The Magazine For Pump Users Worldwide

October 2005

PUMPS & SYSTEMS

pump-zone.com

OPPORTUNITIES IN WASTEWATER

Also inside:

- Extending Seal Life
- Removing Noxious Odors from Wastewater
- Coatings Improve Pump Efficiency

Extending Seal Life

with Bi-Directional Mechanical Seal Pumping Rings

Richard Smith, AESSeal, Ltd., and Heinz P. Bloch

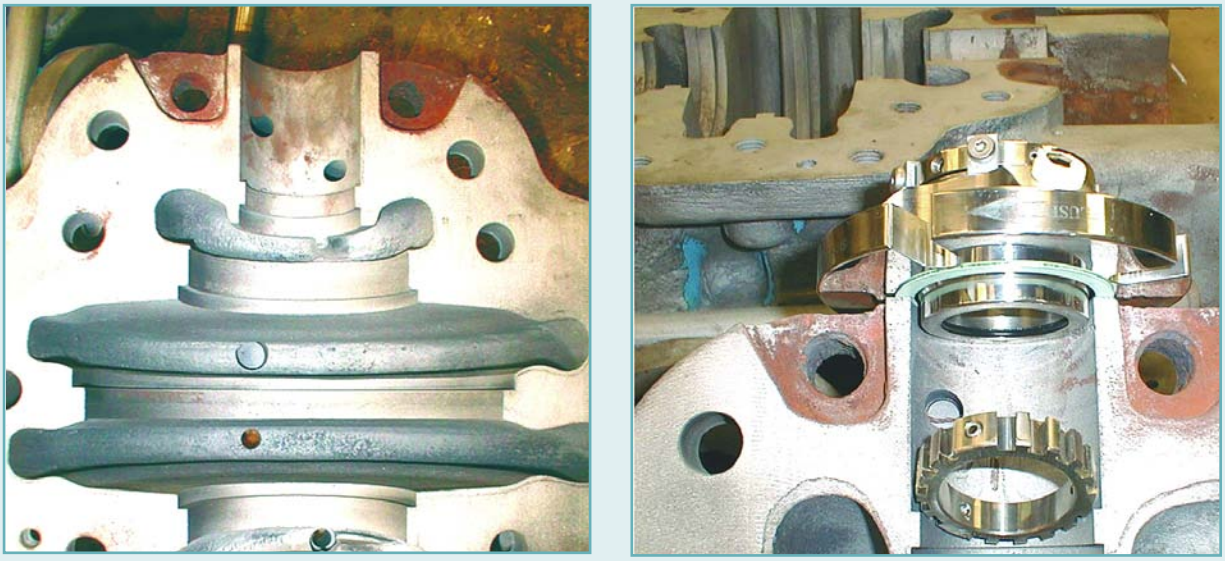

Figure 2. A traditional paddle-type configuration with tangential ports is shown on the left. This configuration is shown in a non-elegant application of Plan 23 on the right.

API Plan 23 wasn't widely accepted due to the complications of applying old-style seal circulating devices or pumping rings. Not any more. New CNC manufacturing technologies now make simple Plan 23 cartridge seals available in a compact format that easily applies to both new and old machines – and modern Plan 23 configurations significantly extend the life of single conventional mechanical seals.Enhanced Cooling

API Plan 23 is one of the seal piping flush plans detailed in the international API 682 mechanical seal standard that is widely used in the hydrocarbon processing industry. Plan 23 essentially changes the environment in which the seal operates by cooling and circulating the fluid contacting the seal faces.

To understand how the plan works, consider a greenhouse or botanical garden enclosure that creates a controlled climate enabling delicate tropical plants to thrive in a benign environment regardless of the harsh, cold conditions outside. Plan 23 achieves a similarly benign seal environment by using a throat bushing to effectively isolate the seal chamber from the pump chamber (Figure 1). The small volume of liquid in the seal chamber circulates through a local cooler.

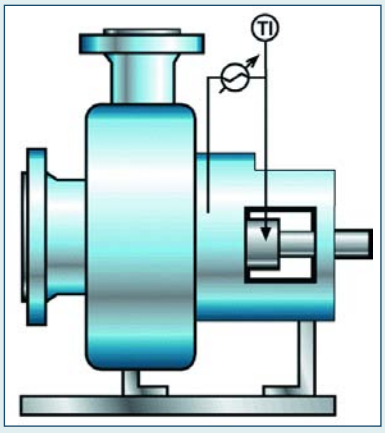

Figure 1. Plan 23 schematic.

Plan 23 is used on hot applications and minimizes the load on the cooler by cooling only the heat generated by the seal faces and heat soak through the seal chamber casing. In traditional layouts, the liquid circulates from a pumping ring in the seal chamber through this cooler and back to the seal chamber. Note that the seal pumping or circulating device is at the very heart of Plan 23.

Reliability

A few guidance notes in API 682 focus on reliability, such as:

Annex A 4.8 – "Plan 23 . . . . . is the plan of choice for all hot water services, particularly boiler feed water," and "Plan 23 . . . . . is also desirable in many hydrocarbon services where it is necessary to cool the fluid to establish the required margin between fluid vapor pressure and seal chamber pressure."

6.1.2.14 (note) – ". . . . . maintaining an adequate vapour pressure margin helps protect the seal faces against localized boiling of the process fluid at the seal faces. This can cause loss of seal-face lubrication and subsequent seal failure . . . . ." and "Lowering the flush fluid temperature is always preferable to pressurizing the seal chamber."

These notes direct our attention toward seal chamber circulating devices.

Seal Chamber Pumping Rings (Circulating Devices)

Many pumping rings found in mechanical seals are based on a straight vane or paddle-type configuration (Figure 2).

Representing a very small and rather inefficient impeller, typical pumping rates achieved with traditional pumping rings are very low. They operate only in the plane where the ports and the paddle are located (see API 682 and the notation in paragraph 7.2.4.2). Tangential porting is required and in many instances, the paddle directs little or no liquid flow over the seal faces.

Though pumping screws are more efficient, they must rely on close working clearance between screw periphery and housing bore. This close gap can be a serious liability in situations where shaft deflection or concentricity issues exist. Maintaining a close gap also contradicts the API 682 requirement of a minimum radial clearance of 0.060-in (1.5-mm) stipulated in API 682, paragraphs 8.6.2.3 and 6.1.2.6 (Figure 3).

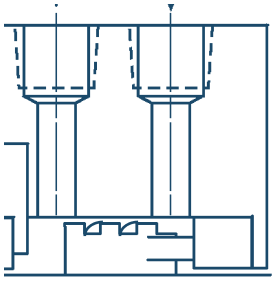

Figure 3. Screw type API 682 clearances.

Poor efficiency associated with these relatively large clearances tends to make screw devices almost as ineffective as the traditional pumping rings. Moreover, traditional pumping screws are unidirectional, leaving ample opportunity for human error on between-bearing pumps, where left-hand devices are obviously required on one end and right-hand devices on the other end.

An Important Alternative Solution

An innovative manufacturer of mechanical seals has developed a unique bi-directional pumping device that imparts relatively high head, and an especially high flow rate, even with the large clearances prescribed by API 682 (Figure 4).

Figure 4. A bi-directional large clearance taper cavity pumping ring.

Computerized fluid dynamic (CFD) methods optimized this bi-directional pumping ring design, creating a considerably more efficient option that provides Plan 23 sealing (Figure 5).

Figure 5. Using the latest CNC machining techniques, a series of helical vanes are cut in both directions at an approximate angle of 45-deg. The ring is given a shallow tapered contour and operates in a taper-bored cavity.

Incorporation Into Cartridge

This patented pumping ring is applied in over 3,000 of the manufacturer's standard (SMSS) single cartridge stationary mechanical seals (Figure 6).

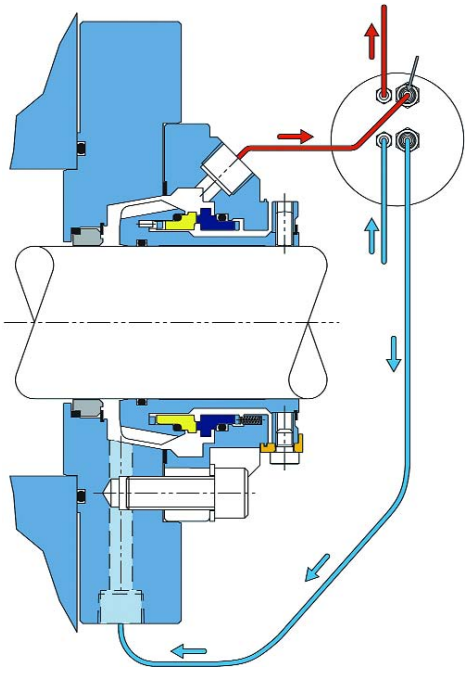

Figure 6. An SMSS 23 section.

The bi-directional pumping contours are sculptured into an extended cartridge sleeve. The associated gland plate provides the taper cavity, secondary port and throat bushing. The unit is a compact self-contained design, simply applied to and incorporated within existing pumping machinery. Monolithic faces provide face stability. Stationary springs provide self-aligning capability which addresses concerns with pumps at high temperature, where loss of perpendicular alignment of seal chamber face-to-shaft is a potential issue (see API 682, paragraph 6.1.1.5, and the pertinent note for stationary seals).

Tanker Tells the Story

The advantages of Plan 23 over those of Plan 21 are interesting. In a Plan 21 flush layout, process fluid

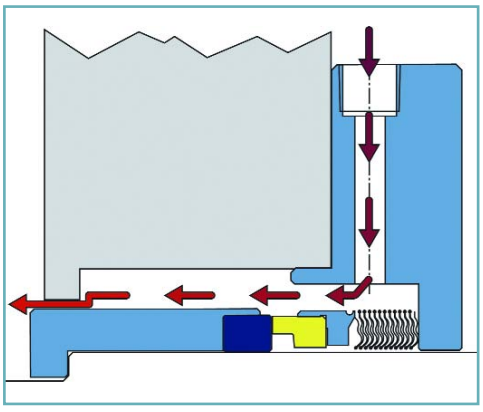

Figure 7. A Plan 21 flush layout.

circulates from the discharge of the pump through a restriction, cooler and into the seal flush (Figure 7).

One important application was on a VLCC crude tanker, where exhaust gas economizer water circulation pumps operated at 356-deg F (180-deg C) and 308-psi (21-bar). The pumps were furnished with a 35-mm diameter stationary bellows mechanical seal and API Plan 21 configuration. Service life of the seals was less than 12 months.

Special software was used to calculate cooler heat loads for both Plan 21 and Plan 23 operation. Plan 21 results demonstrate the seal would operate in excess of 244-deg F (118-deg C), with a cooler load in excess of 40-hp (30-kW).

The same parameters for Plan 23 operation calculated significant efficiency improvement. Seal faces now operated in a seal chamber temperature of 134-deg F (57-deg C), with a cooler load of 1.7-hp (1.3-kW), or 1/20th of the heat load of the Plan 21 condition. An SMSS 23 mechanical seal replacement has now been in service for four years, with the customer enjoying annual savings of over $6,000.

Comments from the API 682 standard anticipate and endorse these results:

"In a Plan 23, the cooler only removes seal face-generated heat, plus heat soak, from the process."

"This duty is usually much less than that in a Plan 21. Lessening the duty is very desirable because it extends the life of the cooler."

"The industry has considerable negative experience with Plan 21 because of cooler plugging."

Lessons Learned

Plan 23 offers improved vapor pressure margin in the seal chamber to extend seal reliability. The reduced working temperature of the seal from Plan 23 operation prevents coking on the atmospheric side of many mechanical seals in hydrocarbon services, which again enhances seal life.

These are all positive impacts on pump MTBF – and on corporate profits. **P&S**

Richard Smith is a sales engineer at AESSeal, Ltd., Mill Close, Bradmarsh Business Park, Rotherham, United Kingdom S60 1BZ, +44 (0)7775 706321, www.aesseal.co.uk, r.smith-@aesseal.co.uk.

Heinz P. Bloch is a Consulting Engineer with Process Machinery Consulting in West Des Moines, IA 50266 (www.machineryreliability.com). He can be reached at hpbloch@mchsi.com