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Current status and commissioning tests of the HeSS experimental facility

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1. Introduction

The helium cooled ceramic reflector (HCCR) concept was proposed as a cooling system for fusion breeding blankets. The HCCR type test blanket module (TBM) and its sub-systems, including a helium cooling system (HCS), are developed to install in ITER machine until 2030 [1, 2].

The HeSS (Helium Supply System) has been constructed and operated to develop the HCS design and operation procedures and also to validate key components of the HCS and GAMMA-FR, a safety analysis code for fusion reactor systems since 2011 [3, 4]. In present study, current status of HeSS and its commissioning tests results are briefly described.

2. Present status of the HeSS facility

The HeSS facility is constructed to demonstrate to the HCS, so the HeSS facility is consists of the components (such as circulator, pre-heater, recuperator, cooler) with the same specifications as the design of the HCS and the specifications are summarized in Table I [5].

The helium circulator had been developed and the first prototype circulator was manufactured in 2016. Through several test operations and design modifications for the following three years, the present second prototype circulator was manufactured and installed in the HeSS facility in 2019 [6]. The HeSS facility can provide up to 8 MPa pressure and 300 ℃ temperature of helium gas flow to a plasma facing component or the HCCR TBM mock-up installed in the high heat load test facility (KoHLT-EB, Ref. 7).


Fig. 1. Picture of HeSS (2020)

Table I: Specifications of the HeSS facility

Working fluid	Helium
Circulating capacity	Centrifugal impeller and air foil bearing type helium circulator 150 kW (up to 70,000 rpm) Pressure ratio of 1.1 (@8 MPa pressure with 1.5 kg/s of inlet helium flow condition)
Heating capacity	150 kW
Recuperating capacity	PCHE type heat exchanger Effectiveness of 0.92 (1.5 kg/s of 1st and 2nd channels helium flow)
Cooling capacity	PCHE type heat exchanger Effectiveness of 0.95
Connected heat load facility	KoHLT-EB (300 kW of electron beam type high heat load test facility)

After verifying the integrity of the circulator through the circulator verification test and checking the seal-tightness of the pipes, and upgrading I&C system with EPICS, all hot pipes and components (heater and recuperator) are insulated with 5 cm thickness of ceramic wool.

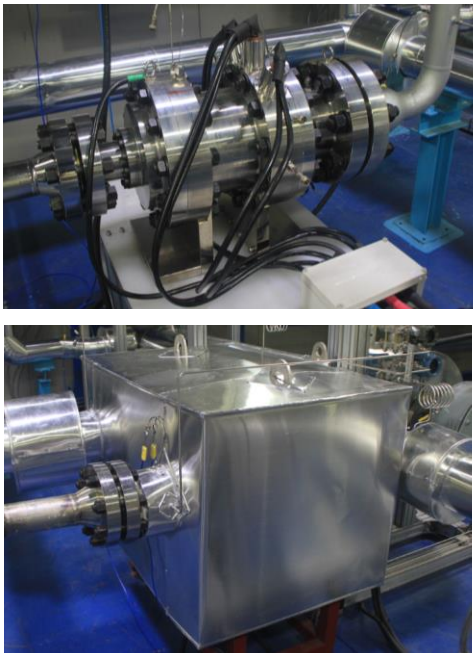
Fig. 2. The upgraded prototype helium circulator and the insulated recuperator installed in HeSS (2020)

3. Commissioning tests

The commissioning tests were performed over two days. I&C system was verified and the components (especially the circulator) was checked through trial run on the first day and the I&C system and the components operated well during the test. On the second day, performance data for the circulator (performance curve) and for the recuperator (effectiveness factor) were obtained in order to compare with their design parameters. The performance test conditions are summarized in Table II. The working fluid and test pressure are argon gas and 10 bar, respectively instead of helium gas considering expense.

Figure 3 shows the performance test results of inlet and outlet temperature in the hot side and cold side of the recuperator. The effectiveness factors for the hot side and cold side are calculated with the measured temperature results for each test step.

When inlet temperature of the hot side is higher than outlet temperature of the hot side (test step 1, 2, 3, and 5), the hot side effectiveness (ε_h) is higher than the cold side effectiveness (ε_c), while the other case (test step 4) ε_c is more higher. The reason this difference in the effectiveness is that the heat capacity of the recuperator is too big (the weight of the heat exchanging core block made of SS316L is more than 1.2 tons), so the recuperator has yet to reach thermal equilibrium during the test. Based on the measure effectiveness, the real effectiveness is higher than the design value of 0.92, so performance of the recuperator is higher than the design target value.

4. Conclusions and future works

The HeSS facility has been modified by upgrading the helium circulator and the I&C system and the commissioning tests were performed to verify the components and I&C system and to obtain the performance data for the circulator and the recuperator.

More performance tests are to be performed in order to understand characteristics of the components thereafter and operation scenario tests for the HCS will be performed to verify the preliminary operation scenario and to update the operation scenario in detail.

Table II: performance test condition and procedure

Working fluid	Argon gas (10 bar)
Flow rate (circulator speed)	0.364 kg/s (12.0 kRPM)
Test procedure	① Circulator ON, Heater ON Set Temp. as 100 °C ② Set Temp. as 150 °C ③ Set Temp. as 200 °C ④ Circulator OFF ⑤ Heater OFF

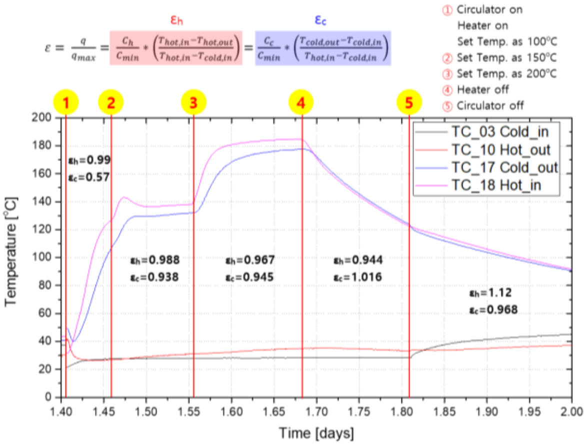

Fig. 3. Performance test results of inlet/outlet temperature of the recuperator and of the measured effectiveness factors

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