YP690 MPa Class Heavy Gauge Steel Plates with Low Temperature Toughness for O□shore Structures

Grade	YS (MPa)	TS (MPa)	El (%)	vE (ave.) (J)	
AB EQ70/ DNV E690	≧690	770–940	≧14	−40˚C	(L)≧69 (C)≧46

Specimen: 14ϕ×70GL
YS: Yield strength, TS: Tensile strength, El: Elongation, vE: Absorbed energy

150 mm C Forging G = of

JFE Steel applied a combined forging and plate rolling process using continuous casting slabs to commercial production of heavy gauge steel plates with product thicknesses exceeding 100 mm, and established a manufacturing process that improves the internal soundness and homogeneity in the thickness direction of steel plates after plate rolling by applying a forging process to annihilate the porosities by pressure that unavoidably exist in the slab interior during continuous casting. This process has already been applied to steel plates for boilers, pressure vessels, etc.[3,4]. This report introduces the features of YP690 MPa class heavy gauge steel plates with low temperature toughness, which are produced by the continuous casting (CC)-forging-rolling processes.

Due to the heavier gauge and stricter low temperature toughness requirements for steel plates for offshore structures, it is necessary to satisfy both internal soundness to the center-of-thickness position and strength and toughness requirements. JFE Steel has adopted the continuous casting-forging-plate rolling processes in order to satisfy these requirements. In these processes, the internal soundness of steel plates is improved by adding a forging process for the continuous casting slab production route in order to annihilate porosities in cast slabs by pressure. As a result, mechanical properties at the

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plate center-of-thickness position can be improved. This process has been formally approved as a special practice mitigating the reduction ratio limitation of thickness from a cast slab to finished plate, and makes it possible to manufacture heavy gauge steel plates with excellent internal soundness in product thicknesses up to 180 mm from 310 mm thick continuous casting slabs (reduction ratio: 1.72).

In the developed steel, both high strength and low temperature toughness, namely, YP≧690 MPa and −40°C toughness, are demanded. The hardenability of the developed steel is optimized by adjusting alloying elements such as Cr, Mo, etc. and adding B and other microalloying elements. Toughness is improved by securing a mixed microstructure of martensite and lower bainite microatructure, together with addition of the optimum amount of Ni.

Low temperature toughness is improved by refining the prior γ grain size by controlling the temperature in each of the processes of heating, rolling, and heat treatment. This makes it possible to achieve mechanical properties which satisfy all the requirements of the applicable standards without excessive addition of Ni.

In addition to this chemical composition design, because the porosities in continuous casting slabs can be annihilated by applying the above-mentioned continuous casting-forging-plate rolling processes, it is possible to manufacture steel plates with excellent internal quality at the center-of-thickness in a short production time without adopting the ingot casting-breakdown rolling process.

and show the chemical compositions and mechanical properties of the developed steel AB EQ70/DNV E690 with plate thicknesses of 155 mm and 180 mm. Strength and excellent low temperature toughness which amply satisfy the respective standards can be obtained, including the center-of-thickness (1/2t) position.

shows the performance of welded joints under two heat input conditions as examples of the welded joint performance of the developed steel AB EQ70/DNV E690. In all cases, joint strength and high weldment toughness which satisfy the standard values for the base metal under each standard has been obtained, and the welds of the developed steel possess excellent welded joint performance.

As a heavy gauge steel plate for offshore structures, JFE Steel developed a YP690 MPa class steel plate which satisfies −40°C low temperature toughness requirements in thicknesses up to 180 mm. The developed steel plate is manufactured by the continuous casting-forging-TN forg 5 ъ ng-ḥ ḥ ring-ri # ȳ ˘ ng- ² ȳ Ð s -TN ċ in