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Texture-controlled YP460 N/mm^2 Class Heavy Thick Plate for Ultra-large Container Carriers

Kazukuni Hase
Technology Planning Department, JFE Steel Corporation
Tokyo, Japan

Katsuyuki Ichimiya and Keiji Ueda
Steel Research Laboratory, JFE Steel Corporation
Kurashiki, Okayama, Japan

Tsunehisa Handa
Steel Research Laboratory, JFE Steel Corporation
Chiba, Japan

Taiki Eto
West Japan Works, JFE Steel Corporation
Kurashiki, Okayama, Japan

Masahiro Aoki
Plate Business Planning Department, JFE Steel Corporation
Tokyo, Japan

A YP460 N/mm^2 class steel plate with a thickness of up to 100 mm for ultra-large container carriers has been developed by thermo-mechanical control process (TMCP). The developed YP460 steel plate has an excellent brittle crack arrest toughness of over 11,000 N/mm$^{3/2}$. The characteristics of the plate include a highly oriented texture and excellent Charpy impact toughness by means of an advanced TMCP for the prevention of brittle crack propagation. The alloy design of the plate is a relatively high carbon equivalent to satisfy the required tensile properties; however, good weldability is achieved as a result of its low weld cracking parameter alloy design.

INTRODUCTION

Recently, the size of container carriers has increased as the volume of container freight between Asia and Europe expanded. The first large container carrier with a capacity of more than 10,000 TEU (twenty-foot equivalent unit) was constructed in 2005 for transport efficiency improvement. However, the size of container carriers is continuing to expand, and construction of ultra-large container carriers with capacities of more than 20,000 TEU began in 2016. The thickness and strength of the steel plates applied to the upper hull structure of large container carriers—for example, the hatch-side coaming and upper deck—have been increasing in order to secure the structural strength required by the large cargo opening deck structure.

YP390 and YP460 class steels with thicknesses of more than 70 mm have been developed and put into practical use in the construction of large container carriers (Nishimura et al., 2007; Ichimiya et al., 2008). Fracture toughness is required in these thick steels to ensure the safety of the hull structure and suppress brittle fracture, which leads to catastrophic sea accidents. Therefore, E grade steels are used for the upper hull structures. Because it is very difficult to suppress crack initiation in weld joints perfectly, even though careful attention is paid to suppressing welding defects during the welding procedure, thick plates with excellent crack arrestability must be used in the hatch-side coaming and upper deck to suppress brittle crack propagation even if a crack initiates at the weld joint.

The crack arrestability of thick plates for hull structures has been studied in an industry–academia collaboration committee, the "Brittle Crack Arrest Design Committee of the Japan Welding Engineering Society," and the study's results have been summarized and incorporated in Class NK "Guidelines on Brittle Crack Arrest Design" (Nippon Kaiji Kyokai, 2009). In the guidelines, the minimum brittle crack arrest toughness (Kca) of the steel at -10°C is to be 6,000 N/mm$^{3/2}$ for plate thicknesses between 50 and 80 mm, and the block joint is to be shifted more than 300 mm in order to stop brittle crack propagation from the hatch-side coaming to the upper deck and from the upper deck to the hatch-side coaming by the structural discontinuity effect. A new unified requirement (UR) concerning the crack arrest design was issued by the International Association of Classification Societies (IACS) in January 2013. Both the use of steel plates with excellent crack arrestability and structural discontinuities such as weld line shift between the hatch-side coaming and upper deck or crack arrest holes in the block-to-block butt welds are required when YP460 steel with a thickness between 50 and 100 mm is used in the construction of large container carriers (International Association of

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KEY WORDS: Container carriers, YP460, heavy thick steel plate, brittle crack arrestability, arrest toughness, texture.