

§4. Effect of Container Composition on Compatibility of a RAFM Steel with Liquid Lithium

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Fe-Cr-W based RAFM (Reduced Activation Ferritic/Martensitic) steels are widely regarded as promising blanket structural materials, because of its low activation properties, radiation resistance and industrial maturity. Blanket concepts with liquid Li (Li) breeder/coolant provide attractive options for high tritium breeding ratio, high efficiency and simplicity of blanket system. For the RAFM/Li concepts, the compatibility of RAFM with liquid Li is a concern. However, only the corrosion behavior of conventional ferritic steels in Li was studied in previous research. No data was available for the compatibility of RAFM steel (Fe-Cr-W) with liquid Li.

In the recent experiments, the corrosion characteristics of the RAFM steel, JLF-1 (Fe-9Cr-2W), in a static and flowing Li was investigated[1]. The purpose of this experiment is to go further to investigate the corrosion behavior of RAFM steel and the phenomena of phase transformation. JLF-1 steel was exposed to in static Li at a temperature of 600°C for 250h in containers made by Fe-9Cr, SUS316L (18Cr-12Ni-2Mo), Mo and Nb. The corrosion characteristics of JLF-1 specimen in different container were investigated. The results are compared with those reported in previous works.

The weight change of specimens exposed in four containers at 600°C for 250h was presented in Fig.1. According to the results, JLF-1 specimens lost weight in Fe-9Cr, Mo and Nb container, while the specimens gained weight after exposure in SUS316L container. The maximum value of weight loss was observed in new Mo container. The weight loss of JLF-1 specimen exposed in Fe-9Cr container was about half of that in Mo container.

Different composition of the container led to the difference in microstructure of the specimens after exposure in Li. Fig.2 presented the metallographic observation on the cross section of JLF-1 exposed in four different containers. After exposure in Fe-9Cr and

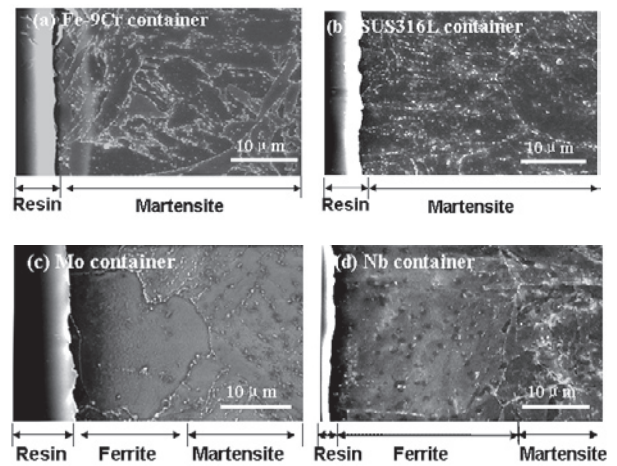


Figure. 2 The cross section of JLF-1 after exposure in different containers

SUS316L containers, the cross section of JLF-1 specimens presented the martensite with fine lath structure as shown in Fig.2 (a) and (b), though a ferritic layer formed on the surface, as shown in Fig.2 (a) and (b). The carbides precipitated along the austenite grain boundary and lath boundary. On the other side, according to Fig.2(c) and (d), the phase transformation from martensite to ferrite was observed on the cross section after exposure in Mo and Nb containers. The figures show that the depth of the phase change on JLF-1 specimens is about $\sim 8\mu\text{m}$ and $\sim 20\mu\text{m}$ in Mo and Nb case separately. In the phase transformation zone, the density of carbide precipitates decreased drastically. The depth of ferritic zone in Nb case is almost double that in Mo case. It seems that the Nb container strongly enhanced the phase change from martensite to ferrite during the Li exposure.

According to the weight loss results presented above, the JLF-1 specimens showed different weight change in various containers. The specimens lost weight in Fe-9Cr, Mo and Nb containers, while they got weight after exposure in SUS316L container. Moreover, the weight loss in Fe-9Cr container was almost half of that in Mo and Nb cases. It is thought that the weight loss was mainly caused by the distribution of alloy elements, such as Fe, Cr and W in static test. In Mo and Nb case, the Fe, Cr and W in liquid Li came only from the JLF-1 specimens. On the other side, in Fe-9Cr and SUS316L case, Fe and Cr came from specimens and container materials. This means that the dissolution of Fe-9Cr and SUS316L container suppress the weight loss of JLF-1 specimens. The container surface which contacts with Li is estimated to be 98.1cm^2 , almost 4 times larger than the total surface of specimens. This can explain the weight loss of JLF-1 specimens in these two cases was much lower than that in Mo and Nb cases. Furthermore, because the solubility of Ni is much higher than that of other elements, a large amount of Ni dissolved into Li during the exposure and deposit on the surface of specimen in SUS316L container. The precipitation of Ni led to the weight gain in SUS316L case.

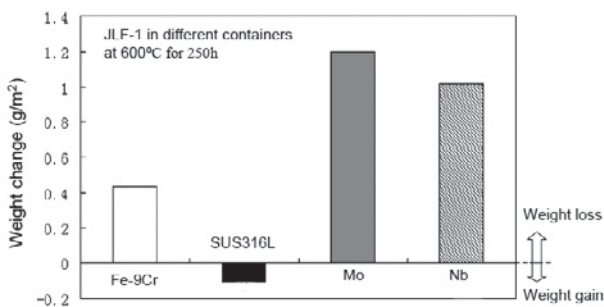


Figure.1 Weight loss after Li exposure in different container at 600°C for 250h

[1] Q. Xu, M. Kondo, T. Nagasaka, T. Muroga, M. Nagura, A. Suzuki Fusion Eng. and Des., 83 (2008), 1477-1483.