SULZER

December 2020

Sulzer White Paper

Sealed with a cord – Sulzer's state-of-the-art sealing concept for axial split pumps

Sulzer's state-of-the-art sealing concept for axial split pumps

Axially split single and multi-stage pumps are commonly used to transfer large volumes of water at high pressure in power generation and water management applications. Operators of this equipment rely on pump manufacturers to deliver cost-effective, reliable and durable machinery that takes advantage of the latest developments in technology and materials science to improve performance.

As one of the world's leading original equipment manufacturers, Sulzer is at the forefront of pump design, engineering and technology. One of its recent projects looked at how the cost of large industrial axial split pumps could be streamlined without affecting performance.

Heike Tischler, Senior Development Engineer at Sulzer, explains the process behind the development of the company's latest sealing concept for axially split pumps.

Design review

When specifying new pieces of equipment, several factors are considered including product price, efficiency, reliability and ease of maintenance. Of these, efficiency should be a priority because energy consumption over the service life of the pump can account for over 60% of total lifetime costs, depending on the application. However, efficiency is reliant on many factors that are governed by the application itself. Further to this, reliability is influenced by design as well as the maintenance regime and how it is implemented.

Product price and ease of maintenance are largely determined by the materials used as well as the quality of the design and manufacturing processes. In these high pressure pumps, the volume of material required to cast the outer casing is precisely calculated to ensure optimum sealing at the parting line.

The sealing of an axial split casing needs to fulfil two main requirements:
- Tightness to the ambient surroundings
- Tightness between areas of different pressures within the casing

The calculations involved in creating the design of the outer casing are complex, but essentially, they need to ensure a large enough surface area with sufficient bolt strength to exert the necessary clamping force on the gasket. In low pressure applications, a liquid silicone sealant is commonly used while other designs use a solid, flat gasket that requires considerable pressure to activate it.

The joint calculation to size such housing connections adds this force to that generated by the internal hydraulic pressure to determine the overall clamping force. Clearly, a higher force will lead to larger bolts or studs as well as thicker flange material in the casing halves – hence adding weight and material costs.

Sealing principles

Engineers at Sulzer have been reviewing current pump designs and looking to reduce the volume of materials in the casing flanges, reducing overall weight as well as the cost of materials. This process has led to the development of an innovative sealing concept that does not require any additional gasket force to activate it.

The design is based on the sealing principles of an O-ring, which is seated in a machined groove in the mating face of the pump casing. The sealing properties of the elastomer O-ring are activated by the pressure that has to be sealed. This is illustrated in figure 1.

Due to the internal pressure the casing deforms slightly which results in a gap between the mating flanges. The penetrating pressure activates the o-ring. This causes the O-ring to be pushed against the groove wall on the low-pressure side and deform to a "D" shape, increasing the contact area between the elastomer and the flange surface.

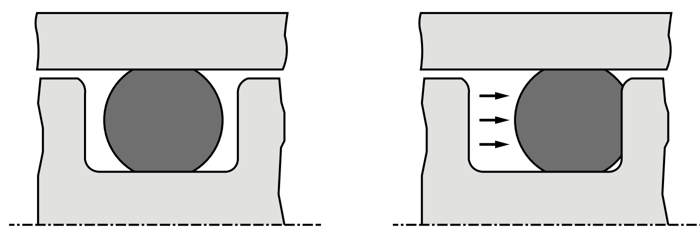


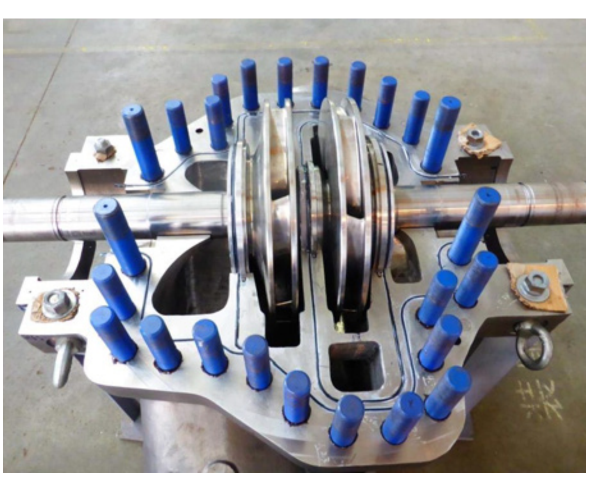
Figure 1: Cross-section of O-ring and seal groove, assembled and under pressure

Pressure calculations

However, without sufficient clamping force, the gap between the mating flanges can increase sufficiently to allow the O-ring to be forced into the gap. The high pressures involved in these applications can cause the O-ring material to extrude into the gap and ultimately fail.

This illustrates the importance of the joint calculation and of ensuring that a proper seal is achieved to maintain reliable production. In this case, the O-ring is a self-energizing seal, meaning that it is activated by the pressure that is being sealed. Now, in the joint calculation, the pressure to activate the seal is zero, reducing the clamping force required. This in turn reduces the bolt size and the volume of material needed in the joint flanges.

In terms of the pump casing design, the O-ring sealing concept offers a lower casting weight of between 5 and 10 percent, depending on the pump specification and metallurgy. This is achieved, in part, by being able to position smaller clamping bolts closer to the hydraulic contour.



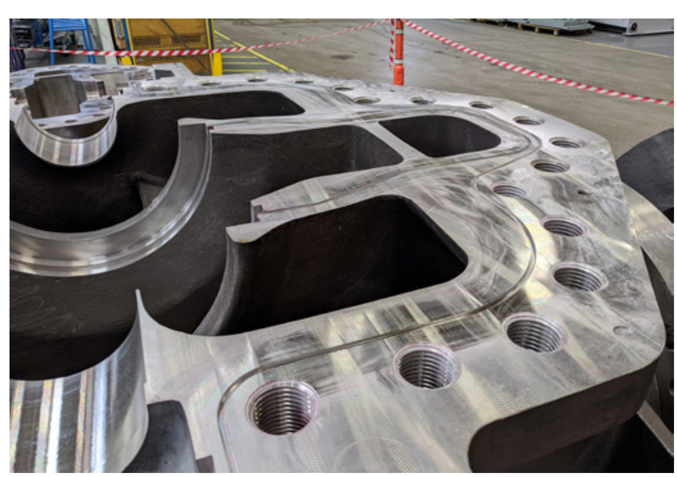


Figure 2 & 3: O-ring sealing at lower pump casing

Figure 4: Test rig at the Sulzer facility

Striking a cord

Taking a closer look at the sealing concept, it uses O-ring sealing principles and materials in a cord that can be installed in a machined groove of specific dimensions. The axial split of the pump casing means that the cord sealing between case pressure and atmospheric pressure must terminate at the mechanical shaft seal at each end of the pump.

In the same way, the seal cords between the various pump stages must also terminate at the stationary wear rings on the rotor shaft. Depending on the pump arrangement, there may need to be a T-joint of two O-ring cords. These aspects of the design are proprietary to Sulzer.

For such crucial parts of the design where the sealing capability must be maintained, several solutions were investigated in the process of developing the optimum solution. Each design was evaluated and assessed on a small test rig before the most reliable solution was selected.

The O-ring concept also has a distinct advantage over liquid and flat gasket designs when the time comes for periodic maintenance. The more traditional gaskets require a considerable amount of time to completely remove them and clean the mating surfaces of the pump casing. In contrast, the O-ring seal is easily replaced during routine maintenance, reducing overall downtime.

Implementation

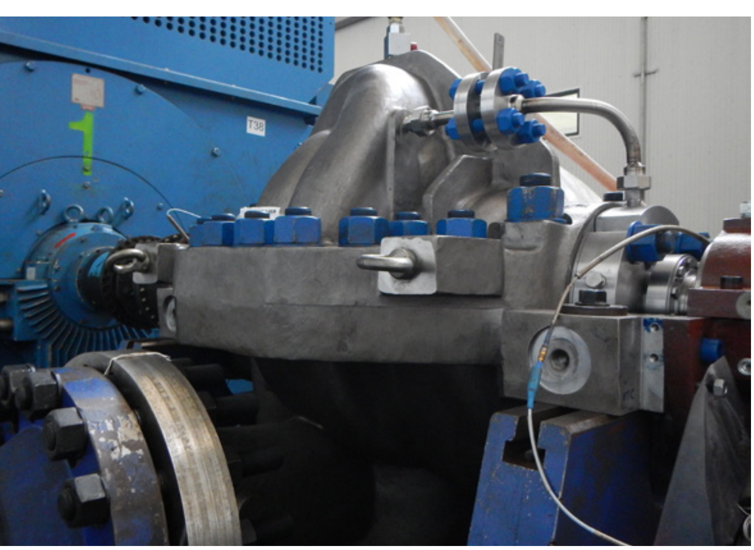
Having established the prototype and proven the design concept, the final step was to implement the solution in a range of full-scale pumps. As with any pump build at Sulzer, the finished design undergoes a hydrostatic pressure and a performance test.

The first test involves only the casing, which is pressurized to a value approximately 1.5 times the operational discharge pressure. This procedure is monitored for a set period of time, to assess the reliability of the seal at an elevated level.

The second test is performed on a fully assembled pump that is connected to a drive motor and installed on a test loop to check all aspects of pump operation, including the sealing system. Additional sensors are used to measure stage pressures as well as flowrates to verify the pump specification against actual performance.

To date, Sulzer's innovative sealing concept has been implemented and tested on over 60 pumps with design pressures up to 110 bar (1'600 psi). These are now in service with customers around the world having helped to optimize material costs and simplify maintenance routines.

Figure 5: Typical example for axial split pump, here type MSD



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