

# Performance test for the helium circulator of the HeSS test facility

E. H. Lee<sup>1)\*</sup>, S. K. Kim<sup>1)</sup>, H. G. Jin<sup>1)</sup>, C. W. Shin<sup>1)</sup>, D. W. Lee<sup>1)</sup>, and S. Cho<sup>2)</sup>

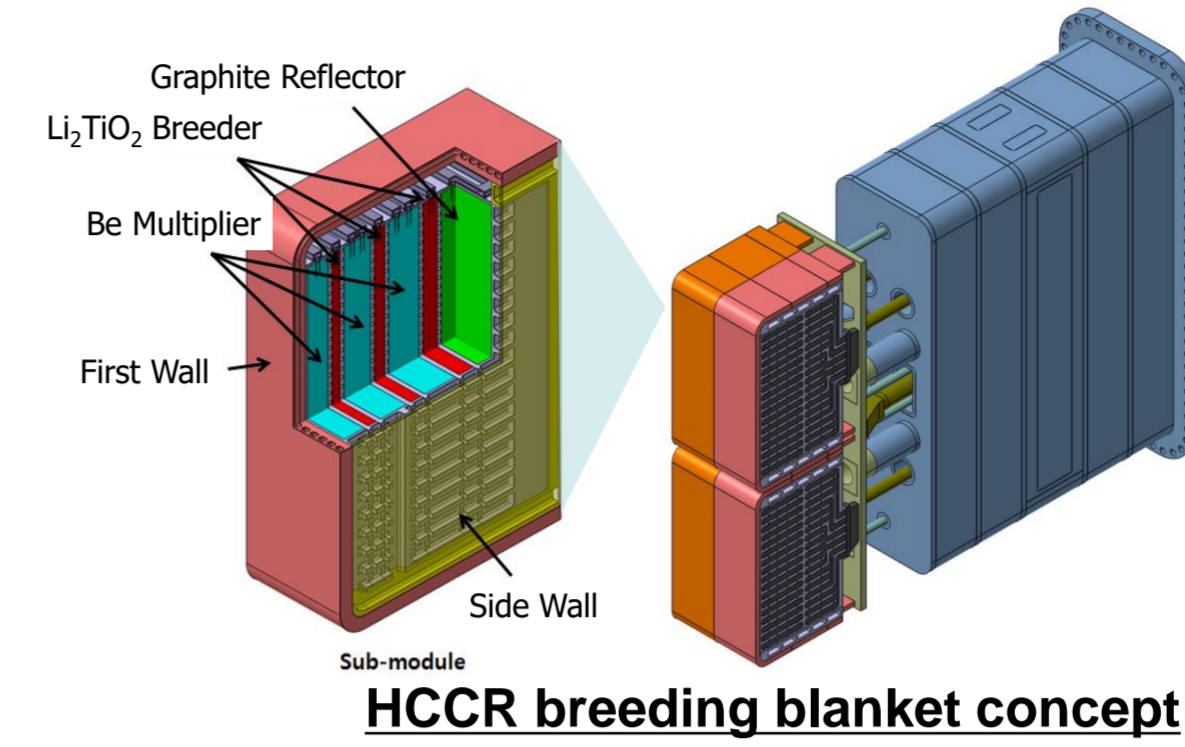
<sup>1)</sup> Korea Atomic Energy Research Institute, Daejeon, Republic of Korea : [ehl@kaeri.re.kr](mailto:ehl@kaeri.re.kr)

<sup>2)</sup> Korea Fusion Energy Institute, Daejeon, Republic of Korea

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## 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. The HCCR TBM is designed to be cooled down with helium coolant, which is supplied with 8 MPa, 300 °C and 1.14 kg/s of flow condition. The Helium Supply System (HeSS) had been constructed to verify the HCS design and to obtain operational test data and experiences. Recently, the status of HeSS construction and its commissioning tests were briefly introduced.
- In this poster, present status of HeSS facility and performance test results of the circulator is described.



- 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

## Present status HeSS facility

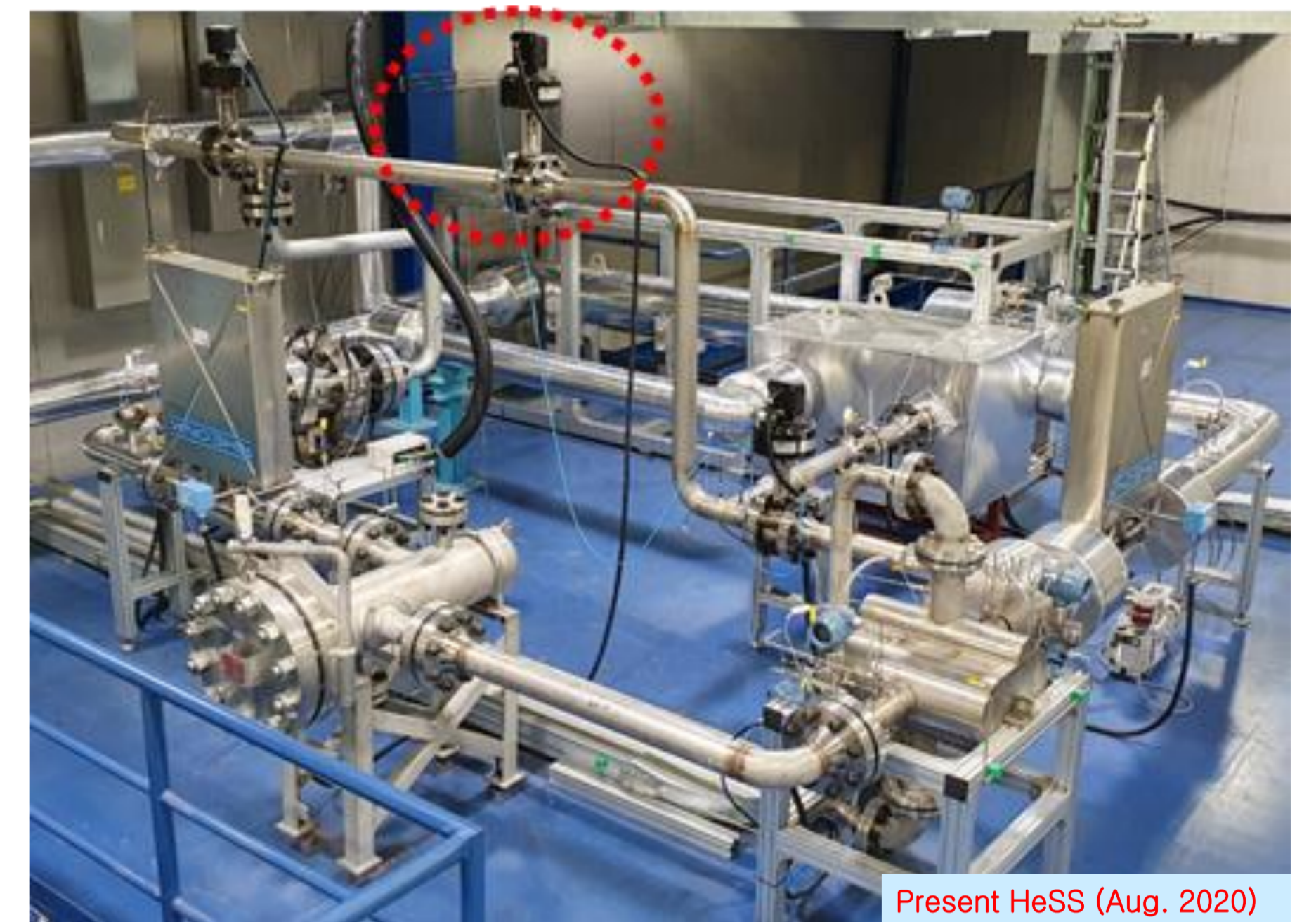
- The present HeSS facility is designed and constructed to obtain experimental data and operation experience for the HCS, so HeSS consists of key components, such as circulator, recuperator etc., with specifications consistent with the HCS components. The specifications of the key components of HeSS are summarized in Table I.
- The first real-scale helium circulator had been installed at HeSS in 2016. 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 modified to improve the axial load through increase of motor power and decrease of shaft length. The second prototype circulator has been redesigned and manufactured by Jinsolturbo; the company designed and manufactured the formal circulator. The upgrade real-scale circulator was installed at the HeSS facility in 2019 and trial test operation was performed successfully.
- Considering the HCS design, present HeSS facility has been modified by installing additional control valve on the main pipeline (between the circulator and the pre-heater) for control helium flow

Components of HeSS	Specifications
Pre-heater	Power: 150 kW, Operating/Design press.: 10/8 MPa Operating/Design temp.: 300/450 °C
Circulator	Power: 150 kW Pressure ratio: 1.1 Operating/Design press.: 10/8 MPa Operating/Design temp.: 50/100 °C Speed: up to 70,000 rpm Flow rate: 1.5 kg/s
Recuperator	Effectiveness: more than 0.92 Operating/Design press.: 10/8 MPa Operating/Design temp.: 300/450 °C

Specifications of the key components of HeSS



Former HeSS (Feb. 2020)



Present HeSS facility (adding CV on the main pipe)

## Performance tests of the circulator

- The upgraded circulator was tested to check integrity and to obtain performance curve. Several mechanical tests: such as 1) corona discharge test for the stator of high speed motor, 2) high pressure and leakage test for the body vessel, 3) high speed rotor tests with dummy/real impellers to check rotor dynamics and air foil bearings. After completing the mechanical tests successfully, performance curve data of the circulator was obtained with the HeSS test facility.
- Performance tests for the circulator were conducted with argon and helium gases and various pressures conditions (Table II) and the flow rate in each test condition was corrected to non-dimension values to compare with the reference conditions of 80 bar, 50 C helium condition.
- Following figures shows the circulator performance curve results. The pressure ratio test results according to the corrected flow rate in each test are measured in groups with each corrected speed (Nc), showing the performance characteristics of the circulator well. During the performance tests, the exit temperature could be measured under conditions where thermal equilibrium had not been fully achieved. In addition, the circulator is not insulated, so the heat released to the environment from the circulator is not considered. Therefore, additional tests will be carried out to obtain more accurate efficiency data by measuring the exact power applied to the circulator.

Table 2. Performance test condition

Gas	Argon	Helium
Pressure [bar]	10, 20, 28.9	20, 40, 60, 80
Speed (Nc) <sup>1)</sup> [%]	30, 40, 50, 60, 70, 72.8	20, 30, 40, 50, 60, 70, 72.8

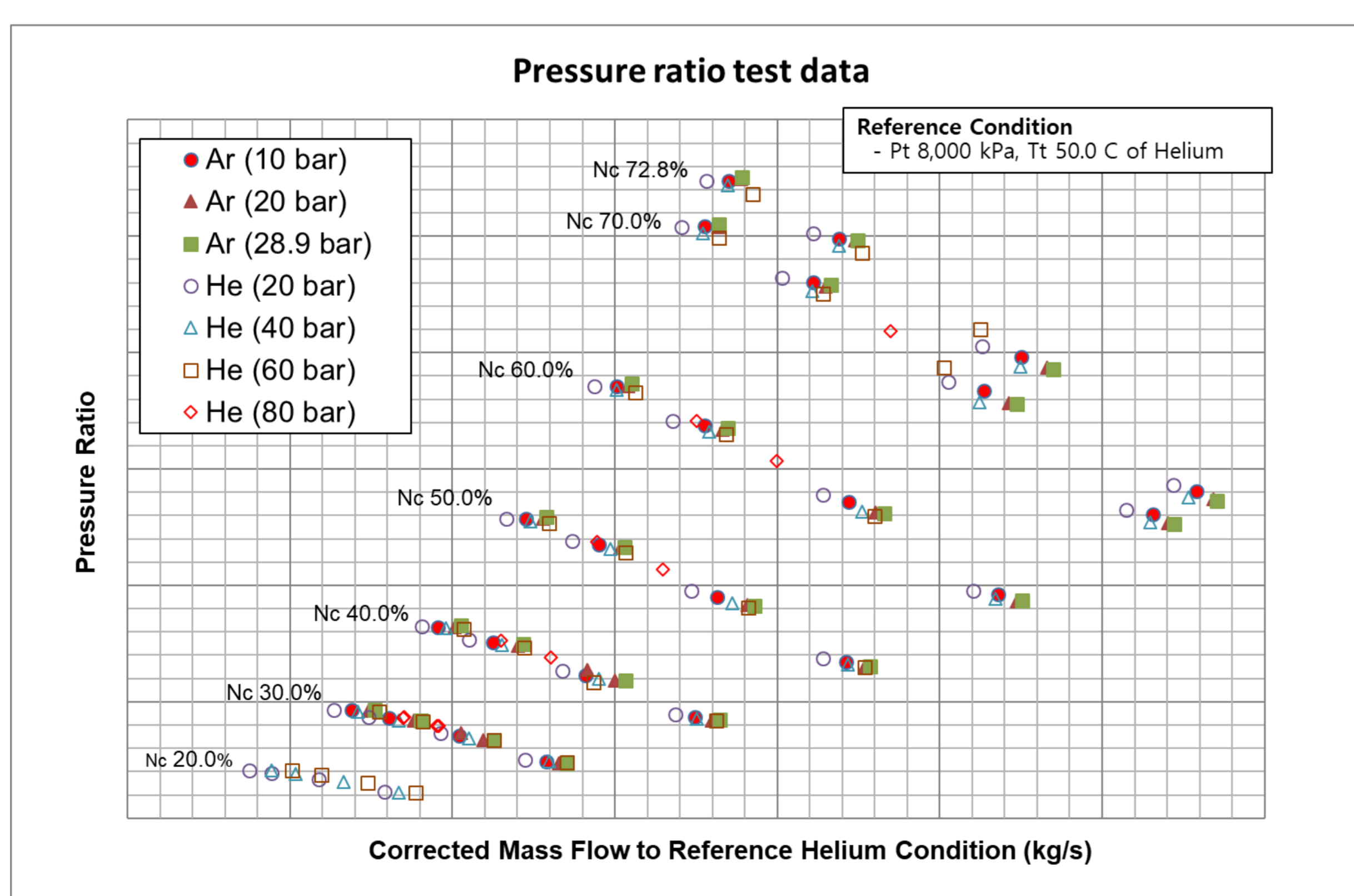
<sup>1)</sup> Non-dimensionalized using the corrected speed at each test condition over the corrected speed at 8 MPa, 50 °C with 70,000 rpm.

※ Corrected impellar speed:  $[(RPM)/\sqrt{\gamma RT}]$

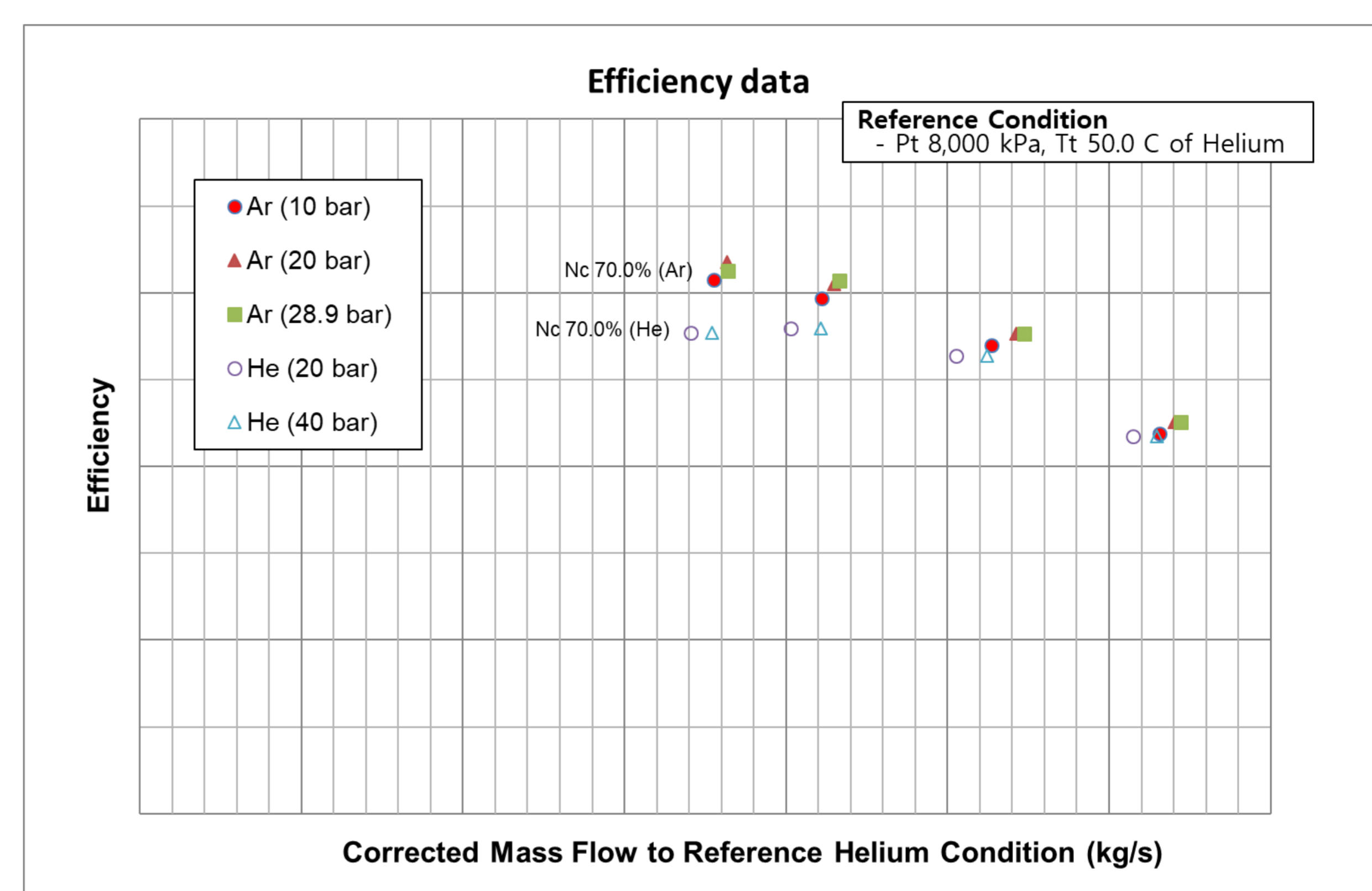
※ Corrected mass flow rate:  $[(kg/s) \times \sqrt{\gamma RT}]/(\gamma P)$

$\gamma$ : specific heat ratio

R: specific gas constant



(a) Pressure ratio test data



(b) Efficiency curve test data

## Conclusions and Future Works

The HeSS facility has been modified by adding a control valve on the main pipeline to control helium flow and the performance tests were conducted for the upgraded real-scale circulator installed HeSS with various pressure of argon and helium gases conditions. The performance curve data were successfully measured to identify the circulator characteristics: however, only 60 bar of helium performance test results shows far from the other test results. Investigation and re-tests shall be carried out to find the cause of this disharmony. Operation scenario for the HCS will then be tested to verify the preliminary operation scenario and to update the HCS operation condition and procedure in detail.