Practical Application of Laser Arc Hybrid Welding to Shipbuilding

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ABSTRACT

To establish practical operation and apply Laser-Arc Hybrid Welding (LAHW) to shipbuilding, processing tests were performed in a variety of edge preparation methods, fixturing methods of plates, and chemical compositions of materials. As a result, satisfactory quality of LAHW joints was achieved without any additional operation work, equipment and material specification to common shipbuilding procedures. In this investigation, an experimental formula to estimate accurate fracture toughness of welding joints was proposed which correct results of Charpy V notch impact test by results of Deep Notch fracture test. Furthermore, the effectiveness of LAHW to reduce welding deformation was verified by experiments and numerical simulations.

KEY WORDS: Laser-Arc Hybrid Welding; Shipbuilding; Quality of Welding Joint; Hardness; Toughness; Fatigue Strength; Welding Deformation.

INTRODUCTION

Laser and Laser-Arc Hybrid Welding moved in application to shipbuilding by European shipyards in the 1990s under the approval of European classification societies. Currently several European shipyards are employing them for the actual production. Generally Laser and Laser-Arc Hybrid Welding is very sensitive to fairness of plate edge, tolerance of joint fit-up, or chemical composition of materials, and such characteristics require heavy special equipment when they are applied. Therefore, they have not been so popularized to other shipyards due to a large amount of investment which is a kind of bottleneck for introduction. This study present a new developed LAHW procedure, which is applicable to common shipbuilding procedure without any such special equipment or special works. This study also propose an evaluation method for fracture toughness of LAHW joints, which was developed in order to cover the problems found in usual Charpy V notch impact tests. Furthermore availability of the main target of LAHW to reduce welding deformation of structures was quantitatively studied by means of some experiments and numerical simulations.

CURRENT APPLICATION IN EUROPEAN SHIPBUILDING

Gerritsen and Howarth (2005) introduced that some European shipyards have employed LAHW to actual production such as Meyer Werft of Papenburg, Germany, Odense Steel Shipyard, Denmark, Blohm+Voss, Germany, etc. Meyer Verft published the outline of welding procedure in panel line in their website. They are applying LAHW to butt welding and fillet welding, in which special devices cramping steel plates are employed. It is understood that rigid requirement to accurate joint fit-up make such devices necessary. Also it is commonly known that edge preparation by machine milling is required to obtain sufficient fairness of joint surface for LAHW. These equipment and preparation work is quite unusual and challenging to conventional shipyards and thus they have been a kind of bottleneck for most of shipyards to employ LAHW. From a view point of joint quality, a concern has been the high hardness in heat affected zone (HAZ) of LAHW joints due to low heat input. Since hardness of welding joint is much affected by chemical composition of steel plates, it could be easily imagined that a sort of restriction to chemical composition of steel plates may be necessary in LAHW. However this restriction is not practical to shipyards because of expected extra price of steel plates and complexity of plate control assuming that normal plates for ordinary welding and special plates for LAHW is handled together in the same shop. Although such restriction of chemical composition of steel plate has not been found as far as authors investigated, study for relation between joint quality and chemical composition of steel plates is considered to be necessary.

PRACTICAL APPLICATION OF LAHW TO SHIPBUILDING

Edge Preparation

Currently the major cutting method of steel plates for ship structures is plasma cutting and gas cutting. A sample of plate edge cut by plasma is