Warsaw University of Technology
EURATOM-IPPLM Association

24th Symposium on Fusion Technology

11 - 15 September 2006 - Palace of Culture and Science, Warsaw, Poland

24th SOFT 2006

TOPIC: E - Magnets and Power Supplies
(P1-E-257)

Development of Optimum Manufacturing Technologies of Radial Plates for the ITER Toroidal Field Coils

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A stainless steel structure called a radial plate is used in the toroidal field (TF) coils of the International Thermonuclear Experimental Reactor (ITER) in order to support large electromagnetic force generated in the conductors. It is a 13.7 m x 8.7 m D-shaped plate having 11 grooves on each side in which conductors are wound. Although severe dimensional accuracy, for example flatness within 2 mm, and tight schedule that all radial plates for 9 TF coils (63 plates) have to be manufactured in about 4 years are required in manufacture of the radial plates, there are no industries in the world who have manufactured a large complicated structure like the radial plate with high accuracy.
Japan Atomic Energy Agency (JAEA) has been studying rational manufacturing method and developing the optimum manufacturing technologies of the radial plates in order to satisfy the above requirements in collaboration with the Ishikawajima-Harima Heavy Industries Co., Ltd. (IHI). Several trial manufactures of radial plates have been performed to clarify the following key points.
・Effect of nitrogen content in material on machinability
・Effect of cutting direction of a piece on deformation caused by machining
・Effect of machining shape (curve or straight) on machining condition
・Effect of laser welding technique on penetration and welding deformation
Three different 316LN materials having nitrogen content of 0.12 %, 0.17%, and 0.20% were used to investigate nitrogen content effect on machinability. Machinability of lower nitrogen content material was slightly better than that of higher nitrogen content material. Three sectoral pieces were cut by plasma cutting technique from a hot rolled plate without any difficulties and one of them was machined to a curved segment of the radial plate having the same size as actual one. However, unacceptable large deformation over 5 mm flatness was found during machining which would be caused by curved shape of grooves and/or cutting direction from the original plate. Detailed investigation suggested that cutting direction should be parallel to a rolling direction of the plate. Results of welding trials by using fiber laser technique showed that fiber laser could penetrate thickness of 15 mm in 5kW power, which was larger value compared with YAG laser technique. The optimum manufacturing method based on the investigations of manufacturing technologies is also given in this paper.