TECHNICAL ISSUES OF REDUCED ACTIVATION FERRITIC/MARTENSITIC STEELS AS THE STRUCTURAL MATERIAL OF FUSION BLANKET SYSTEM

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Reduced activation ferritic/martensitic steels (RAFMs) are recognized as the primary candidate structural materials for fusion blanket systems. These steels have been developed based on substantial industrial experience with high chromium heat resistant ferritic/martensitic steels (such as modified 9Cr-1Mo), but with Mo and Nb replaced by W and Ta, respectively, and it is expected to have sound engineering bases, such as fabrication technology and materials database to use RAFM as the structural materials for pressure equipment. It is also important to develop irradiation database and design methodology of fusion neutron irradiated structure to use RAFM as the structural material for fusion neutron irradiated pressure equipment. The technical issues have recently been identified as the key R&D issues on materials engineering for DEMO blanket under the International Fusion Energy Research Centre (IFERC) project in the Broader Approach (BA) activities between EU and Japan.

(1) The fabrication technology and the materials database must provide highly attractive properties, especially with respect to high thermal efficiency, availability, reliability, irradiation resistance, and reduced activation capability.

(2) Appropriate techniques must be defined to incorporate the fracture/rupture properties of the irradiated materials into an engineering procedure that allows ensuring the integrity of the components for the safe operation of a fusion power reactor.

(3) Methods need to be developed to predict the deformation and fracture behavior of structures under irradiation from materials database by modeling/simulation of materials behavior.

As the final outcome, these (1) ~ (3) will be the bases for DEMO design criteria and licensing. The objective of this paper is to review the R&D status of RAFM, especially F82H (Fe-8Cr-2W-V,Ta) developed in Japan, and to identify the key technical issues for the design and fabrication of an DEMO blanket suggested by recent achievements in Japan.

New 5t F82H heat was melted in a part of BA activity and plates with four different thicknesses (15, 25, 45 and 90mm) were fabricated. Tensile and Charpy impact properties of the15mm plates were evaluated and proved that it is comparable to those of F82H IEA-heat [1]. An assessment on the DEMO specific welding technologies with emphasis on mechanical restraint factor and hot cracking sensitivity was conducted to obtain basic information on RAFM welding and indicated that little or no susceptibility to solidification cracking was observed for F82H with small impact of Ta content compared with that of stainless steels, even though the hot cracking sensitivity increased as Ta concentration increased. Various irradiation data was verified and re-arranged as the data base to derive the preliminary prediction formula of irradiation effects, and it was indicated that the test temperature dependence of yield stress does not change before and after irradiation, even if the specimen has large irradiation hardening.

[1] S. Jitsukawa, A. Kimura, A. Kohyama, et.al., J. Nucl. Mater. 329–333 (2004) 49–56