§6. Corrosion Behavior of SUS410-SUS410, SUS316-SUS316 and SUS410-SUS316 TIG Welded Joints in Li

Tsisar, V. (Physico-Mechanical Institute of National Academy of Sciences of Ukraine),
Kondo, M., Muroga, T., Nagasaka, T.

Introduction

Liquid lithium (Li) is a candidate tritium breeder and coolant material for self-cooled blanket of fusion reactor. Therefore the compatibility of structural materials with liquid Li at high temperatures is still one of the critical issues of up-to-date reactor materials science. In spite of the numerous experimental data regarding corrosion issues of conventional steels in liquid Li there is a serious gap concerning corrosion behavior of its welded joints (WJ). The aim of the present work, therefore, was to investigate the corrosion behavior of SUS410-SUS410, SUS410-SUS316 and SUS316-SUS316 WJ in liquid Li at 600ºC versus zones of WJ (BM, HAZ and WM).

Experimental

The tube samples of SUS410 and SUS316 steels were joined by means of the Tungsten Inert Gas (TIG) welding (Fig. 1). After welding the samples were heat treated at 800°C/7.2 ks in and air cooled. Then tubes were sectioned into the specimens by low speed cutter and surface of samples was polished and cleaned by ethanol. Thus, three types of WJ were prepared: SUS410-SUS410, SUS316-SUS316 and SUS410-SUS316. The corrosion tests were carried out in static "pure" Li at 600°C for 250 h.

After tests the samples were cleaned to remove Li by flowing water followed by the cleaning using acetone and ethanol. The scanning electron microscopy (SEM) equipped with energy dispersive X-ray spectrometer (EDX) was used to determine morphological, structural and compositional changes depending on the regions of WJ. Vickers hardness was measured under the loading of 50 gf.

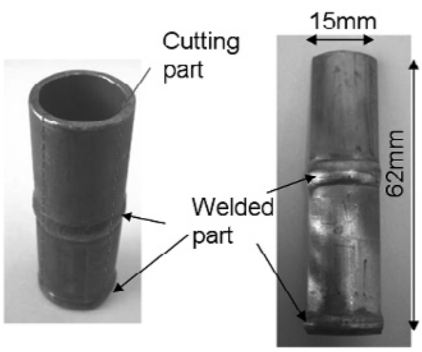

Fig. 1. TIG welded joints samples.

Results

The main peculiarity of corrosion interaction of BM, HAZ and WM zones of SUS410-SUS410, SUS316-SUS316 and SUS410-SUS316 WJ becomes apparent in the fragmentation of surface structure in comparison with the bulk one. The fragmentation of grains was inherent for both ferritic and austenitic structures of WJ tested (Fig. 2). The structure fragmentation, it was supposed, is caused by Li since the dissolution of steel components (Ni, Cr) occurs mainly along grain boundaries and sub-boundaries – paths with increased diffusion mobility of elements. Therefore, as a result, the defectiveness of the sub-boundaries increased resulting in the transformation of the low-angle sub-boundaries into the large-angle. In general, no significant compositional differences induced by corrosion in BM, HAZ and WM possessed by the different grain size but the same phase state (ferritic or austenitic) were observed. Corrosion interaction consisted in the dissolution of Cr and Ni from the near-surface layers (Fig. 2, a2, a3). It is believed that the larger length of grain boundaries reaching surface (i.e. more fine-grained structure) the bigger contribution of grain boundary diffusion into the total dissolution [1It is also reported that the bigger grain size the dipper is the penetration of Li [2n our work the penetration depth of Li was not evaluated because of cleaning procedure, however it is known that it corresponds usually to the thickness of corrosion layer depleted in Cr and/or Ni [1-2] Thus, in our case, it did not exceed ~ 3 μm.

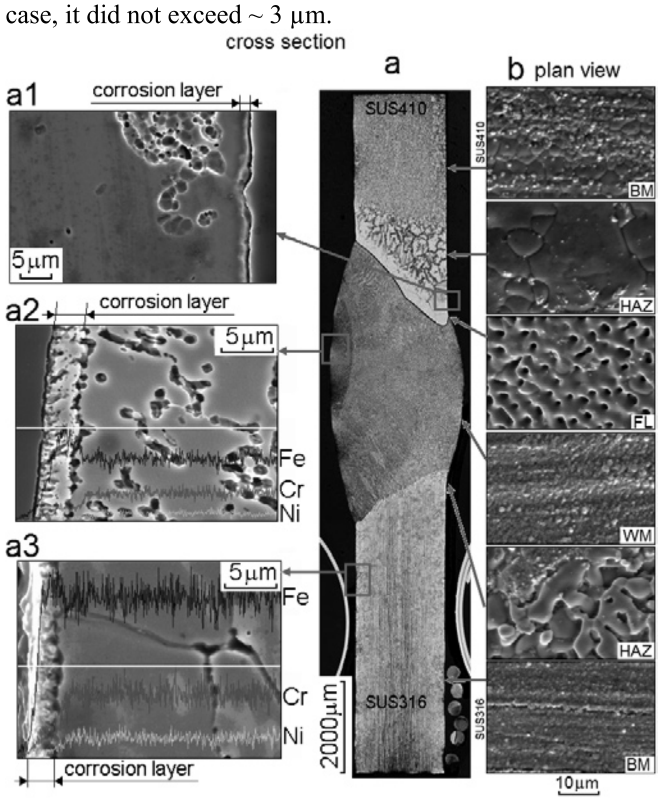

Fig. 2. Surface and cross section morphologies of SUS410-SUS316 TIG welded joint after exposure to liquid Li at 600ºC for 250 h. a - general view and detailed view of cross section versus: a1 – heat affected zone (HAZ); a2 –; a3 – weld metal (WM); a3 – base metal (BM); b – plan view of weld regions after corrosion test.

1) N.M. Beskorovaynyi, A.G. Ioltuhovski, Structural materials and liquid metal heat-transfers, Moscow, Energoatomizdat, 1983;
2) G.M. Griaznov, V.A. Evtikhin, L.P. Zavialski et al., Material science of liquid metal systems of thermonuclear reactors, Moscow, Energoatomizdat, 1989.

Acknowledgements
This study was supported by UCFF004 and Grant in aid for scientific research (A), (2007-2009) 19206100.