IFERC Newsletter

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DEMO R&D Activity

Development of Reduced Activation Ferritic/Martensitic Steel

Reduced activation ferritic/martensitic (RAFM) steels have been developed as structural materials for the DEMO blanket since the 1980's, and many RAFM steels have been proposed in ITER participants countries as candidate structural materials for the DEMO blanket and for the ITER-TBM (Test Blanket Module). F82H (Fe-8Cr-2W-0.04Ta-0.2V-LN) and EUROFER97 (Fe-9Cr-1.1W-0.12Ta-0.2V-0.03N) are the most promising RAFM steels, and now the standardization of the production of the material has been initiated, even though there is no design rule yet for the use of RAFM.

RAFM steels were designed by making only minor changes in the composition of high Cr heat resistant steels, e.g., Mo to W and Nb to Ta in Mod9Cr-1Mo (Grade91, ASME Section II), to meet the activation limitation for shallow land burial. Undesired impurities are expected to be removed as much as possible, but it is also clear that there will be a practical limit to the removal of impurities, such as Co, Cu, Ni, Mo and Nb. Furthermore, the removal of some key elements, which control mechanical properties, such as Al and N, means that a compromise has to be found between the waste disposal scenario and the performance demand. This is particularly important for the fabrication of large-scale heats corresponding to the amounts required for the construction of DEMO, which are estimated to be up to 11,000 tons in the case of SlimCS.

In Broader Approach (BA) activities, large scale melting has been conducted in order to demonstrate reproducibility in the fabrication process of F82H with appropriate reduced activation levels and properties. . F82H-BA07, the first heat, was fabricated in 2007 with 5 ton VIM (Vacuum Induction Melting) followed by re-melting process (ESR: Electro Slag Remelting), and its properties were shown to be equivalent or better than those of the F82H-IEA heat.

For fabrication at DEMO scale, VIM is not the appropriate method as the maximum VIM furnace size is 10t. Taking into account the impurity control requirement, the electric arc furnace (EAF) is the likely candidate for large scale production, and it is very important to demonstrate reproducibility in the fabrication of F82H with appropriate properties at that scale.

Thus, the melting of F82H, so called F82H-BA12, was conducted in 2012 with 20t of EAF produced by Daido Steel Co., Ltd. Ladle refining and ESR remelting processes were used to achieve inclusion free, low N steel. The blast furnace iron was used as raw material. The fabricated ingots were forged into slabs (270×500 × 2200mm) and billets (ϕ210 × 2600 mm). It was clearly shown that Ni is the impurity that has to be removed above all, and Mo in the case of the first wall components, in order to meet the shallow land burial limit after 100 years of shut down. Limitation of N will be an issue as N cannot be reduced below 100ppm in a large-scale melt.

BA activities are developing methods to estimate the effects of fusion neutron irradiation, with emphasis on the embrittlement and loss of plasticity that will occur at low temperature irradiation, in order to establish the technical basis to design a DEMO blanket system which can be used in the various loading modes expected in DEMO. (*Hiroyasu Tanigawa*)

BA07 5t VIM heat

Slab : 150 × 420 × 1500 (mm)

BA12 20t EAF heat

Slab : 270 × 500 × 2200 (mm)

Billet : ϕ210 × 2600 (mm)