Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 29-30, 2014

Present activities of the Helium Supply System for ITER HCCR TBM

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1. Introduction

In Korea, the HCCR (Helium Cooled Ceramic Reflector) Test Blanket Module (TBM) has been developed to be tested at ITER for development of tritium breeding technology [1-4]. The HCCR TBM is designed cooling down by the helium cooling system (HCS) with high temperature and pressure (300-500 ℃, 8 MPa) helium gas and its mass flow rate is 1.5 kg/s during normal operation.

The scaled-down helium supply system (HeSS) had been constructed and modified to obtain thermal-hydraulics test data, operational experience and to validate the HCS design in 2011-2013 [5]. The first HeSS was constructed in 2012, however more than 2 MW of heating power is required to heat up room temperature to 300 ℃ for normal operation helium flow condition of the HCS (=1.5 kg/s). In 2013, a recuperator was installed in the HeSS facility to reduce the required heating power from 2 MW to 150 kW and to control helium mass flow rate and the temperature more effectively, yet the circulator was able up to 0.5 kg/s of helium mass flow which is only one third of normal operation condition of HCS.

In present status, a full-scale helium circulator is developing in Jinsolturbo Co. and the real-scale circulator will be installed in the HeSS facility by end of 2014.

2. Present activities of the HeSS facility

Present HeSS consists of the helium pre-heater (150 kW), the PCHE type helium cooler and recuperator, the filter, and the 1/3-scale circulator to supply 300 ℃ and 8.0 MPa of helium gas flow with a maximum 0.5 kg/sec.

The diffusion-bonded heat exchanger (so-called PCHE, printed-circuit heat exchanger) is installed in HeSS as a recuperator because of its high efficiency and compactness. The helium mass flow rate is controlled by handling the RPM of the circulator and bypass valve-1, and the temperature is controlled by the electric power of the pre-heater and bypass valve-2.

The HeSS was tested a trial run with about 2 MPa nitrogen gas as working fluid. During the trial operation, however, the circulator had broken down. In the thorough overhaul of the circulator, it was found out that the axial bearings were failed as shown in figure 1. When the circulator was designed, one of the important design requirements was the pressure ratio in order to overcome pressure drop of the loop for helium circulation with 0.5 kg/s of mass flow rate. So, the axial bearing was mainly designed to endure the axial load came from the helium compression. In the trial run, all valves were open and any mock-up was not installed in the HeSS. There is, therefore, little pressure drop in the loop and it cause the anti-axial load in the circulator. Unfortunately, the anti-axial load, which is generated by operation with condition of little pressure drop, was not consideration of the circulator design requirements.

(a) Journal bearing

(b) Thrust bearing

Fig. 1. Pictures of the damaged bearings

3. Specifications of the full-scale circulator for HeSS

A full-scale circulator is developing by Jinsolturbo Co. solving the revealed problems and the circulator will be installed in the HeSS facility by 2014. Major differences of the full-scale circulator design are pressure ratio for full-scale helium mass flow and magnetic coupling between an impeller and a shaft. The circulator is designed mechanically separated between the impeller and the shaft so that a drive motor operates in air environment in order to avoid corona effect problem. The rotational momentum is transfer from the shaft to the impeller by magnetic coupling device. The 3-D modelling of the circulator and magnetic coupling device are shown in figure 2 and the technical specifications of the circulator are summarized in table I.

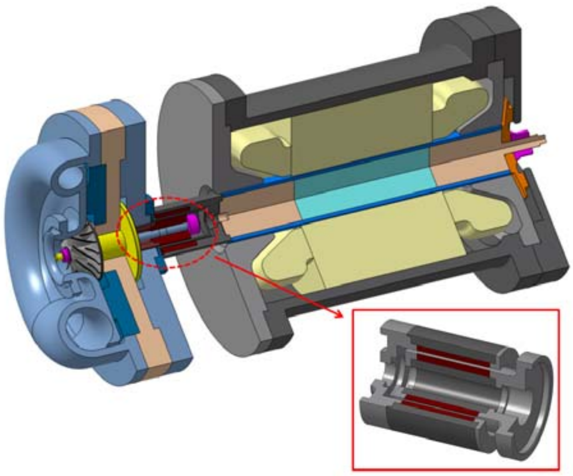

Fig. 2. 3-D modeling of the full-scale circulator and magnetic coupling device

Table I: Specifications of the full-scale circulator

	Technical Specifications
Operation (Design) Conditions	50 (100) ℃ @ at inlet / 8.0 (10.0) MPa /
Flow capacity	1.5 kg/s of pressurized helium gas (8 MPa)
Pressure ratio	1.1
Mechanical speed	70,000 RPM
Overall power consumption	Less than 150 kWe
Power supply	380 V, AC 3-phases

4. Conclusions

A 1/3 scaled-down helium supply system was constructed to obtain thermal-hydraulics test data, operational experience of the HCS and to validate the HCS design in 2013 at KAERI. During the trial run, however, the scaled-down circulator was failed because the anti-axial load caused failure of the journal and thrust bearings. To solve the revealed problems and to make full-scale mass flow rate, the full-scale circulator is developing by Jinsolturbo Co and it will be installed in the HeSS facility by 2014.

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