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Effect of welding heat input on the crack arrestability of thick steel plate welds

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ABSTRACT

Effect of welding heat input on the crack arrest toughness was investigated for the thick steel plate welds. EH grade steel plate of 80mm thickness was used in this study. Electrogas welding (EGW) and flux cored arc welding (FCAW) were adopted to prepare the welded joints. Temperature gradient ESSO test was performed to measure K_{ca} values with the variation of welding heat input. It was found that the welding heat input gave influence on the propagation path of brittle crack along the welds.

KEY WORDS: Crack arrest toughness, welding heat input, crack path, electro gas welding, flux cored arc welding

INTRODUCTION

Recently, as the containerships have been larger and larger above 13,000 TEU for the economical transportation, there has been much demand for the stronger and thicker steel plate in shipbuilding industries. They started introducing EH40 or higher grade steel with a thickness of 80~100mm into the construction of real ship structures. As the containership became larger, fracture toughness of the steel plate got to be an important factor for the integrity of ship structures. Among the various parameters of fracture toughness, crack arrest toughness (K_{ca}) has attracted interest due to the concept of "double integrity" suggested to prevent the propagation of brittle crack (Inoue et al, 2007).

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.

For the steel plate above 65mm, it was reported (Inoue et al, 2007) that the high heat input welds show 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 itself. 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 performed for the high heat input welds and focused on the effect of plate thickness only although there could be other factors 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.

Therefore, in this study, it was aimed to investigate the effect of welding heat input on the crack arrestability of thick steel plate welds. Quantitative analysis by temperature gradient ESSO test was conducted to clarify the effect of welding heat input for flux cored arc welding (FCAW) and electro gas welding (EGW) joint of thick steel plate with the thickness of 80mm.

EXPERIMENTALS

Materials

EH36 grade steel plate with the thickness of 80mm was used in this study. Chemical composition and tensile properties are summarized in Table 1 and 2. FCAW and EGW processes were used to prepare the welded joint for crack arrest test. Detailed welding condition and Charpy impact energy are shown in Table 3.

Table 1. Chemical composition of EH36 steel plate (wt%).

Steel	C	Si	Mn	P	S
EH36 (80mmt)	≤0.08	0.14	1.55	0.004	0.002

Table 2. Tensile properties of EH36 steel plate (at 1/4 thickness).

Steel	YS (MPa)	TS (MPa)	El (%)	$_vE_{-40℃\ ave}$ (J)
EH36 (80mmt)	434	544	24	347

Table 3. Welding condition and Charpy impact energy for welded joint.

Welding process	Heat input (kJ/mm)	Voltage (V)	Current (A)	Speed (cm/min)	$_vE_{-20℃\ ave}$ (J) at root	
					WM	FL
FCAW	1.5	30	280	33	64	112
EGW	53	42	390	3.7	61	226