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Wed-Af-Po3.14-05 [4]: Examination and Assessment of Large Forged Structural Components for the Precompression Structure of the ITER Central Solenoid

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Large structural forgings of complex shape are required for several components of the precompression structure of the ITER Central Solenoid, consisting of a stack of six electrically independent modules and featuring a total height of 18 m and a diameter of over 4 m. The precompression structure allows the vertical tensile loads to be reacted and adequate preload to be maintained, in order to insure the contact between the modules during plasma operation. Several components of the precompression structure such as tie plates, lower and upper key blocks, lower and upper components are machined from open die forgings of an unprecedented combination of complex shape and large size. The selected material is FXM-19, a high strength nitrogen bearing austenitic stainless steel particularly suited for application at temperatures as low as 4.5 K. A specific manufacturing schedule including redundant multidirectional forging is applied in order to achieve the required properties and microstructure of the final parts.

The paper summarises the lessons learned from the series production of the components. The achievement of a fine and homogeneous microstructure, which is of paramount importance for final inspectability of the parts and to obtain the mechanical properties, is particularly challenging taking into account their large size. It requires a perfect mastering of the whole manufacturing process, from the steelmaking route, based in some cases on sequential remelting of electrodes from different master heats to create large Electroslag Remelted (ESR) ingots, to the sequence of the thermomechanical steps, from the initial upsetting of the ingots to the final solution annealing of the as-forged parts.

Non-Destructive Examinations are based on stringent acceptance criteria. A fine microstructure is indispensable to allow full volumetric inspection with sufficient lateral resolution. The paper illustrates how inspectability of the full thickness of the parts by Ultrasonic Testing, compatible with the criteria imposed by the technical specification and the structural requirements of the single components, is only possible in absence of unrecrystallised areas or excessive grain growth.

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