§52. Correlation between Microstructure and Hardness of a Low Activation Ferritic Steel (JLF-1) Weld Joint

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Fe-Cr-W ferritic steels are candidate low activation materials for fusion reactor structural components. In comparison with other candidate materials, i.e. vanadium alloys and SiC/SiC composites, the low activation ferritics are recognized to be established industrial materials. For the application of these materials to fusion reactors, technologies relating to component fabrication are becoming major issues. Characterization and optimization of the welding procedures have been considered to be particularly important in the construction of complex components such as the fusion blanket.

Japanese universities have been promoting a test program of a low activation Fe-9Cr-2WVTa alloy named JLF-1 [1,2]. Recently a 1.5 ton heat of JLF-1 was made (JLF-1-HEAT2), and 15mm and 25mm thick plates were distributed to each of the parties for surveillance tests. TIG and EB weld joints of these plates were also available. The microstructural observations and hardness measurements on JLF-1 and its TIG weld joint is performed. Emphasis is placed on the relation of microstructure with local hardness at various positions on the weld joint.

The macrostructure shows clearly the distribution of the base metal, the heat affected zone (HAZ) and the weld metal. In the weld metal, the fine structure reflects the heating history during the repeated welding passes. The vickers hardness (Hv) is highest (Hv240 - Hv290) in the weld metal and lowest in the heat affected zone.

Details of the hardness distribution in the weld metal across the plate is shown in Figure together with the higher magnification macrostructure of the corresponding area. The figure shows that local hardness at the white lines observed is higher than that in the surrounding area. This hardening seems to be due to rapid cooling after the next adjacent pass of the welding.

Distribution of lath width with position of the weld joint is investeigated. The lath width was estimated from TEM micrographs as an average separation of the boundaries. Thus the values represent average of the thickness and the width without any contribution from the length. The figure clearly indicates a relation between the hardness and the lath width.

The tensile data imply qualitative relationships between lath width, hardness and yield stress; with the decrease in lath width, both hardness and yield stress increase. However, it was shown that in the martensitic steels, not only TEM-observable defects such as grain (lath) boundaries, precipitates and dislocations but also TEM-invisible defects such as substitutional and carbon atoms contribute to the mechanical properties. Further characterization of microstructure is needed in order to establish the correlation.

References

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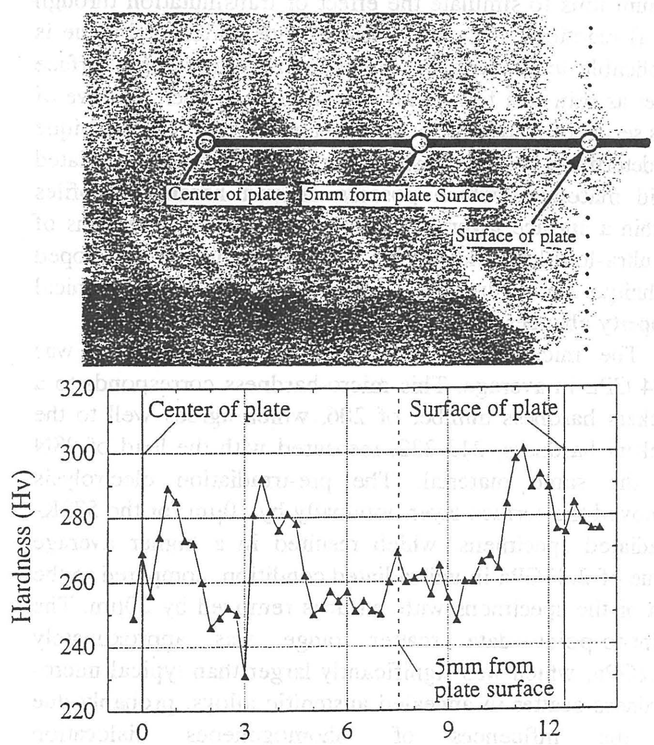

Fig. Details of hardness distribution in the Weld Metal.