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Effect of Thickness on the Crack Arrest Toughness of Thick Steel Plate Welds

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ABSTRACT

Effect of thickness on the brittle crack arrest toughness value (K_{ca}) of thick steel plate welds has been investigated. Steel plates with the thickness of 50 and 80mm were used and electro gas welding process was adopted to prepare the welded joints. Temperature gradient ESSO test was performed to measure the K_{ca} of the welds. Quantitative analysis was conducted to compare K_{ca} value with the variation of plate thickness. Also, the propagation path of brittle crack along the welding line was investigated.

KEY WORDS: ESSO test; crack arrest toughness; brittle fracture; ship building steel

2 INTRODUCTION

Along with the rapid increase in the size of container ship, the steel plate used for ship hulls has been increased in thickness. The growing capacity of large scale ships such as containers is the cause of increase in the thickness and the strength of steel plates for shipbuilding (Yamaguch, 2005). Thicker steel plates are usually used for strength deck construction, including hatch side coaming, sheer strakes and longitudinal bulkheads of large container ships, because of the restrictions on designing hull girder strength for their large hatch openings. A typical example of the strength deck construction of a large container ship is shown in Fig. 1. The toughness and the resistance to brittle fracture of steel plate tend to decrease for thicker plate which is so-called thickness effect (Nakano, 1992).

The 147th research committee of the Shipbuilding Research Association of Japan (SR147 committee, 1978) has performed the investigation on the crack arrest toughness of the high heat input welds with the thickness below 40mm. They concluded that a long brittle crack can be arrested after the brittle crack deviated from the welding line into the base metal.

Recently, Nippon Kaiji Kyokai (Class NK) suggested that the brittle crack arrestability and crack initiation toughness show the low values and they participated in the establishment of the relevant standards. The several researchers have been contended that the fracture toughness of heavy thick plates decreases dramatically if the plate thickness is over 65mm (Inoue, et al., 2007).

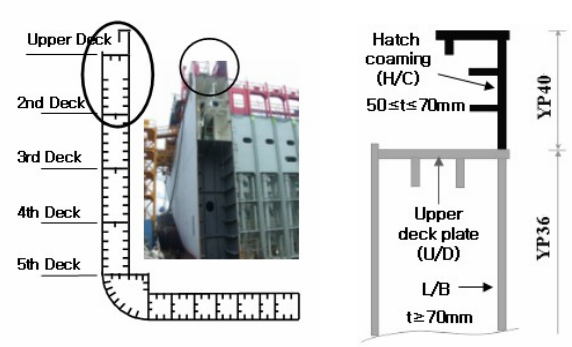

Fig.1 Example of strength deck construction of a large container ship.

For the steel plate above 65mm, it was reported that the high heat input welds shows the straight propagation along the welding line without deviation into base metal and do not have enough K_{ca} to arrest a running brittle crack in the welded joint. Based on these results, they suggested that the welded joints of the thick steel plate cannot ensure the capability to arrest a brittle crack.

However, previous studies were mainly focused on the effect of plate thickness to control the crack propagation path (straight or deviated) such as welding heat input, residual stress and so on. Also, there is no report to measure K_{ca} of the welded joint for thick steel plate quantitatively above 60mm in thickness.

In this study, several crack arrest test were conducted in order to investigate the effect of thickness on crack arrest toughness, K_{ca} and propagation path of the thick steel plate welds with the thickness of 50 and 80mm.

A BRITTLE CRACK ARRES TOUGHNESS TEST

Materials and crack arrest test methods