# Integrated Operational Testing of a Helium Circulator for Fusion Helium Cooling Systems

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## 1. Introduction

In fusion reactors, the blanket system plays a key role in tritium breeding and high-temperature heat extraction. The Helium Cooling System (HCS) is designed to remove thermal power from the blanket while maintaining controlled pressure and temperature conditions under various operational scenarios.[1] The HCS must accommodate plasma start-up, normal operation, power variation, and maintenance conditions. Therefore, verification of the circulator performance and system-level operational characteristics is essential for ensuring stable long-term operation.

To support this objective, the Helium Supply System (HeSS) has been established at KAERI as an integrated experimental facility for component qualification and scenario-based testing under high-pressure helium conditions. This study summarizes the status of operational verification of the helium circulator installed in HeSS and outlines ongoing validation activities. [2]

## 2. Helium Supply System and Test Configuration

HeSS is a closed-loop helium test facility composed of a helium circulator, PCHE-type economizer, water cooler, preheater, control valves, and instrumentation systems. The facility is designed to simulate representative pressure and temperature conditions of the HCS. The helium circulator is a high-speed, oil-free turbomachine designed to operate under high-pressure helium environments. Structural upgrades were recently implemented to improve vibration stability and enhance operational stability. Internal flow stabilization features were introduced to mitigate fluid-induced instability observed during earlier development phases. The PCHE economizer separates high- and low-temperature loops in an eight-shaped configuration, enabling efficient heat recovery while minimizing system pressure losses. Control valves are used to regulate differential pressure and simulate various operating scenarios. The current test campaign focuses on integrated operation of the upgraded circulator within the HeSS loop to evaluate performance trends, controllability, and stability characteristics under operating conditions.

Fig. 1. Photograph of the Helium Supply System (HeSS) facility with the helium circulator and the economizer

## 3. Operational Verification of the Helium Circulator

The verification activities are conducted to confirm that the circulator can provide the required pressure rise and flow control capability while maintaining stable mechanical behavior. Tests are performed by varying valve positions and rotational speed across a wide operating range. Compared to earlier development stages, improved operational stability has been achieved following structural modifications. Stable aerodynamic behavior has been observed within the presently tested operating region, and no abnormal vibration trends have been identified under controlled high-speed conditions. In addition to steady-state verification, preparations are underway for extended operational tests to evaluate system response during transient scenarios and to assess long-term reliability.

## 4. Conclusion

This study presents the status of operational verification of the helium circulator within the Helium Cooling System test facility at KAERI. Integrated testing in HeSS has demonstrated improved operational stability and controllability of the upgraded circulator under representative high-pressure conditions. Further verification under extended operating scenarios and long-term operation will support reliability enhancement of helium cooling systems for fusion blanket applications.

## 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 (KFE-IN2603)

## REFERENCES

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