THE MICROSTRUCTURE OF CLAM STEEL AND ITS INFLUENCE ON MECHANICAL PROPERTIES

Shaojun Liu[1], Qunying Huang[1, 2], Lei Peng[1], Yanfen Li[1], Chunjing Li[1], Qinsheng Wu[1], Bo Huang[1], Yican Wu[1, 2], FDS Team

[1] *Institute of Plasma Physics, Chinese Academy of Sciences, Hefei, Anhui, 230031, China*
[2]*School of Nuclear Science and Technology, University of Science and Technology of China,Hefei, Anhui, 230027, China*

Corresponding author: sjliu@ipp.ac.cn

The Reduced Activation Ferritic/Martensitic (RAFM) steels have been considered as the primary candidate structural materials for the DEMO fusion reactor and the first fusion power plant because of their better void swelling resistance, better thermo-physical and thermo-mechanical properties compared with the austenitic stainless steels. A series of R&D activities on China Low Activation Martensitic (CLAM) steel are being carried out in the Institute of Plasma Physics, Chinese Academy of Sciences (ASIPP), China, and it has been selected as the primary candidate structural materials for China Dual Functional Lithium Lead (DFLL) Test Blanket Module.

The microstructure analysis of CLAM has been done by optical microscopy, scanning electron microscopy, transmission electron microscope and X-ray diffraction (XRD). The results showed that the microstructure was composed of dispersively distributed carbide particles and lath martensite phase with high density dislocation, and there was no retained austenite detected by XRD. The XRD also showed that the lattice distortion of quenched sample surface was higher than that of sample center, and contrary result to tempered sample. The results of selected area electron diffraction and energy dispersive X-ray spectroscopy showed that the main precipitation phases were Cr-rich $M_{23}C_6$ carbide formed mainly within the lath boundaries and prior-austenite grain boundaries and Ta-rich MX particle formed mainly on the laths and lath boundaries.

Production scale is the key index of CLAM steel for industrialized application. A heat of 300Kg, named as HEAT 0603A, was fabricated in 2006, and then hot-forged and rolled into different specifications for experiment tests. The tensile test results showed that the tensile strength of HEAT 0603A was higher than that of HEAT 0408B (a 25Kg ingot) at RT, and contrary result at elevated temperature. The total elongation of HEAT 0603A was lower than that of HEAT 0408B at all tested temperatures, and the difference became smaller with the increase of the tested temperature. The result of microhardness testing also showed that the hardness of HEAT 0603A was higher than that of HEAT 0408B.

HEAT 0603A was similar with 0408B in chemical composition and heat treatment. Macro-mechanical properties were mainly determined by the microstructure, and the comparative analysis of microstructure was carried out to study its influence on mechanical properties. The results showed that lath width of HEAT 0603A was about 200nm, while it was about 300nm of HEAT 0408B. According to Hall–Petch's equation, the finer lath width was the main possible reason for higher room temperature strength of HEAT 0603A. Higher

heat forging deformation degree is considered as the main reason leading to reduced martensite lath width in HEAT 0603A.

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Corresponding Author: Shaojun Liu
sjliu@ipp.ac.cn
Institute of Plasma Physics, Chinese Academy of Sciences
Hefei, Anhui, 230031, China
Tel:+86-0551-5592424
Fax:+86-0551-5593328