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Corrosion test for ARAA in the Experimental loop for liquid breeder

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1. Introduction

Korea has developed two Test Blanket Modules (TBMs) for participating the ITER TBM program; a Helium Cooled Solid Breeder (HCSB) TBM and a Helium Cooled Molten Lithium (HCML) TBM, respectively. Recently, a solid type TBM HCSB was decided to be tested in the ITER, and the name was changed to a Helium Cooled Ceramic Reflector (HCCR) considering the unique concept of using the graphite reflector. Korea Atomic Energy Research Institute (KAERI) has developed the latter one to be tested in the ITER [1-5]. The liquid-type TBM is one of candidate TBM for KO Demos. In this concept, helium (He) and liquid lithium (Li) were used as a coolant and a breeder, respectively. A ferritic-martensitic steel (FMS) was considered as a structural material and the Advanced Reduced Activation Alloy (ARAA) is being developed as a HCCR TBM structural material. However, according to our strategy for developing the liquid breeder TBM and its more relevant DEMO concept, liquid breeders not only considered liquid lithium but also lead-lithium (PbLi). An Experimental Loop for Liquid breeder (ELLI) was constructed for the purpose of validating the electromagnetic (EM) pump design, which designed and fabricated by ourselves; testing the effects of magneto-hydro-dynamics (MHD); and investigating the compatibility of PbLi using structural materials such as ferritic martensitic steel. The schematic diagram of the experimental loop is shown in Fig. 1. The performance test on each component such as heaters, the control systems for heating the loop were performed and the characteristic tests with a magnet and the EM pump were carried out [6-8]. The first corrosion tests using ELLI were performed with grade 91 FMS steel during 250 hours in 2011 [9]. In this study, the corrosion tests with developed ARAA were carried out in the ELLI loop using EM pump to investigate the corrosion behavior of ARAA, and the test results will be compared the previous corrosion tests of FMS corrosion specimens.

2. Corrosion Test in the ELLI

A newly being developed ARAA steel was used for corrosion test-specimens. The corrosion test for the ARAA was performed to investigate the corrosion behavior of ARAA in flowing PbLi. A 15mm length tubular-type, with a 10 mm diameter and 1 mm thickness, samples were fabricated using the ARAA for corrosion specimens. The fabricated tubular-type specimens were fixed at a post using wires as shown in Fig. 2. Three sets of the corrosion specimens were installed to three test pots as shown in Fig. 3. A series corrosion tests were carried out during ttwo separate experiments. The experiments were performed at 150 h, and 100 h for each test, respectively. After first corrosion test experiments with a duration of 150 h, some of specimens were replaced to compare the corrosion status for exposed times of the specimens. The replaced specimens were test-pot 1(#1 : Gr.91, #2 : ARAA) with same material and test-pot 2(#3 : Gr.91, #4 : Gr.91) with different type ARAA(#3 : coated-1 ARAA, #4 : coated-2 ARAA). After installing the specimens into the loop, a corrosion test was performed while the EM pump was operating with a 0.16 m/s flow rate at 340 °C for 250 h for all ttwo experiments. Fig. 4 and 5 show the temperatures measured at five positions in the loop during each experiment with heat-up and shut down and the flow rate of the liquid breeder, respectively.

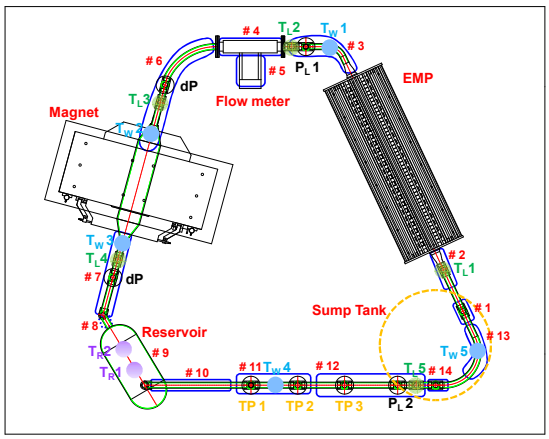

Fig. 1. Schematic diagram of the experimental loop.

Fig. 2. Photograph of the corrosion specimen.

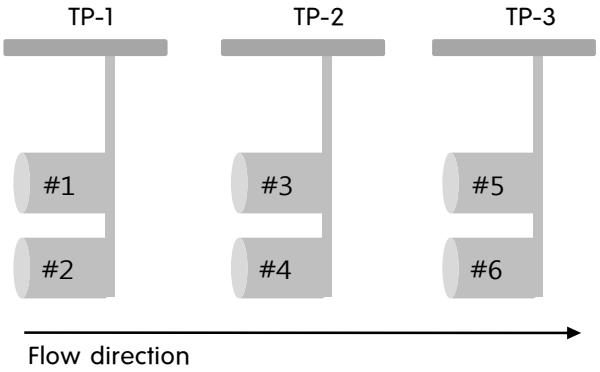

Fig. 3. Schematic diagram of specimens of the test pots.

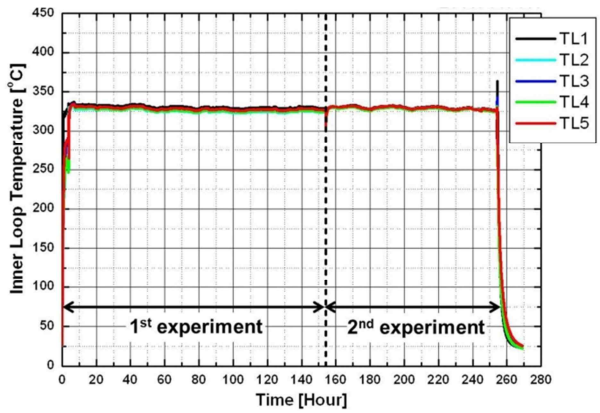

Fig. 4. Measured temperatures in the loop during two times experiments

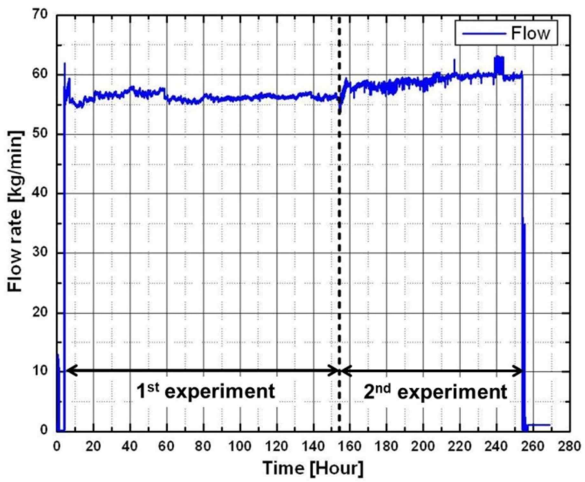

Fig. 5. Measured flow rate during two times experiments.

3. Conclusions

Long term operation tests with the EM pump were carried out. During the two separate experiments, an EM pump was operated for 250 h with a speed of 0.16 m/s (0.95 Kg/s) for corrosion tests. The corrosion test for the ARAA was performed to investigate the corrosion behavior of ARAA in flowing PbLi. After micro structural observation on the ARAA surface and elemental analysis were done using a scanning electron microscope (SEM), the corrosion results of the ARAA specimens will be compared with the results of FMS steel.

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