Upgrade the helium circulator for the HeSS experimental facility

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1. Introduction

In general, Helium, Water, Liquid Metal coolants are considered as a cooling system for fusion breeding blankets. In Korea, a helium cooled ceramic reflector (HCCR) concept was adopted to be tested as a Test Blanket Module (TBM) and the design of TBM and R&Ds for relevant systems are performed through the ITER TBM program in Korea [1, 2, 3]. A helium cooling system (HCS) has been developed for removal heat from the HCCR during operations

The HeSS facility was constructed to validate the HCS design and its operation methods and also to validate the GAMMA-FR code, developed a safety analysis code for fusion reactor systems. During the HeSS experimental operations, several improvements with the prototype helium circulator were carried out and the circulator should be modified. In this paper, present design of HeSS facility and the circulator are briefly described.

2. Present design of the HeSS facility

The HeSS facility (Fig. 1) is constructed to provide helium gas flow to a mock-up to be installed at the high heat load test facility (KoHLT-EB) with high pressure (8 MPa) and high temperature (300 ℃) conditions up to maximum 1.5 kg/s. The key components of the HeSS facility are the pre-heater, the circulator and the PCHE type heat exchangers (recuperator, cooler) and the major specifications for the key components are listed in Table 1 [4, 5, 6].

Fig. 1. Picture of the HeSS experimental facility (in 2019)

Table I: Specifications for key components

Components of HeSS	Specifications
Pre-heater	Power: 150 kW, Operating/Design press.: 10/8 MPa Operating/Design temp.: 300/450 ℃
circulator	Power: 150 kW Pressure ratio: 1.1 Operating/Design press.: 10/8 MPa Operating/Design temp.: 50/100 ℃ Speed: up to 70,000 rpm Flow rate: 1.5 kg/s
Recuperator (PCHE type)	Effectiveness: ~ 0.92 Operating/Design press.: 10/8 MPa Operating/Design temp.: 300/450 ℃

3. Upgrade the helium circulator

The prototype helium circulator had been developed and was installed at HeSS in 2015 [7]. Several design improvements for the circulator were identified due to huge axial load during the HeSS operations. It was necessary to improve the circulator design to reduce the axial load, so the design had been improved to reduce the axial load. The second prototype circulator has been modified by Jinsolturbo; the company designed and manufactured the formal circulator. The upgrade circulator is installed at the HeSS facility on March in 2019 and trial test operation is being under performed in present. The picture and the improvements of the present helium circulator are showed in Fig. 2 and summarized in Table II, respectively.

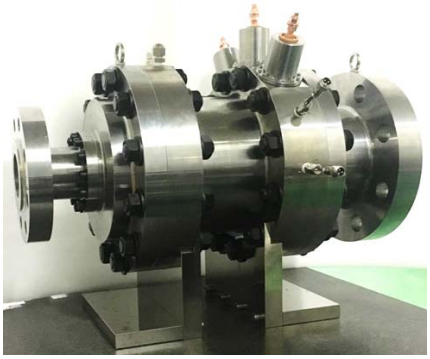

Fig. 2. The upgraded prototype helium circulator (in 2019)

Table II: Design improvements for the helium circulator

Design	Contents of improvement
Motor power	Increase from 120 kWe to 150 kWe
Shaft length	Decrease than formal design
2^{nd} cooling path	Simplified than formal design
Mitigation for axial load	An axial load reducing device added to design; Axial load is reduced by more than three times compared to the formal design

4. Conclusions and future works

Recently the prototype helium circulator has been improved to solve several problems due to the huge axial load by the manufacturer. The upgrade helium circulator is installed at HeSS and the trial run test is in progress to verify the upgraded circulator. After the trial run test, performance tests for the key components (pre-heater, circulator, and recuperator) of HeSS will be started and the tests results to be used for developing and validating the components model in the GAMMA-FR code.

REFERENCES

[1] S. Cho et al., Overview of helium cooled ceramic reflector test blanket module development in Korea, Fusion Engineering and Design, Vol.88, p. 621, 2013.
[2] S. Cho et al., Design and R&D progress of Korean HCCR TBM, Fusion Engineering and Design, Vol.89, p.1137, 2014.
[3] S. Cho et al., Investigation of technical gaps between DEMO blanket and HCCR TBM, Fusion Engineering and Design, Vol.136 part A, p. 190, 2018
[4] E. H. Lee et al., Design and Analysis of a High Temperature and Pressure He Supplying System, 24th Symposium on Fusion Engineering, Chicago, Illinois, USA, 26-30 June 2011.
[5] E. H. Lee et al., STATUS OF HELIUM SUPPLYING SYSTEM CONSTRACTION WITH A HIGH HEAT FLUX TEST FACILITY, Fusion Science and Technology, Vol.64, No.3, p. 641, 2013.
[6] E. H. Lee et al., Design and Construction of a Helium Cooling System for the HCCR TBM, 28th Symposium on Fusion Technology, San Sebastian, Spain, Sep. 29 - Oct. 3, 2014.
[7] E. H. Lee et al., Performance Test of a Helium Circulator for the Helium Cooling System of the HCCR-TBS, 26th Symposium on Fusion Engineering, Texas, USA, May 31-June 4, 2015.