCD) coating technology, when applied to Flowserve base materials, reduces the coefficient of friction significantly and measurably, and reduces the likelihood of overheating when the seal is subject to unfavorable conditions. For example, when pumps...
begin to cavitate, less liquid is in the pump for full seal-face lubrication. UNCD coatings help to reduce the likelihood of seal-face surface damage.

Standard mechanical seals installed in the first targeted pumps tended to last less than seven days. Microcrystalline diamond (MCD) films also were ruled out. With its larger diamond structure, an MCD face must run against another MCD. UNCD faces have a finer crystalline structure, giving Flowserve the option, if needed, to run a UNCD seal face against a standard face.

Thorough Testing and Trials
Slurry seal coatings, including UNCD faces, are tested extensively at the Flowserve Slurry Center of Excellence research and development facility. “There is a purpose-built building that houses a complete computer-controlled pump loop that can test seals dynamically to 120°C [250°F] and to 3500 kPa [500 psi],” explains Marc Abrahams, sales engineer and slurry development manager from the Flowserve Slurry Seal Center of Excellence in Australia.

The Center evaluated run-time differences, comparing standard silicon carbide and tungsten carbide seal faces with UNCD faces in fully flooded, partially dry, and fully dry tests. The UNCD faced seals yielded measurable increases in MTBR for identical conditions, ranging from five times to up to 15 times for complete dry running.

When Flowserve was assured that the UNCD technology could be produced with unmatched repeatability, a field trial began at the refinery. The trial involved three Flowserve LR between-bearings pumps in the refinery’s caustic liquor, washer overflow area. Pump 1 was fitted with a competitor’s seals that had already logged months of service.

In February 2013, Pump 2 was fitted with a pair of UNCD SLC seals, replacing gland packing and allowing a direct comparison to the adjacent Pump 1. In August 2013, when the Pump 2 seals were still running strong at six months, Pump 3 was fitted with Flowserve UNCD SLC seals. Finally, the competitor’s seals on Pump 1 failed and were replaced with Flowserve seals in February 2014. All three Flowserve Worthington 8LR-13 pumps were now successfully running with the UNCD-coated SLC seals.

Easy Decision
The refinery’s maintenance leaders were impressed with the new UNCD technology. The Flowserve UNCD-faced SLC seals remained in service under adverse pump operation for 11 months, exceeding the planned six-month trial and the competitor’s product life. In addition, the service life of the new seals is improved significantly compared to a standard mechanical seal’s seven-day span on the same pump and application. Even when pump performance declined because of scale buildup, UNCD seal integrity remained. After pump shut-down, disassembly, and inspection, the seals were found to be in very good condition. “Only one pair of seals fitted with UNCD seal faces has been removed from service, and we were thrilled to be advised that it was not due to seal failure. Scaling within the pump clogged the impeller and reduced product flow significantly,” says Abrahams.

By February 2014, the decision was made to end the trial period and upgrade all seals that suit the refinery’s Flowserve LR pumps without modification (6LR-13 and 8LR-13) to UNCD seal faces. UNCD-faced SLC seals will be fitted as the current non-UNCD SLC seals are removed from service.

Conversion and Expansion
To date, the refinery has committed to 24 seals in the washer overflow and similar applications. A total of 16 seals have been converted so far, including six pumps in the field that use 12 seals, and four spare seals in the warehouse. In addition to the Flowserve Worthington between-bearings washer overflow pumps, the plant’s end-suction hydrocyclone feed pumps, the Flowserve Worthington between-bearings filtrate pumps, and the spent liquor dilution pumps are being converted.

Furthermore, three additional UNCD SLC seal trials in even harsher slurry environments have been requested. This includes the precipitation stage of the refinery, where the “filtrate” has a higher dissolved solids content than the liquor overflow pumps. The benefits of a UNCD face against a tungsten carbide face SLC seal will be compared. The new trials are scheduled to begin soon.

Visit www.flowserve.com/Products/Seals for more information about Flowserve seal technology.
When a vital oil refinery in Spain experienced a sats gas plant compressor failure, the unit was shut down, causing a significant disruption of production and lost revenue. The refinery normally processes more than 100,000 barrels of crude oil per day.

The unspared light ends compressor, used to liquefy and separate gases, suffered an unexpected and extremely expensive oil seal failure. Refinery engineers traced the failure to faulty wet mechanical seals and isolators.

With help from Flowserve, the refinery turned the incident into an opportunity to rethink its seal technology. The compressor’s manufacturer proposed a wet seal retrofit requiring compressor modifications, but the refinery chose to increase reliability and cut expenses with a Flowserve compressor seal retrofit to dry gas seals.

**Positive History with Flowserve**

The refinery initially looked only to its OEM for a remedy. Fortunately, Flowserve had an excellent relationship with refinery operators. The plant was a long-time user of Flowserve products and services, and an application engineer had been stationed on-site since 2010 as part of a Flowserve LifeCycle Advantage (LCA) agreement, which included replacing “bad actor” seals to improve performance of the plant’s 550 pumps. The agreement included a commitment to increase the pumps’ mean time between repair (MTBR) each year.

“With an LCA, our strength is to have an engineer from Flowserve on-site dedicated to meeting end-user needs. Having someone with expertise inside the refinery is really helpful for the customer,” says Andrea Asti, sales engineer at Flowserve.

In addition, Flowserve completed dry gas seal retrofits at the refinery previously that had met or exceeded performance expectations. Gaspac L tandem seals with an interstage labyrinth installed in a coker gas compressor in 2003 were serviced only twice during routine turnarounds. Gaspac D double seals installed in a methane mix compressor in 2007 were serviced just once during a routine turnaround.

When the on-site engineer became aware of the retrofit plans, he asked for and was given a chance for Flowserve to submit a proposal.

**Two Approaches Considered**

The OEM’s retrofit proposal involved upgrading one of
its own wet seals, but this required modifications to the compressor shaft and housing. The cost of modifications would contribute to a higher total package cost, and the refinery couldn’t easily return to the original wet seal type.

Flowserve offered several reasons to switch to dry gas technology, including the seal lubricating oil leakage costs and de-gassing contaminated oil costs. Seal oil support systems can fail despite precautions, and replacement components that meet the specifications are expensive. In addition, maintenance on the seal support system while the machine is running is a safety hazard.

Dry gas seal technology has several advantages. It eliminates the need for an oil system to lubricate the seals, which reduces oil consumption costs and process contamination losses. It eliminates the need to remove gas from the oil, which prevents fugitive emissions and the risk of gas in the oil tank. Also, the system is easier to maintain and less prone to hazardous risks, and its operation is more reliable. In addition, dry gas seals can run in both directions using T-groove technology.

The Flowserve North America and Europe Compressor Teams collaborated to develop a proposal for a seal and seal support system that satisfied the refinery’s operating parameters. They proposed a dry gas seal retrofit for the compressor with no machine modifications. The scope included two Flowserve Gaspac D double-compressor seals, two Circpac LO carbon ring seals for bearing protection, a buffer/barrier gas panel, and spares.

Retrofit Selection
The Flowserve solution would deliver a safer, faster, more reliable retrofit than what the OEM suggested. In October 2011, Flowserve was awarded the full mechanical turnkey retrofit project.

“Flowserve’s extensive experience with this type of job and our excellent relationship with the refinery, its corporate headquarters, and the company globally, were major reasons for Flowserve’s selection,” says Torsten Bernicke, product manager at Flowserve. “The modification-free approach and successful use of dry gas seals on other plant compressors contributed as well.”

The scope of work included:

- Removal of the wet seals and wet seal support system from the compressor.
- Supply and installation of new Flowserve Gaspac D seals with T-groove face geometry for bidirectional rotation.
- Supply and installation of Flowserve Circpac LO bearing isolation seals.
- Supply and installation of a new gas control panel, complete with piping and wiring.
- Support in the commissioning of the seals and panel.
- Rotor dynamic analysis to check compressor stability with dry gas seals.

Following the retrofit to dry gas seals, the compressor successfully started up in July 2012.

Business Benefits
The project was completed on time and on budget to the refinery’s satisfaction. By converting the compressor seals before start-up, the refinery saved more than $100,000. The retrofit eliminated seal oil support system costs related to oil consumption, de-gassing, and maintenance. The improved MTBR of the dry gas compressor seals will increase the refinery’s profitability.

The Flowserve on-site application engineer and local customer support provide ongoing benefits. The LCA has improved pump MTBR from 37.5 months to more than 53 months, saving the refinery hundreds of thousands of dollars. The Flowserve seal population has grown from 3% to 15% under the agreement; the number will increase as further opportunities for performance improvements are found.

Visit www.flowserve.com/Products/Seals/Compressor for more information.
The technology leader in compressor reliability solutions

Flowserve has the technical expertise to provide superior products and solutions for your compressor operations and sealing requirements.

We are the leading-edge service provider for dry gas seal retrofits, high-end compressor seal troubleshooting, seal support engineering and world-class gas conditioning systems.

Through the convergence of technologies and experience from trusted names in gas seal and system manufacture, application, and retrofitting, Flowserve presents more opportunities for reliable equipment operation than ever before.

Features of our Gaspac dry gas seal line include innovative solutions to hang up, reverse rotation, reverse pressurization, and centering of rotating components. Seals feature our Precision Face Topography with a choice of the patented uni-directional Advanced Pattern Groove and the bi-directional T-Groove, plus a choice of dynamic sealing options, all within a universal housing.

Flowserve has extensive experience in dry gas seal retrofits including many of the world’s first retrofit applications. Other services include rotor dynamic and gas phase analysis. Field services include installation, commissioning, troubleshooting and failure analysis.

Experience In Motion flowserve.com