

§3. Influence of N on the Corrosion Behavior of RAF/M JLF-1 Steel in Static Li

Tsisar, V., Kondo, M., Muroga, T., Nagasaka, T.

Introduction

A combination of Reduced Activation Ferritic-Martensitic (RAFM) steel and liquid Li is a potential attractive blanket option. However, the compatibility studies of RAFM steels with Li are still scarce. Because it is known that N in Li can intensify strongly the corrosion of structural materials [1], the effect of N impurity is one of the key concerns for the use of RAFM steels facing liquid Li. The aim of this work, therefore, is to investigate the effect of N impurity on the compatibility of RAFM JLF-1 steel with Li.

Experimental

The corrosion tests of JLF-1 steel (wt%: 8.93Cr, 1.96W, 0.64Mn, 0.49Ni, 0.21V, 0.10C, 0.015N) were carried out in static Li containing 0.5 wt % N at 600°C for times up to 20, 120 and 250 h.

The corrosion losses were determined after exposures. The chemical composition of Li and morphological and compositional changes in the near-surface layers of steel samples were revealed by means of ICP-MS, SEM-EDX and XRD analyses and Vickers hardness measurements.

Results

Samples showed intensive weight losses during first 120 h while with time (250 h) the weight losses became slower (Fig.1). Corrosion attack proceeded most intensively along the boundaries of steel structural constituents such as prior austenitic grains, martensite packets and blocks causing formation of the extremely relief surface with a “dimple-pebble”-like appearance (Fig. 2 a). The porous weakened zone depleted severe in Cr was observed beneath the relief surface (Fig. 2 b). The martensite to ferrite transformation occurred in the corrosion layer.

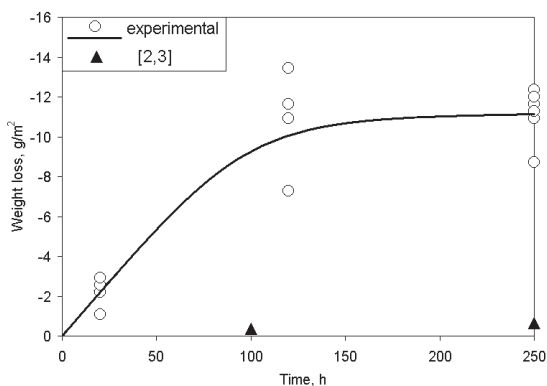


Fig. 1. Weight loss kinetics of JLF-1 steel samples in N-containing Li [0.5 wt%N] at 600°C. ○ - measured values for Li[0.5 wt%N]; ▲ - values for Li[0.004 wt%N] from [2, 3].

It was deduced, based on the obtained results, that the JLF-1 steel underwent severe corrosion attack in N-containing Li resulted in marked morphological, compositional and structural changes of steel near-surface layers. The experimental data were compared with these obtained under the same conditions but for “pure” Li (0.004 wt%N, ▲ – symbols in Fig. 1) [2, 3]. It was determined that at 600°C the weight losses of JLF-1 steel in N-containing Li were at least fifteen times higher than these for “pure” Li. Thus, the presence of N impurity in the liquid Li intensifies substantially the corrosion of JLF-1 steel that is in a good agreement with the literature data generalized in [1].

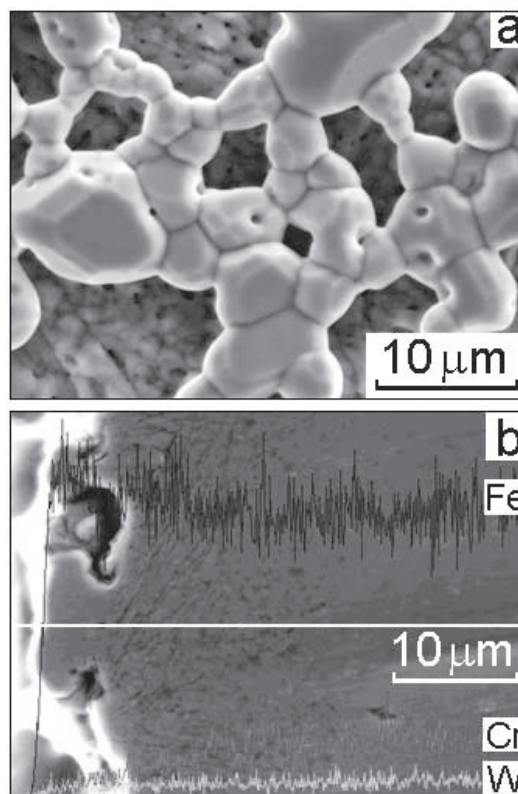


Fig. 2. Surface morphology (a) and elemental profile (b) through the cross section of JLF-1 steel exposed to Li[0.5 wt%N] at 600°C. a - 120 h; b - 250 h.

It was proposed that at the initial stage of interaction the corrosion mechanism consists in the reaction diffusion between (Li-N) clusters and chromium carbides caused formation of complex reaction product of type $\text{Li}_x\text{Cr}_y(\text{C}, \text{N})_z$ followed by the penetration of lithium into the steel substrate. With time the corrosion mechanism is changed – the bulk diffusion mechanism prevails resulted in formation of porous Cr-depleted zone.

- 1) V.N. Mikhailov et al. Lithium for fusion reactors and space nuclear power systems of XXI century // Moscow.: Energoatomizdat (1999) 528 p. (in Russian).
- 2) Qi Xu et al. Fusion Science and Technology, **52**, 3 (2007) 609-612.
- 3) Qi Xu et al. Fusion Engineering and Design, **83**, 10-12 (2008) 1477-1483.