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Preliminary calculation of the Pebble Bed Micro Model Using MARS-GCR

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1. Introduction

The pebble bed micro model (PBMM), which is a three shaft, inter-cooler, recuperator, is model of closed Brayton power conversion unit (PCU) for high temperature gas-cooled reactor of next generation power plant [1]. In order to obtain data for validation of safety analysis code, MARS-GCR has been developed for Gas-Cooled Reactor (GCR) [2]. In this study, MARS-GCR code is simulated in the pebble bed micro model (PBMM) and these results were compared with the experiment data.

2. Analysis and Results

The PBMM is a model of Brayton cycle with nitrogen as working fluid and with better understanding of the mechanisms and processes in the dynamic behavior of PCU in the PBMM. A schematic diagram of the PBMM power conversion cycle for MARS-GCR code is shown in Fig.1.

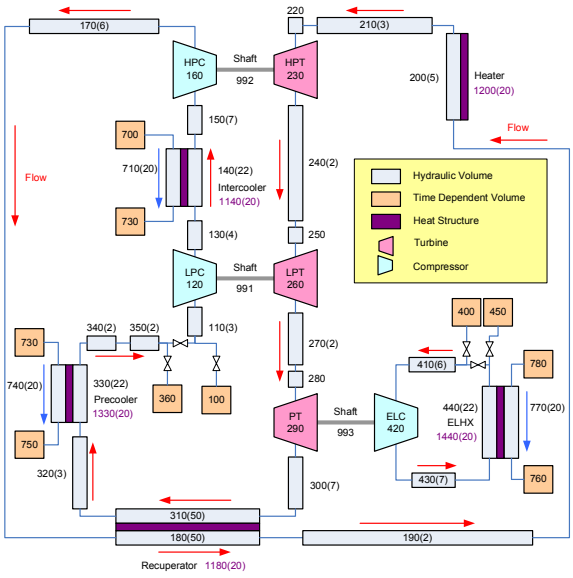

Fig.1 Schematic diagram of the PBMM

MARS-GCR code, which was extended for GCR applications, was implemented in the properties of nitrogen, helium and CO_2 as fluids and circulator model by modified existing pump model. The thermodynamic property tables cover a wide scope from subcritical, saturated and supercritical states. MARS-GCR code that was the improved MARS code was verified and validated with various steady state and transient problems by using NIST database [3].

The compressor performance is calculated by the pressure ratio between inlet and outlet and the efficiency which are calculated by rotational speed and mass flow rate [4].

The steady state calculations of PBMM are carried out using MARS-GCR code. The pressure boundaries at the inlet of lower pressure compressor (LPC) are 95 kPa and 115 kPa. Heater power is maintained as 650 °C heater outlet temperature. The boundary conditions of secondary sides are tabulated in Table 1.

Table 1. Boundary conditions in 95 kPa case

Suction pressure of LPC	94 kPa	113.5 kPa
Heater outlet temperature	644.6 °C	647.6 °C
Cooling water flow rate		
Pre-Cooler	2.05 kg/s	2.05 kg/s
Inter-Cooler	1.63 kg/s	1.63 kg/s
External Load Cooler	1.20 kg/s	1.20 kg/s
Cooling water temperature	14.2 °C	14.8 °C
Cooling water pressure	350 kPa	350 kPa

The inlet temperature and pressure of cooling water is 14.2 °C and 350 kPa. The mass flow rate of pre-cooler, inter-cooler and external load cooler is 2.05 kg/s, 1.63 kg/s and 1.2 kg/s. The results of MARS-GCR for safety analysis of three shaft PCU are acceptable [5]. The results of MARS-GCR in steady states are good agreement with experiment as shown in Fig. 2 and 3.

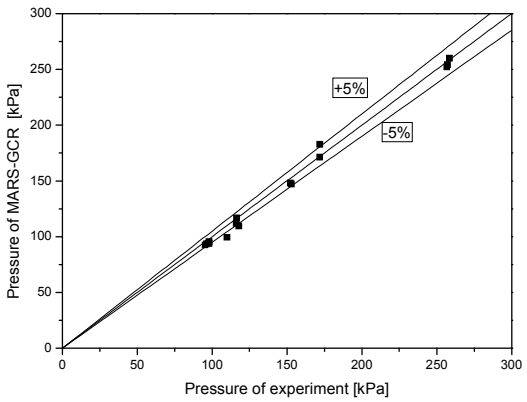

Fig.2 Comparison of MARS-GCR and experiment

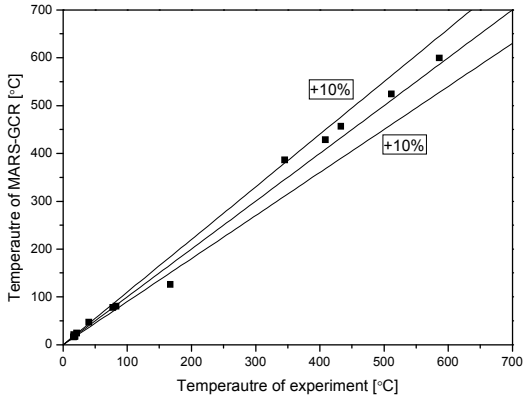

Fig.3 Comparison of MARS-GCR and experiment

3. Conclusions

MARS-GCR code is carried out to simulate the three shafts power conversion system of PBMM using nitrogen as working fluid. The calculations of steady state were compared with experiment results and are predicted in good agreement.

ACKNOWLEDGEMENT

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