Status of the HeSS test facility for ITER HCCR's HCS

Eo Hwak Lee[1)]*, Chang Wook Shin[1)], Suk-Kwon Kim[1)] , Dong Won Lee[1)], and Mu-Young Ahn[2)]

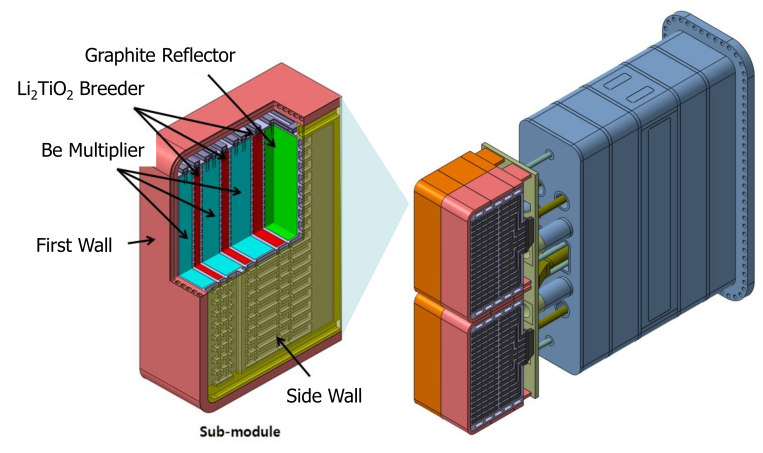
[1)] *Korea Atomic Energy Research Institute, Daejeon, Republic of Korea : *ehl@kaeri.re.kr*

[2)] *Korea Fusion Energy Institute, Daejeon, Republic of Korea*

PO9B09

Introduction

- HeSS (Helium Supply System) is an experiment facility for design verification and experimental data production of the ITER HCCR TBM's HCS (Helium Cooling Ceramic Reflector Test Blanket Module Helium Cooling System). HeSS consists of a circulator, recuperator/cooler (printed circuit heat exchanger type), heater and filter and it was built with real-scale components to the HCS. HeSS can supply high temperature (300 °C) and pressure (8 MPa) of helium flow (1.5 kg/s) to a TBM first wall mockup [1].
- In this paper, present status of HeSS including experimental and maintenance works and near term experimental plan are presented.

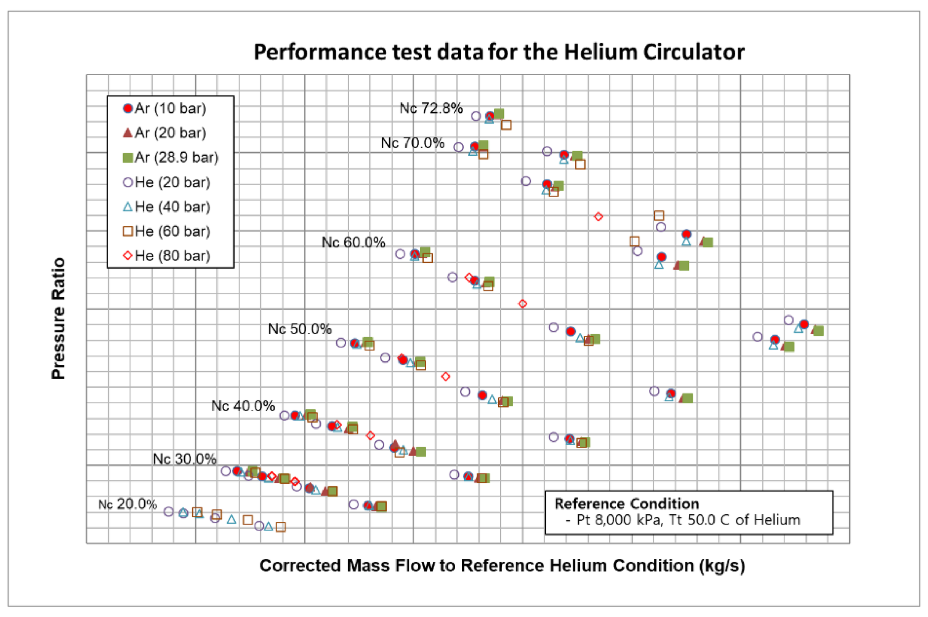


HCCR breeding blanket concept

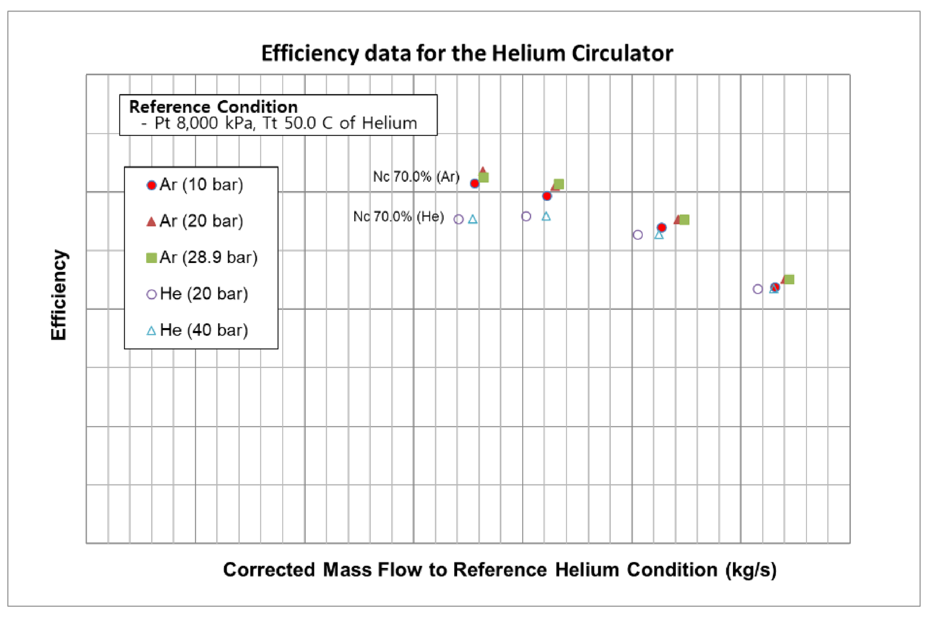
- Four-sub-module Concept
  - Manufacturability
  - Transportation of Irradiated TBM for PIE
  - Reduction of EM Force
  - Endurance of Internal Over-pressure
- Graphite Pebbles as Neutron Reflector
  - Reduce the Amount of Be Multiplier up to 50%
  - Reduce the difficulty of handling Be
  - Decrease of Cost
  - Comparable Nuclear Performance

HeSS status and experimental works

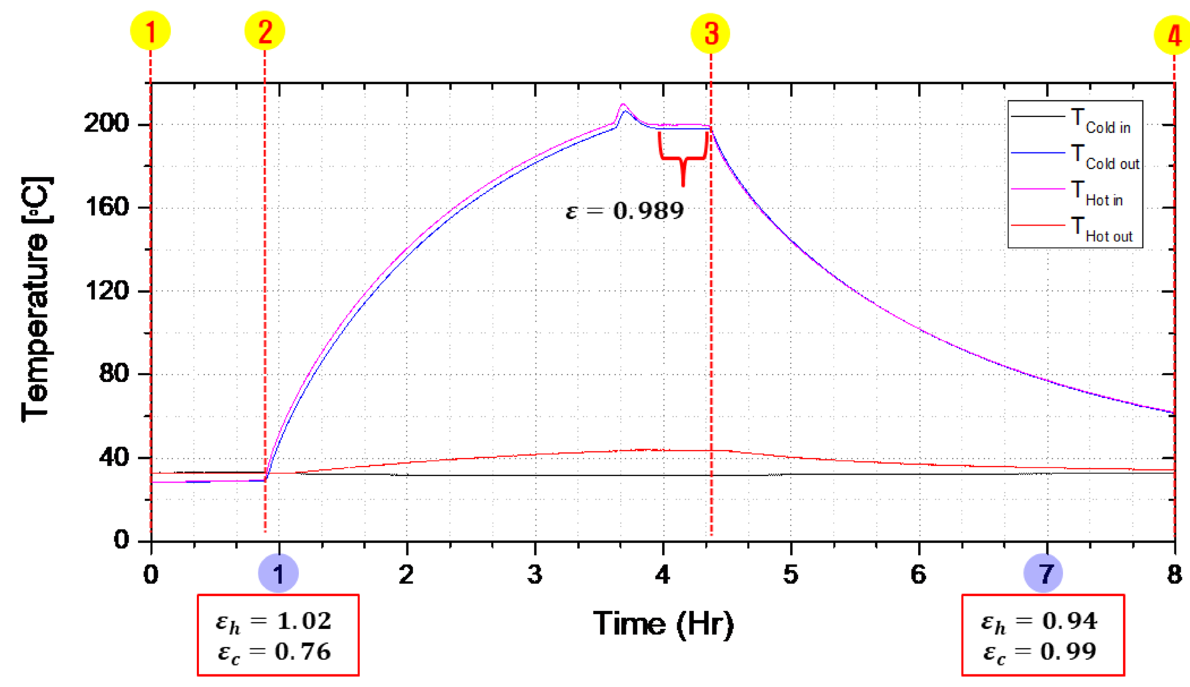
- With the real-scale helium circulator installation in 2019, the construction of HeSS was completed and trial tests was performed successfully [2]. The components tests carried out for the circulator and the recuperator to understand performance characteristics of the HeSS main components.
- Pressure ratio and efficiency data of the circulator were measured using argon and helium gases up to 8 MPa pressure conditions. The measured pressure ratio data are well grouped according to the corrected flow rate in each test data and it shows that the pressure ratio data measured successfully [3]. The efficiency data were obtained by measuring the circulator inlet/outlet temperature. However, this did not consider the heat released out of the circulator and thus could not obtain accurate efficiency data. Therefore, additional tests should be performed to obtain accurate efficiency data by measuring the exact power directly applied to the circulator.
- Effectiveness factor of the recuperator was obtained for single test condition by measuring inlet/out temperatures of each hot/cold side circuits of the recuperator. The effectiveness was measured as 0.989, which was much higher than the minimum design value of 0.92 [3]. Further tests with various flow/temperature conditions are needed to better understand the heat transfer characteristics of the recuperator.



Performance curve test data for circulator

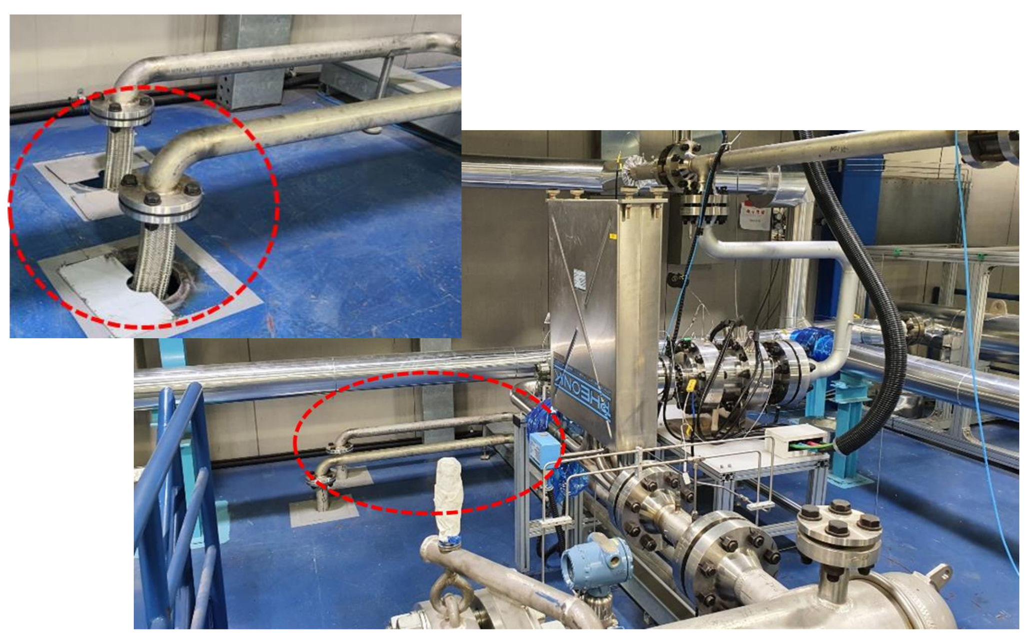


Efficiency curve test data for circulator

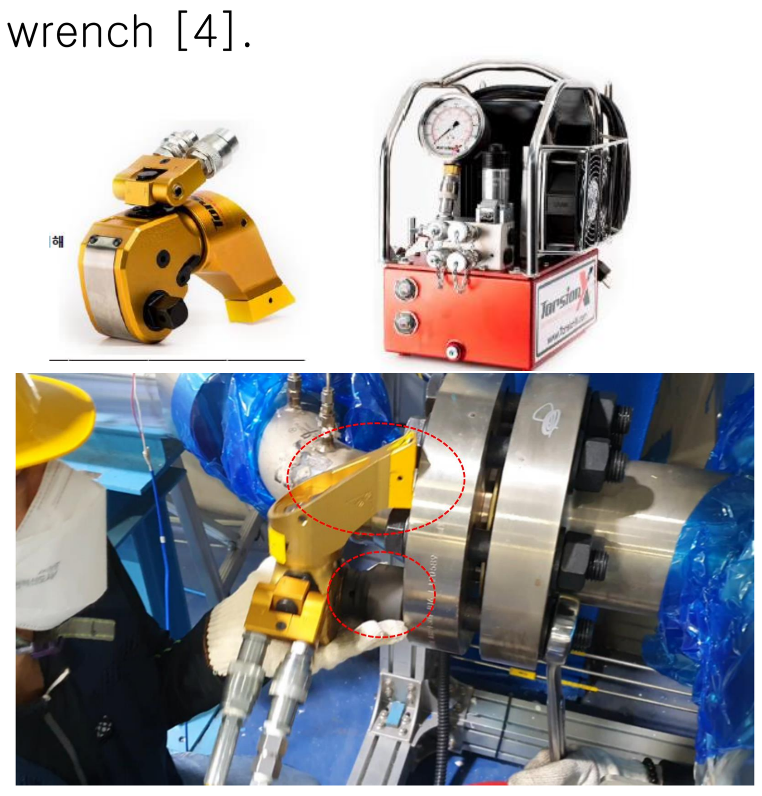


Effectiveness test data for recuperator

- During the performance tests, several items to be improved and modified at HeSS were identified. The vibration from the main helium loop is enough to handle, but the vibration from the secondary water coolant pipes cannot be ignored. This causes problems with the integrity of the Coriolis type flow meter near the water coolant pipes. To solve this problem, flexible hoses are installed in the coolant pipes and the support is reinforced on the flowmeter flanges in present.
- Components and pipes of HeSS (with specification of the helium pipes are DN80, Sch. 80/160 with #900 and #1500 of flanges) were initially assembled manually without any power tools and it was hard to assemble properly to minimize helium leakage. Therefore, the components and pipes of HeSS will be re-assembled in compliance with ASME PCC-1 using a hydraulic torque wrench [4].



Flexible hoses for coolant pipes



HeSS re-assembled with hydraulic torque wrench

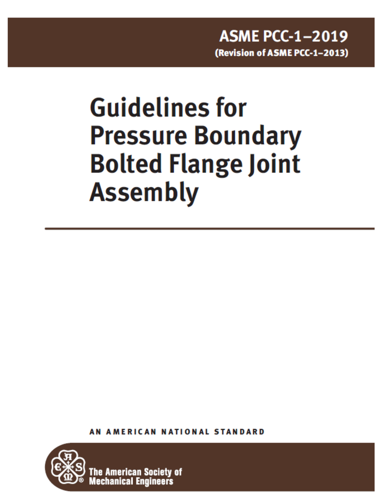


Table 1 Torque Increments for Legacy Cross-Pattern Tightening Using a Single Tool

Step	Loading
Install	Hand tighten, then "snug up" to 15 N·m (10 ft-lb) to 30 N·m (20 ft-lb) (not to exceed 20% of Target Torque). Check flange gap around circumference for uniformity. If the gap around the circumference is not reasonably uniform, make the appropriate adjustments by selective tightening before proceeding.
Round 1	Tighten to 20% to 30% of Target Torque (see section 12). Check flange gap around circumference for uniformity. If the gap around the circumference is not reasonably uniform, make the appropriate adjustments by selective tightening/loosening before proceeding.
Round 2	Tighten to 50% to 70% of Target Torque (see section 12). Check flange gap around circumference for uniformity. If the gap around the circumference is not reasonably uniform, make the appropriate adjustments by selective tightening/loosening before proceeding.
Round 3	Tighten to 100% of Target Torque (see section 12). Check flange gap around circumference for uniformity. If the gap around the circumference is not reasonably uniform, make the appropriate adjustments by selective tightening/loosening before proceeding.
Round 4	Continue tightening the bolts, but on a circular clockwise pattern until no further nut rotation occurs at the Round 3 Target Torque value. For indicator bolting, tighten bolts until the indicator rod retraction readings for all bolts are within the specified range.
Round 5	Time permitting, wait a minimum of 4 h and repeat Round 4; this will restore the short-term creep relaxation/embedment losses. If the flange is subjected to a subsequent test pressure higher than its rating, it may be desirable to repeat this round after the test is completed.

Tightening flange (bolts) procedure in ASME PCC-1 [4]

Summary and future plans

HeSS was constructed and its main components were tested to obtain performance characteristic data. During the tests, the vibration and helium leak issues were identified. In present, HeSS is under maintenance and modification to solve these problems. Additional performance tests will be performed to obtain more data and to understand performance characteristics of the circulator and recuperator. Then, HCS operation scenario test will be follows.

REFERENCES

[1] E. H. Lee et al., Status of helium supplying system construction with a high heat flux test facility, Fusion Sci. and Tech. Vol. 64, No. 3, pp. 641-644, 2013
[2] E. H. Lee et al., Current status and commissioning tests of the HeSS experimental facility, Transactions of the KNS Virtual Spring Meeting, 2020.
[3] E. H. Lee et al., Performance test and modeling with GAMMA-FR of helium circulator and recuperator for helium cooled breeding blanket, Fusion Engineering and Design, 166 112299, 2021
[4] Guidelines for pressure boundary bolted flange joint assembly, ASME PCC-1-2019, the American Society of Mechanical Engineers, 2019

ACKNOWLEDGMENTS: This work was supported by the R&D Program through the Korea Institute of Fusion Energy (KFE) funded by the Ministry of Science and ICT of the Republic of Korea (NFRI-IN2103)

KAERI 한국원자력연구원