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COMPLEMENTARY PRODUCTS AND DEVICES

DRY GAS SEAL SYSTEMS FOR EQUIPMENT WITH SLOW SHAFT ROTATION

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Dry gas seal (DGS) systems used by the scientific-production firm Greis-Inzhiniring to equip power-generating plant have been investigated. Specifications of DGS of slow-speed reactor stirrers for stirring reaction mixture in acetic acid production are given. A schematic diagram of the instrumentation panel of the DGS of the reactor stirrer is given and its functions are listed and the merits of the DGS are shown.

Dry gas seal (DGS) systems of rotary shafts began to be actively promoted in the sealing engineering market in the 1980s. Currently, DGS are the most reliable, efficient, and safe seals and are effective substitutes for conventional seals (slit, face, labyrinth, etc.) in various fields of engineering. Today, nearly 70% of the centrifugal compressors made in the world are fitted with DGS systems.

Use of DGS systems of rotary shafts makes it possible:

- to enhance the quality of the pumped medium because of prevention of its fouling by the sealing fluid (oil, water, etc.);
- to eliminate expenditures for loss, regeneration, and replacement of the sealing fluid itself;
- to eliminate energy consumption for functioning of start-up and main sealing fluid pumps;
- to reduce frictional losses in the seals by an order of magnitude; and
- to increase reliability of the equipment and substantially reduce the cost of current (routine) maintenance through elimination of a large number of bulky equipment forming a part of the sealing fluid system (start-up and steady (continuous) pumps, oil ejectors, degassers, pressure tanks, etc.).

The areas of application of DGS systems are expanding steadily. New materials and technologies are coming into use, which make these seals usable for sealing at ever higher pressures, temperatures, and diameters of the shafts of the devices being sealed.

Several types of equipment, which NPF Greis-Inzhiniring fit with DGS systems, are distinguishable.

Centrifugal Compressors

In October 2007, the service life of the first DGS systems installed on centrifugal compressors for ammonia production at Akron in Velikii Novgorod was 12 years. In this case, the DGS systems were used continuously with a short annual break for scheduled maintenance of the equipment. The trouble-free operating time of the first DGS system reached as many as 100,000 hours. On a recent inspection it was found that the state of the seal assemblies makes it possible to extend the overhaul time of the equipment to two years.

Centrifugal Pumps

Installation of DGS systems on centrifugal pumps confirmed the urgency of their use for complex and corrosive chemical fluids since they ensure double sealing and have high corrosion resistance and chemical stability.

NPF Greis-Inzhiniring OOO, Sumy, Ukraine. Translated from Khimicheskoe i Neftegazovoe Mashinostroenie, No. 11, pp. 27–29, November, 2007.

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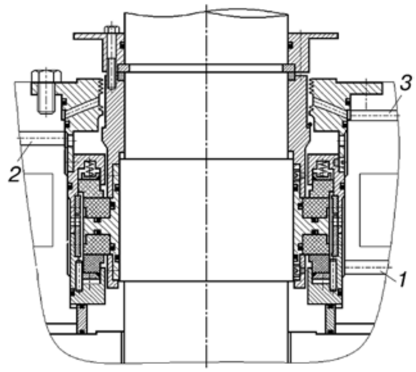

Fig. 1. Design of the DGS unit of the reactor stirrer.

Turboexpanders

Installation of DGS systems on natural-gas turboexpanders at local power plants making secondary use of the energy of the compressed gas greatly simplified the task of the turboexpander designers. If usual seal lubrication systems were to be installed, it was imperative to develop the lubricating system and to increase the dimensions of the turboexpander itself; the operational qualities of the unit may be impaired if the lubricant gets into the working gas.

Steam Turbines

Installation of DGS systems on steam turbines helps save substantial volumes of power (driving) steam that escape through the end-labyrinth system. Use of DGS sharply raises the economic indices of the turbine.

An evidence of the high reliability of the Greis-Inzhiniring products is that all DGS systems manufactured and supplied by this enterprise since 1994 are being used successfully.

Thanks to the obvious merits of the DGS systems, they are usable for equipping not just equipment for which use of dry seals is considered traditional. Quite often, requests are received for installation of DGS systems on equipment with slow shaft rotation (less than 300 rpm).

In this context, statically relieved seals were made for slow-rotating equipment. They were successfully put into service on a reactor stirrer for acetic acid production at Nevinnomysskii Azot in November 2004, on a reactor stirrer for caprolactam production at KuibyshevAzot in Togliatti in January 2005, and on a reactor stirrer for acetic acid production at SGPP Ob'edinenie Azot (Severodonetsk) in April 2005.

A special feature of the reactor stirrer is slow shaft rotation (from 20 to 300 rpm) at which it is difficult to create a stable gas-dynamic layer. So it was decided to replace the gas-dynamic seals (a gas wedge is formed between the seat and the face upon rotation of the shaft) with statically relieved seals (detachment of the face and formation of a seal gap occur under static condition when pressure is applied).

For such slow rotation speeds, the gas-dynamic component of the force of face detachment hardly affects seal performance, so the grooves on the working surface of the rotating seat are bidirectional (reversible). This helps reduce the probability of errors in seal assembling, simplify supply of spare parts and reduce their requisite number, and use the seals for reactors where reversible shaft rotation is possible.

Let us examine the design peculiarities of the statically relieved seals with reference to the DGS unit of a vessel with a reaction mixture stirrer for acetic acid production (Fig. 1).

The DGS unit is made in the form of a back-to-back double seal where the double end-labyrinth is blown out with barrier nitrogen. In such a scheme, the DGS unit consists of two stages of dry gas seals facing each other and a double end-labyrinth.

The buffer gas is supplied to the seal through the channel *1*. The inner stage of the seal restricts access of the buffer gas into the process and the outer stage, escape to the atmosphere.

TABLE 1

Parameter	Production	
	of caprolactam	of acetic acid
Medium being sealed	H_2SO_4 – up to 19%; HAC (drops) – up to 24%; NO – up to 11%; N_2 – up to 10%; N_2O – up to 5%; H_2 – up to 64%	CO – 30.2%; CH_3J – 25.9%; H_2O – 19.5%; CH_3COOH – 12.3%; H_2 – 5.2%; N_2 – 4.0%; CO_2 – 2.7%; CH_4 – 0.2%
Shaft rotation speed, rpm	160	89
Pressure of the working medium, MPa	0.07	Static: up to 5.0 Normal condition: up to 2.9
Temperature of the working medium, °C	40–50	20–195
Buffer gas	N_2	Pressure testing: N_2 Normal condition: CO
Pressure of buffer gas, MPa	0.3–0.6	Pressure testing: up to 5.5 Normal condition: 3.2
Leakage* (not more than), liter/min:		
into the process	10	15
to the atmosphere	20	40
Barrier gas for blowing out end-labyrinths	No	N_2
Relative axial shift of the rotor and stator parts of the seal, mm	±2.5	±1.5

* Under normal conditions.

The barrier nitrogen is supplied to the end-labyrinth through the channel *3*. A part of it moves to the side of the seal and through the channel *2* blows out the leakage of the outer stage of the seal to a safe area and the other part escapes straight into the atmosphere.

In the cases where harmless and nontoxic gases (air, nitrogen, etc.) are used as buffer gases, the end-labyrinth can be blown out with barrier air or blowing can be eliminated altogether from the scheme (used in DGS units for reactor stirrer for caprolactam production at KuibyshevAzot, Togliatti).

The specifications of the DGS of the reactor stirrer are cited in Table 1.

The back-to-back arrangement of the double seal is common for equipment where the possibility of buffer gas entry into the medium being stirred or pumped must be restricted in accordance with production conditions.

Depending on the operating parameters of the seals, type of the working medium and the buffer gas, and arrangement of the equipment, use of other versions of seal unit assembly is also possible. Also, the seal unit can be combined with a bearing unit. Such a design can be used to reduce radial wobbling of the shaft in the area of seal unit installation.

The design the instrumentation panel of the DGS is simple and reliable. It includes a standard set of control valves, buffer and barrier gas filters, and advanced control and measuring instruments (Fig. 2). The instruments and transducers (sensors) have electrical leads for connecting DGS instruments with the automated control system (ACS) of the plant department.

Functions of DGS Instrumentation Panel

- cleaning of the buffer gas on an F-1 filter before supply to the seal;
- monitoring of buffer gas pressure with a PISA-01 transducer, transmission of pressure level signal to an automated control system (ACS);

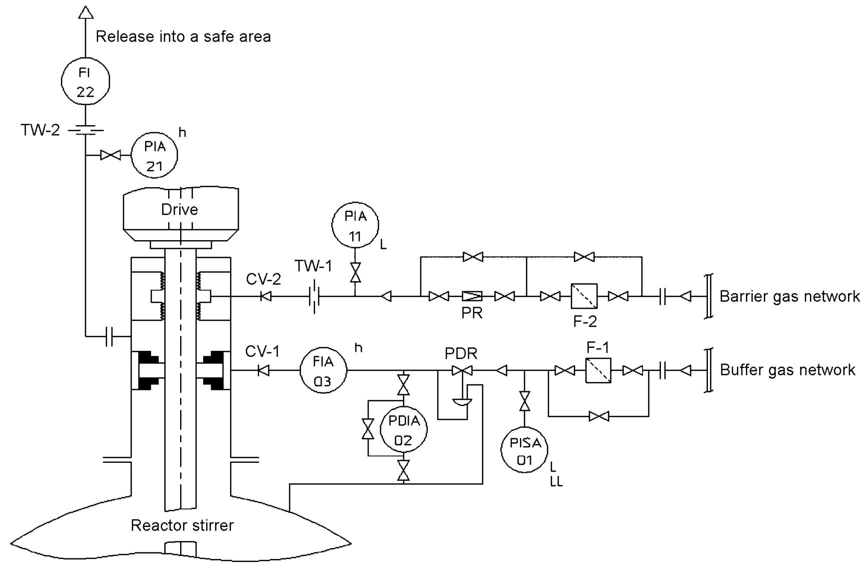

Fig. 2. Schematic diagram of DGS instrumentation panel for reactor stirrer.

• maintenance of the fixed excess of buffer gas pressure above the pressure in the reactor (gas–gas pressure difference) with the help of a pressure difference regulator (PDR);
• monitoring of gas–gas pressure difference with the help of a PDIA-02 transducer, transmission of pressure difference signal to the ACS;
• monitoring of buffer gas flow into the seal (total leakage through the outer and inner stages) with the help of a FIA-03 rotameter, transmission of flow rate signal to the ACS;
• preventing entry of the reaction mixture into the buffer gas network with the help of a check valve CV-1;
• cleaning of barrier nitrogen on an F-2 filter before it is supplied to the seal;
• maintenance of the set barrier nitrogen pressure during supply to the seal with the help of a pressure reducer (PR);
• monitoring of barrier nitrogen pressure with the help of a PIA-11 transducer, transmission of pressure signal to the ACS;
• ensuring the required rate of barrier nitrogen flow to the seal with the help of a calibrated restraining throttle washer TW-1;
• preventing entry of the reaction mixture or of the buffer gas into the barrier nitrogen network with the help of a CV-2 check valve;
• monitoring of leakage through the outer stage with the help of an FI-22 flowmeter; and
• monitoring of leak-tightness of the outer stage with the help of a PIA-21 transducer, transmission of signals of pressure in the outer leakage removal line to the ACS.

While making DGS instrumentation panel, Greis-Inzhiniring tries to ensure maximum compliance of their functions with the operation conditions.

For preparing and coordinating the technical task, the experts of the company familiarize themselves with all technical and technological characteristics of the updated or planned equipment. So, in spite of efforts to standardize the manufactured product, each new familiarized type of equipment needs fresh approaches and designs in the devices of the instrumentation panels.

Dry gas seals were first installed in reactor stirrers in 2004. Operation demonstrated notable merits of the new seal systems resulting from considerable enhancement of reliability and durability of the seals. High reliability was attained by adopting design solutions that may allow complete elimination of contact of the seal surfaces during use, as well as by using advanced materials and surface finishing technologies, which ensures high corrosion resistance in highly corrosive media. As a result, the service life of the seals increases tens of time. In this case, because of 100% sealing of the reaction mixture, ecological cleanness of the equipment increases under hazardous and toxic production conditions.

Thanks to elimination of liquid seal system, the run between overhauls of the equipment increases and operational costs diminish substantially.

In concluding, it must be noted that the experience of operation of DGS systems of NPF Greis-Inzhiniring on reactor stirrers shows them to be highly reliable and efficient and confirms the benefit of wide use of these systems for sealing devices with slow shaft rotation.