Development of t100 mm-YP460 N/mm^2 Class Steel Plate with Excellent Brittle Crack Arrestabilit (ARRESTEX^{TM}) for Large Container Ships

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Abstract:

YP460 N/mm^2 class steel with a thickness of 100 mm, which has excellent brittle crack arrestability (ARRESTEX^{TM}

8 000 N/mm$^{3/2}$) at the hull design temperature.

1. Introduction

The number of maritime shipping containers handled has increased rapidly in recent years, supported by the economic growth of the Asian nations, such as China [1]. Moreover, a response to stricter regulations on ship exhaust gas, which is a cause of global warming, and further improvement of transportation efficiency are also demanded in maritime logistics utilizing container ships. In order to respond to these requirements, the size of container ships is increasing year by year. Around 2000, the loading capacity of the largest container ship was 8 000 TEU (TEU: Twenty-foot thickness exceeding 50 mm is applied to the hull structure, crack arrest design which "propagation of brittle cracks can be prevented in case of crack initiation" is required for container ships contracted for construction after January 2014 by the International Association of Classification Societies (IACS) [5, 6]. As a concrete response to this requirement, steel plates with excellent brittle crack arrestability where "the brittle crack arrest toughness value ($Kca_{(-10^\circ C)}$) exceeds 6 000 N/mm$^{3/2}$ at -10°C" have been applied, in addition to a structural discontinuity created by providing a crack arrest hole or performing welding with the weld

$$Y = vTrs - 12 \times I_{\{100\}} - 22 \times I_{\{211\}} \quad \cdots\cdots\cdots\cdots\cdots (1)$$

$I_{\{100\}}$: Intensity ratio of {100} planes of tested steel plate and reference sample
$I_{\{211\}}$: Intensity ratio of {211} planes of tested steel plate and reference sample

Improvement of brittle crack arrestability by toughness improvement utilizing the grain refinement effect becomes even more difficult with the plate thickness of 100 mm. Therefore, according to the above equat2o08g (enP2 DETEMC /Span <</Lang (en-US)/MCID 325 BD0 l-2.445 2.445

ESSO test. Although the conventional steel displays the general thumbnail shaped fracture surface, as shown in (a), the developed steel shows a split-nail shaped fracture surface as a result of its increased crack propagation resistance in the plate center-of-thickness, as can be seen in (b). The developed steel also maintained this fracture surface morphology at the plate thickness of 100 mm, as shown in (c). Based on these results, it can be understood that texture control fully demonstrates its effectiveness in improving brittle crack arrestability, even with the plate thickness of 100 mm.

In conventional steel plates using only grain refinement, the Kca value decreases as the plate thickness increases, and it is impossible to achieve Kca of 8 000 N/mm$^{3/2}$ even with the smaller plate thickness of 70 mm. The developed steel can secure a high Kca value when the plate thickness is increased from 70 mm to 100 mm because texture control is also used. It is also considered possible to obtain plates that amply satisfy the required Kca value by utilizing this technique, even assuming further increases in plate thickness in the future.

4. Welded Joint Properties of Developed Steel

4.1 Welding Conditions

The performance of multilayer welded joints of the developed steel was evaluated. The welding conditions are shown in **Table 7**. Joints were fabricated by gas

5. Conclusion

A new YP460 N/mm2 class steel plate ARRESTEXTM, which provides extremely high brittle crack arrestability and weldability even with an ultra-heavy thickness of 100 mm, was developed by utilizing precise texture control in addition to the conventional grain refinement technology. It is considered possible to manufacture plates that amply satisfy brittle crack arrestability requirements, even assuming the plate thickness is expanded further in the future and higher Kca values are required.

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