

Heaters and an EM pump performance tests of a Liquid Breeder Loop for ITER TBM

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1. Introduction

Korea proposed and designed a Helium Cooled Molten Lithium (HCML) Test Blanket Module (TBM) to be tested in the ITER. The KO TBM uses He as a coolant and liquid Li is used as a tritium breeder [1]. However, our strategy for developing TBM and more DEMO is to develop the liquid breeder technologies of not only liquid lithium but also lead-lithium (PbLi), which is considered as a tritium breeder in other TBM concepts. An Experimental Loop for Liquid breeder (ELLI) has been constructed for the purpose of testing the effect of magneto-hydrodynamics (MHD), investigating the compatibility of PbLi with structural material such as ferritic martensitic steel, and validating the electromagnetic (EM) pump design, which was designed and fabricated by ourselves [2]. It consists of a sump tank, an EM pump, a magnet, and the measurement devices such as a flow meter, pressure transmitters, differential pressure transmitter and thermocouples. The operating pressure and temperature are 0.5 MPa and 300 °C, respectively, but the higher pressure and temperature conditions can be achieved. For easier filling and draining the PbLi before and after experiments, the whole loop was located on the tilting plate, which can be inclined the loop up to 15 degree. The jacket-type heaters were installed in the entire loop including the sump tank for heating up to the 550 °C. Currently, EM pump performance test is being performed for validating its design.

2. Construction of the Liquid Breeder loop

The Experimental Loop for Liquid Breeder (ELLI) is constructed to test the magneto-hydro-dynamics (MHD) effect in the magnetic field circumstances and to verify corrosion by a liquid breeder. Table 1 shows the major parameters of the ELLI.

Table 1 Major parameters of the ELLI

Parameters	Value
Breeder	Pb-15.7Li
Melting point [°C]	235
Temperature [°C]	~ 550
Pressure [MPa]	0.5 MPa in operation
Flow rate [lpm]	5.5 lpm (10 cm/s) in operation, 60 lpm (110 cm/s) Max.
EM Pump	60 lpm @PbLi
Sump tank	163 liter
Magnet	~ 2.2 T (12 kW) Pole gap : 30 mm

The ELLI is constructed on the base board which can be tilted about by 15 degrees. By tilting the base board, the liquid breeder in the loop can flow into the sump tank for reserving during shot down period. A flow meter, pressure gauges, differential pressure gauge and thermocouples were equipped in the liquid breeder loop for the diagnostics. For material corrosion test, three test pots were set in the loop. To heat up the loop and sump tank, heat jackets were installed on those and the heat jackets has ability to raise the temperature up to the 550 °C. The heating system of the sump tank consists of two set of heaters and two heater controllers. Two thermocouples for measuring temperature of the gas and liquid breeder, three points level detector for measuring the level of the liquid breeder and window view pot are equipped for the diagnostic sensors. The heating system of the experimental loop is composed of the 14 heaters. The diagram of ELLI with heaters and diagnostics is shown in Fig. 1.

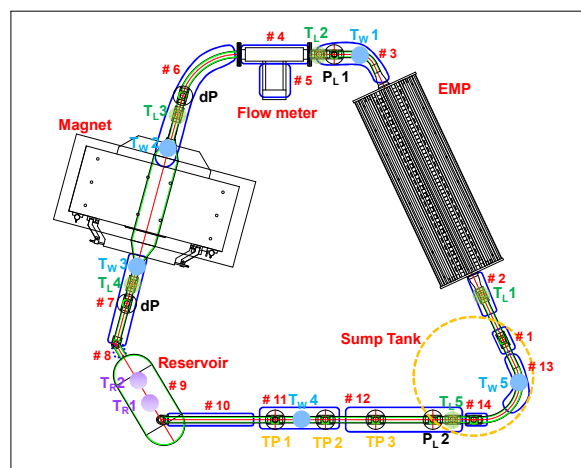


Fig. 1. Schematic diagram of the experimental loop

3. Heater controllers and an EM pump performance test

The heating system for ELLI consists of two heaters and their heater controllers for sump tank and fourteen heater and their heater controllers for experimental loop. The heating system of experimental loop is set to keep around 280 °C in the loop to have proper temperature between the melting point of PbLi and the maximum temperature limit of the mass flow meter. Fig. 2 shows the temperature characteristics measured five points at inner loop and a reservoir.

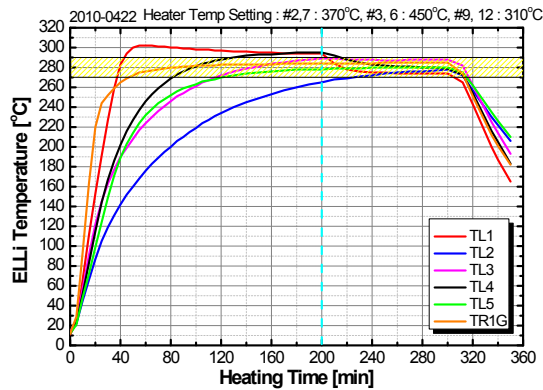


Fig. 2. Temperature characteristics of the heaters of loop.

The EM pump performance test was accomplished by using the experimental apparatus without magnet shown schematically in Fig. 1. The experimental loop was pressurized with Ar gas at 4 kgf/cm^2 to operate the EM pump at optimized design value for maximum flow. By varying the voltage of the EM pump, the flow rate was measured. The measured flow rate of the EM pump is shown in Fig. 3.

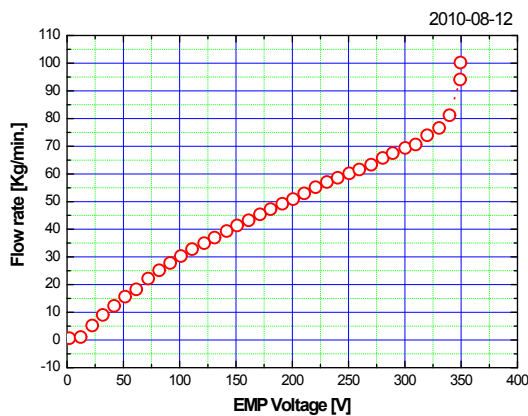


Fig. 3. Measured flow rate of the EM pump at 4 kgf/cm^2 .

4. Conclusions

The Experimental loop for Liquid Breeder has been constructed. The heaters and EM pump performance test is being carried out. The flow rate of the EM pump was approximately linearly changed with varying EM pump voltage.

References

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- [2] Hee Reyong Kim, Jae Eun Cha, Jong Man Kim, Ho Yoon Nam, Byung Ho Kim, DC magnetic field effect on a liquid