YP690 N/mm² Class Heavy Gauge Steel Plates with Low Temperature Toughness for Offshore Structures Manufactured by Continuous Casting, Forging and Rolling Process

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ABSTRACT

YP690 N/mm² class heavy gauge steel plates with low temperature toughness for offshore structures have been developed. In this development, annihilation of cast defects and microstructure control at the mid-thickness are extremely important. JFE Steel established a manufacturing process which makes it possible to produce heavy thick plates from continuous casting slabs with a reduction ratio of around 2. The annihilation of cast defects can be achieved by the hot forging process before hot rolling. An appropriate chemical composition was revealed in view of the optimum hardenability value and a sufficient Ni content for excellent low temperature toughness. Plates with thickness of 155 mm and 180 mm were successfully manufactured by applying the hot forging process and optimizing the chemical composition. As a result, the developed steel plates satisfied the target properties and have received ABS and DNV approvals as EQ70 and E690 grades. Furthermore, the developed steels have already been manufactured commercially.

KEY WORDS: YP690; Offshore structure; Heavy gauge steel plate; High strength steel; Low temperature toughness; Hot forging

INTRODUCTION

As the area of petroleum resource development has expanded in response to increasing energy demand, heavy thickness, high strength and toughness are now required in steel plates for use in offshore structures. The jack-up-rig is one type of offshore structures for resources development. Heavy thickness YP690 N/mm² class steel plates are used in jack-up-rigs because large loads are applied to their legs when the legs are lowered to the ground and lifts up the deck after moving to an offshore oil field. Moreover, with the increasing size of jack-up-rigs, thicker plates tend to be demanded recently.

Annihilation of cast defects and microstructure control at the mid-thickness are extremely important in plates with heavy thickness, high strength and low temperature toughness. The key point for annihilation of cast defects is the manufacturing process, and the key point for microstructure control is optimization of the chemical composition. With regard to the manufacturing process of heavy thick plates, a combination of the heavy reduction rolling and low speed rolling method, center-portion heavy reduction rolling method and high shape factor rolling method have been developed for large ingots and large section continuous casting (CC) slabs in order to eliminate the negative effects of a loose structure and porosities (Tagawa et al., 1976; Tagawa et al., 1980; Tsuyama et al., 1985; Otani et al., 1993; Okayama et al., 2004). However, when heavy thick plates are manufactured from thinner CC slabs, harmful porosities tend to remain due to the insufficient thickness reduction ratio.

Table 1 Target properties for the development steel plates

<table>
<thead>
<tr>
<th>Grade</th>
<th>Thickness (mm)</th>
<th>Tensile properties (Specimen:14q-70GL)</th>
<th>Charpy impact properties vE-40°C(J)</th>
<th>Welding method</th>
<th>Tensile properties</th>
<th>Charpy impact properties vE-40°C(J)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB EQ70 and DNV E690</td>
<td>150 ~ 180</td>
<td>1/4t 1/2t</td>
<td>≥ 690</td>
<td>770 ~ 940</td>
<td>≥ 14</td>
<td>L ≥ 69</td>
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</tbody>
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L: Longitudinal to the rolling direction, T: Transverse to the rolling direction