Large processing equipment places special demands on sealing technology

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This brief case study highlights the challenges seal manufacturers face in designing, building and testing mechanical seals for enormous reactors and crystallisers that are used to make raw materials, such as purified terephthalic acid, for the production of plastics.

In 2013 EagleBurgmann Germany GmbH & Co Kg supplied its largest agitator seal to date, with a shaft diameter of 480 mm. It was destined for use in a facility in China that manufactures purified terephthalic acid. The order, from SPX Flow Technology, comprised 13 agitator seals and supply systems. These were all successfully implemented within the exacting delivery period specified by the customer. The production time alone for the 480-mm seal was 20 weeks. Both the customer and the seal manufacturer were happy with the results – with no discrepancies identified in the agitator seal after a test run lasting 100 hours (**Figure 1**).

Purified terephthalic acid

Purified terephthalic acid (PTA) is a preliminary product used in the production of polyester and polyethylene terephthalate (PET).

It is generally produced from naphtha via the intermediate product paraxylene. At present, paraxylene is converted to terephthalic acid (TA) in large oxidation reactors using acetic acid as the solvent. The TA is then purified using a multi-stage crystallisation process, and any remaining impurities are removed in a hydrogenation reactor.

The continually increasing demand for PTA calls for facilities with ever greater capacity, and thus ever larger equipment such as reactors and crystallisers. New PTA facilities have production capacities in excess of 500 000 tons per year.

Reducing costly downtime

Standard shaft sizes for these types of reactor and crystalliser are now 200 mm or larger. EagleBurgmann's largest shaft diameter to date is 480 mm. The dimensions and weight (up to 1.5 tons) of the mechanical seals needed for such large diameters set new challenges for both seal and machine manufacturer, and the installation team at the facility.

The difficulty with such large seals is managing deformation of the sliding faces, and thus the shape of the sealing gap across the entire sliding face. This is essential to ensure low and stable leakage, and to maintain a minimised sliding-face temperature, which has a decisive influence on the service life of the seal.

The optimum sealing gap shape is determined on the basis of extensive calculations by experts, which are then verified by test runs. EagleBurgmann's test facilities (**Figure 2**) enable seals measuring up to approximately 800 mm to be tested and process conditions to be simulated. The limiting conditions on the test facility are the overall height, the weight and the diameter of the seal housing.

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Tests and customer acceptance tests simulate temperature changes at the sliding faces, and leakage, under almost real operating conditions. After the test run, the seal is allowed to cool down, and is dismantled in the presence of the

Figure 1. Satisfied customer and seal manufacturer *(from left to right)*: Paul Holbeach, Area Sales Manager – Midlands, EagleBurgmann UK; Seo Soo Kyo, Area Construction Manager, China; Robert Blakley, Principal Design Engineer, SPX Flow Technology, Rochester, USA; and Peter Totzauer, Manager, Business Sector Chemicals, Pharmaceuticals, Water, EagleBurgmann Germany.

customer. The sliding faces and other components are then assessed.

Other challenges of PTA manufacturing are the high pressure involved – up to 50 bar – and high temperature, up to 270°C. Therefore, type HSH high-pressure seals are used – generally in the form of a pressurised double seal with integrated bearing. This is a balanced, self-closing seal, that is, the seal remains closed even if the barrier pressure drops, or in the event of a pressure reversal. This prevents any process medium reaching the seal. The cartridge design simplifies assembly, which is particularly important given the enormous weight of the seals.

To withstand the high product temperatures the seals have cooling flanges and housings. Thus, the seal is no longer cooled by the barrier medium, but via an external medium circulating in the flange and housing. In addition, the parts of the seals in contact with the product are made from special titanium alloys since the acetic acid used in the process is extremely corrosive.

Flushing with nitrogen in front of the mechanical seal also prevents the product medium from penetrating into the interior of the seal. This avoids corrosion of the parts of the seal which are in contact with the product, and reliably prevents deposits forming on the seal.

Failure of a large PTA facility would prove to be very expensive, so the seals must offer extremely high operational reliability. For this reason, shrink-fit sliding faces are used. These increase protection against the possibility of broken rings, and minimise the risk of disruption. The operators of such facilities require agitator seals to operate for two to three years to minimise the maintenance intervals. EagleBurgmann has demonstrated in many reference projects – in countries such as Belgium, China and the USA – that its seals fully meet the expectations placed on them. The seal manufacturer has thus become one of the leading suppliers with wide-ranging experience in the use of agitator seals for PTA manufacture.

Supply system

Seal supply systems also play a significant role in the reliability and service life of the seals.

In most cases, API plan 53C is used. This is a supply system in which the barrier pressure is generated with the aid of a pressure booster (**Figure 3a** & **Figure 3b**). A separate cooler may be used for cooling. Circulation is ensured using either the thermosiphon principle, or by forced circulation, for example, using a pump – depending on the viscosity of the supply medium, or load on the seal.

Figure 2. EagleBurgmann's test facilities enable seals measuring up to approximately 800 mm to be tested and process conditions to be simulated.

Pressurisation is accomplished by pistons in relation to the pressure in the sealed space. The barrier pressure is automatically adjusted to the appropriate transmission ratio (generally 1.1 or 1.5). The system is self-regulating, and responds to fluctuations in the fluid pressure in the sealed space. This ensures that the seal operates perfectly, even when exposed to pressure fluctuations.

The ratio between the product pressure and barrier pressure also remains constant at all times, which has a positive effect on the load on the seal, and thus on its service life. The pressure booster also has the advantage of not having to be connected to the nitrogen supply system to generate the barrier pressure.

Correct choice of seal

To summarise, it can be seen that a long service-life and high operational reliability of the shaft seal not only depend on the right choice of seal and materials, but also on how it is operated.

If the characteristics of the manufacturing process and properties of the chemical substances are also taken into account, the maintenance costs can be kept low, and the availability of the facility greatly increased.

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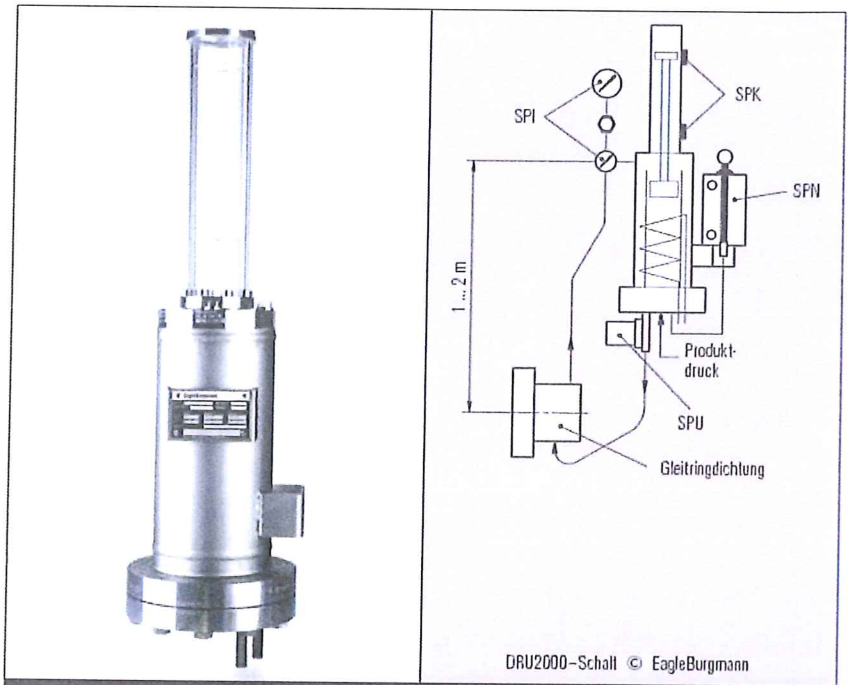

The EagleBurgmann pressure boosting system enables double and tandem seals to be supplied for a wide range of applications (*Figure 3a, left*). Function and installation diagram (*Figure 3b, right*) for a pressure boosting system. The pressure booster must be fitted above the seal. The barrier medium flows via the return line to the tank and is cooled. The fluid is exchanged using the thermosiphon principle, or by forced circulation.