

Demonstration of full scale JJ1 and 316LN fabrication for ITER TF coil structure

Kazuya Hamada, Hideo Nakajima, Katsumi Kawano, Katsutoshi Takano, Fumiaki Tsutsumi, Kiyoshi Okuno
Japan Atomic Energy Agency, Fusion Research and Development Directorate 801-1 Mukoyama, Naka-shi 311-0193 Ibaraki-ken Japan

The ITER Toroidal Field (TF) coil structure consists of coil cases, inter-coil structures and radial plates. A forged JJ1(12Cr-12Ni-10Mn-5Mo-0.2N), forged and hot rolled 316LN will be used for the TF coil structure, depending on stresses generated by the TF coil operation. Required mechanical performances of material used in high stress region is 0.2% yield strength (YS) of more than 1,000 MPa for JJ1, 850 MPa for 316LN and fracture toughness KIC(J) of more than 200 MPam^{0.5} for both materials at 4K. Japan Atomic Energy Agency (JAEA) has performed full scale material manufacturing for ITER TF coil structure to demonstrate a productability and to confirm a mechanical characteristic of materials.

In order to satisfy the ITER requirements, JAEA modified forged 316LN (Strengthen 316LN: ST316LN) based on F316LN specified as ASTM A336 and JIS G3214. The main modification of ST316LN is to increase nitrogen content to 0.2% from 0.16%. Forged JJ1 block (420 mm / 11 tons), forged ST316LN block (390 mm / 26 tons) and two hot rolled ST316LN plates (140 mm / 11 tons and 200 mm / 6 tons) have been manufactured using actual fabrication facilities and processes.

Mechanical properties were measured using the samples taken from these products. As results of mechanical test at 4 K, averaged value of YS for JJ1, forged 316LN and hot rolled ST316LN are 1,126 MPa, 1,078 MPa and 1,066 MPa, respectively. Forged JJ1 and ST316LN blocks showed uniform ultimate tensile strength (UTS) distribution along the thickness direction. In ST316LN hot rolled plates, UTS showed some scattering and mixed area of fine and coarse grains was locally observed at one quarter thickness in the top end portion of plate. Observed coarse grain has a diameter of around 3 mm, which was identified to be a cause of degradation of UTS and elongation. However, the mixed grain condition in the hot rolled plate can be solved by modification of forging process, followed by a hot roll process. Measured KIC(J) was more than 200 MPam^{0.5} for all products.

Therefore, it is concluded that the ITER mechanical requirements for TF coil structure material is achievable in actual JJ1 and ST316LN manufacturing.