§1. Progress in Flibe Corrosion Study toward Material Research Loop and Advanced Liquid Breeder Blanket

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Liquid breeder blanket is promising for DEMO and commercial fusion reactors. Flibe molten salt (BeF_2 + LiF) is a very attractive liquid breeder material. One of critical issues is corrosion of structural materials by HF (TF from tritium breeding) in Flibe. JUPITER-II (Japan USA Program for Irradiation/Integration TEst for fusion Research-II) has successfully exhibited suppression of corrosion by a REDOX control. The next milestone to the blanket development is material corrosion research with convection loop to predict corrosion rate in the blanket condition. Natural convection loop is used to examine the effect of un-saturation of material dissolution into Flibe under small flow velocity (< 0.1 m/s), while non-isothermal forced convection loop can widely control flow velocity (0.1 ~ 10 m/s) and operation temperature, and leads to systematic corrosion tests under the Flibe blanket condition.

A purification system for Flibe has been developed in TNF (The University of Tokyo-National Institute for Fusion Science Flibe Grove box) facility. Scale-up for purification has been demonstrated for application to the non-isothermal forced convection loop. Purified volume for Flibe was 50 g, and then it was increased to 150 g. According to chemical analysis, especially Fe impurity level (<70 mass ppm) was successfully reduced compared with the conventional Flibe (260 mass ppm).

JLF-1 ferritic steel and 316L stainless steel (316L SS) were exposed to the purified Flibe at 773-873 K for up to 2003 hr in static condition, to evaluate basic compatibility with Flibe and corrosion characteristics. The JLF-1 specimens were also exposed to He- (0~1%) HF- (0.003~0.06) H_2O- (0.002~0.009) O_2 gas mixture at 823 K for 2.5~100 hr. Figure 1 shows weight change during the exposure tests. The weight loss of JLF-1 at 823 K was 1.5 g m^{-2} for 2003 hr, which is multiplied to 0.83 μm/yr in corrosion rate. In the same way, corrosion rate for 316L SS at 773 K and 873 K was evaluated as 3.3 and 5.4 μm/yr, respectively. The corrosion rates for both JLF-1 and 316L SS were considered as acceptable level for the structural materials. On the other hand, JLF-1 showed weight gain in the He- (0~1%) HF gas conditions. In the gas conditions, all the corrosion products were remained on the specimen surface, while the products were lost by dissolution in Flibe condition. The fundamental process for weight loss in Flibe is considered as formation of corrosion products shown in the He or He- HF gas, and their dissolution into Flibe. Figure 2 shows the results of XPS analysis on the chemical state of Fe in the corrosion products. According to the peak separation analysis, the ratio of Fe_2O_3 to FeF_3 in the corrosion products was 2.3 – 16. It is said that oxidation was more dominant than fluoridation even in He- 1%HF gas, where F atom concentration was 16 times larger than O atom in the atmosphere. Most of weight change shown in

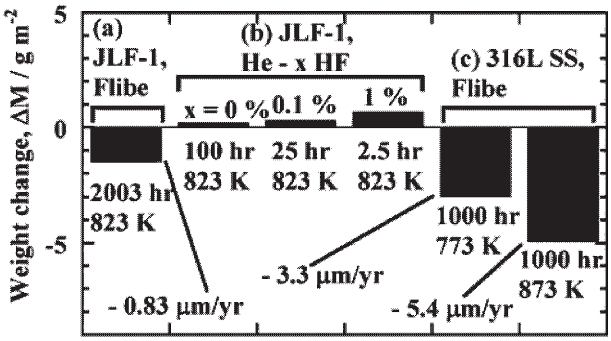

Fig. 1 Weight change after corrosion tests.

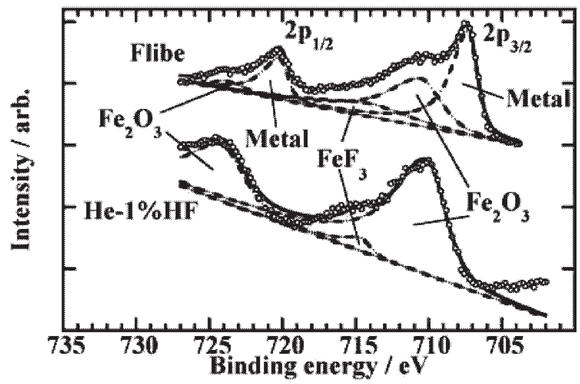

Fig. 2 Photoelectron intensity profile for the corrosion products, and its separation into pure material peaks.

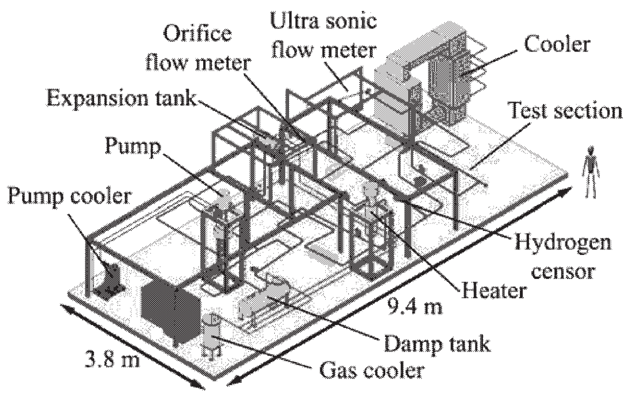

Fig. 3 Material Research Loop

Fig. 1 might be caused by oxide formation and its dissolution into Flibe. Further reduction of corrosion is possible, if oxygen impurity is reduced.

Non-isothermal forced convection loop, Material Research Loop, was designed to investigate the effect of flow velocity (3~10 m/s) and temperature difference (100 $_o$C) in the blanket condition. Figure 3 shows a bird-eye view of Material Research Loop. From the above results, 316L SS is applicable to the structural material. 200 kg or more Flibe is required for the loop, and is feasible with the scale-up of the above-established process. Development of components of the loop, such as valve, flow meter and impurity censor, has been started.

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