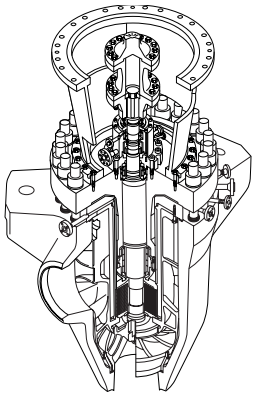


Improved Shaft Seal for 93A Type Reactor Coolant Pump

YASUHIRO SASAKI*1
KAZUYUKI OBATA*1
OSAMU HISAI*2
TOSHIHIKO MATSUO*2
NAOTAKA KOMATSU*3
HIDEKAZU UEHARA*3

1. Introduction

Reactor coolant pump (RCP) that operate in pressurized water reactor serves to transmit thermal energy generated in a reactor to a primary coolant and circulate the primary coolant between a steam generator and the reactor. Such pumps operate at all times while the plant is in operation. A shaft seal which prevents the leakage of coolant from the shaft penetration of the RCP to outside the system are required to perform stably since it is directly coupled to the continuous operation of the pump.

The pump seal system consists of three seals. The first stage seal (hereafter referred to as the No. 1 seal) is a controlled-leakage film-riding face seal. It adopts a non-contact limited leakage system with less variation in characteristics with the passage of time during long period operation (approx. 1 year) under the conditions of high differential pressure (**Fig. 1**).

In a conventional No. 1 seal, the characteristics of the seal would be changed due to variations (disturbances) in pressure, temperature, and water quality around the seal. In the worst case, there was the possibility of that the continuous operation of the plant would be adversely affected. An improved shaft seal with stable characteristics designed to prevent such unstable events is introduced in this report.

2. Functions of No. 1 seal

The No. 1 seal has the function of reducing the pressure of the coolant from 15 to 0.3 MPa and consists of a rotating side seal runner and a stationary side seal ring. Both of the seal runner and seal ring consist of a ceramic faceplate and metallic retainers that fix the faceplates in place (**Fig. 2**).

Two faceplates are positioned opposite to each other. The faceplate of the seal ring is slightly tapered. Clearance is maintained at a constant distance by the force due to the taper acting on the seal ring and the balancing function of the clearance. The faceplates control the amount of leakage that might occur from the seal while the pump is in operation. Conventional seals have several properties in which the amount of leakage varies due to variations in the amount of taper caused when the faceplate is deformed slightly by some disturbance (Fig. 2 (a)).

3. Features of the improved No. 1 seal

Mitsubishi Heavy Industries, Ltd. (MHI) has developed an improved No. 1 seal that has more stable characteristics for dealing with disturbances than that of conventional seals (Fig. 2 (b)).

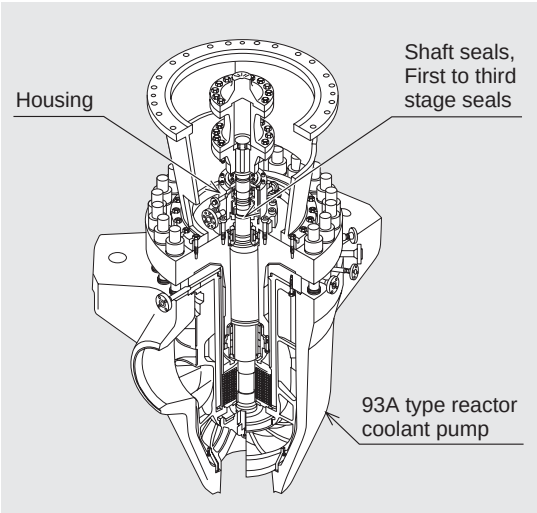


Fig. 1 93A type reactor coolant pump
Birds' eye view of pump and description of shaft seal

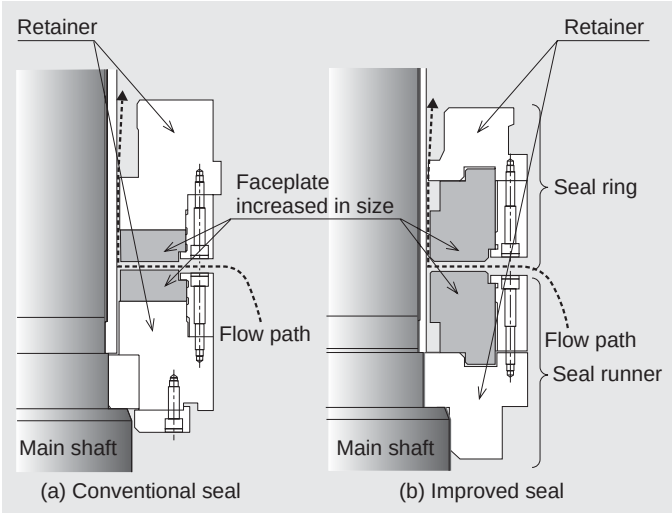


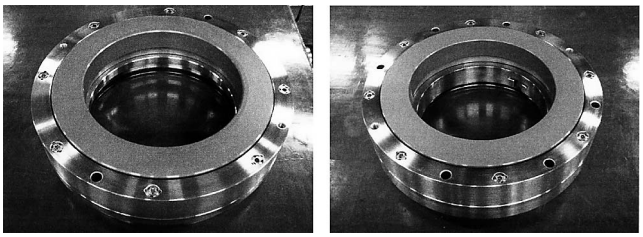
Fig. 2 Features of improved seal
Points of improved over conventional seal

*1 Kobe Shipyard & Machinery Works
*2 Takasago Machinery Works
*3 Takasago Research & Development Center, Technical Headquarters

3.1 Points of improvement over conventional seals

Conventional seals are designed in such a way that the faceplate follows up the deformation of the retainer according to the deformation of the seal by pressure acting on the seal. MHI has found that the force acting on the faceplate varies according to the states of the contact of the two parts and the effects of disturbance. The characteristics vary according to the differences in the state of deformation by several μm for the faceplate approximately 300 mm in diameter.

In the improved seal, the faceplate is increased in size in order to enhance rigidity, so that the amount of deformation against disturbances can be reduced. The ceramic material used in conventional seals has been changed from Al_2O_3 (alumina oxide) to Si_3N_4 (silicon nitride), which has a range of excellent characteristics (**Fig. 3**).



Seal runner　　Seal ring

Fig. 3 Improved seal (View of seal runner and seal ring)

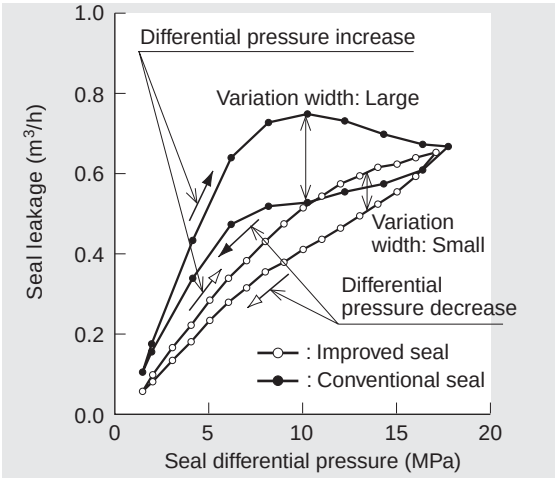


Fig. 4 Characteristics of seal
Comparison between the characteristics of a conventional seal and the improved seal with regard to the amount of leakage for various levels of seal differential pressure.

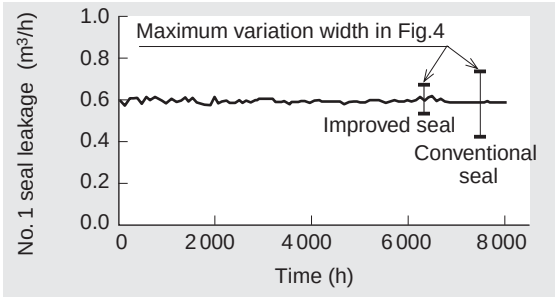


Fig. 5 Results of continuous operation test
Shows stable amount of leakage over a long period of time.

In addition, the interface of the seal with the main shaft of the seal runner, and the interface of the seal with the stationary side seal ring have been made identical to those of conventional seals. The same level of maintainability as that of conventional seals has been secured, and the installation of improved seals has been possible without modifying the pump body.

3.2 Results of verification test

Verification tests were conducted under simulated actual conditions to verify the stable characteristics of the improved No. 1 seal. From these tests, it is confirmed that the characteristics of the improved No. 1 seal are stable, even under conditions in which possible disturbances and estimated deterioration modes in the actual reactor may occur (**Fig. 4**). Since the actual reactor is operated continuously over a period of about one year, operational testing was also conducted for an equivalent period adding up to a cumulative total of one year (approx. 8 000 hours) under the same simulated conditions. As a result, it is confirmed that the improved No.1 seal can maintain stable characteristics for a long period of time (**Fig.5**).

4. Application to actual reactor

After the improved No.1 seal was developed, it has been in continuous use in the actual reactor under stable operation since the middle of October 2004. In the future, the improved No. 1 seal is scheduled to be progressively adopted in reactors of the same type of RCP. Moreover, improved seals based on the same concept are also scheduled to be adopted in reactors in newly constructed plants and other existing types of RCPs, as well.

5. Conclusion

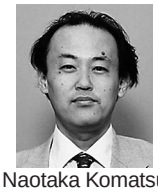
In order to achieve stable plant operation by stabilizing the characteristics of the No. 1 seal adopted in the RCPs, which is a critical component directly linked to the continuous operation of a nuclear power plant, MHI has completed development of an improved No. 1 seal and has started to adopt it in actual reactors. In the future, MHI will progressively promote the application of these types of seals in actual reactors in response to the needs of customers to contribute to the stable operation of such plants.


Yasuhiro Sasaki


Kazuyuki Obata


Osamu Hisai


Toshihiko Matsuo


Naotaka Komatsu


Hidekazu Uehara