Development of Thick YP460 MPa Class Steel Plates for Large Heat-input Welding for Very Large Containerships

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ABSTRACT

In connection with a recent trend toward large scaled containerships, it becomes more important than ever to ensure hull girder longitudinal strength around the deck openings in order to assure the safety and reliability of the hull construction. For this reason, YP460 MPa class steel plates have been applied, which exceed YP390 MPa class, the highest strength standard of the conventional TMCP (Thermo Mechanical Control Process) steel plate. For practical application of YP460 MPa class steel plate, it is necessary to ensure further safety of the ships, as well as to apply high efficiency large heat-input welding.

This report describes the development concept of YP460 MPa class steel plates, and the material characteristics of the base metal and welded joints. The concept is as follows.

First, to reduce MA that may cause the HAZ (Heat Affected Zone) toughness deterioration, C addition and Ceq were reduced as much as possible. In addition, TiN was added for the purpose of refinement of the HAZ structure, and to prevent enlargement of γ grains from large heat-input welding.

Second, to achieve the YP460 MPa class high strength, transformation toughening using a uniform intense cooling process was applied. Third, improvements of the base metal fracture toughness were achieved by refinement of crystal grains using strictly temperature controlled TMCP.

The results were as follows.

(1) As for the base metal toughness, vE-40 was more than 340 J, which cleared the specification value of 53 J. It showed a favorable fracture transition temperature of -80°C or below.

(2) As for the brittle crack arresting characteristics, the temperature gradient brittle fracture test (ESSO) at the minimum design temperature (-10°C) showed a favorable stress intensity factor Kca of 7000 N/mm1.5 or more.

(3) Even by 42 kJ/mm large heat-input welding using single electro gas arc welding, the joint strength cleared the specification value, and the joint toughness posed a favorable Charpy absorbed energy of 53 J or more, at all notch positions in the V-notch Charpy impact test at a test temperature of -20°C.

KEY WORDS: Weldability; Thermo mechanical control process, YP460MPa steel plate, Large heat input welding.

INTRODUCTION

The recent increase in the volume of marine cargo transportation has driven the increase in containership size. As shown in Fig. 1, thick, high-strength steel plate is used for the hatch coaming part around the deck openings of a containership. This type of steel plate is used for reasons related to the structure, featuring openings on the upper deck for loading and unloading of container, as well as to satisfy the requirement of reduction in ship weight to get good mileage. The increase in container ship size requires an increase in the structural strength and control weight increase, which translates into a demand for thicker and stronger steel plates. In addition, measures to improve the efficiency of assembly have been introduced to meet the requirement of reducing the time and costs for shipbuilding. For example, in case of welding, the electro-gas arc welding method has been increasingly adopted, which involves welding 1-path welding of a standing joint with a large heat input. This method requires steel with a high HAZ (Heat Affected Zone) toughness, which can withstand large heat-input welding. As heat input in welding increases with the thickening of steel plate, a required toughness must be secured for very severe heat-input conditions. Kobe Steel has fulfilled this requirement through its TMCP (thermomechanical control processing) and low-carbon technologies, as well as through using of microalloys. At present, ultra-large ships with more than 10,000 containers have been constructed. In Japan, this trend has necessitated the use of YP460 MPa class steel plate, whose strength exceeds even that of the