論　文　の　要　旨

題目 Development of hot-wire welding process for butt joint of thick steel plate

（厚鋼板突合せ継手のホットワイヤ溶接技術の開発）

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The improvement of efficiency in the welding process is strongly demanded, especially in the large-scale ship construction field, since the total welding length exceeds several hundred kilometres. Presently, the thick steel plate has been employed for welding. Which strongly has the demand for high strength, quality, and property of weld metal. In those parts, shapes and sizes of shipbuilding's structures have been fabricated by the welding process. There are essential as well as necessary about high joint efficiency, low fabrication costs, and economical methods. The importance of welding of thick steel sheets that have to use both of the appropriate techniques and parameters. In order to get the product with the required features under employing high-current arc welding especially high-current CO_2 arc welding, tandem CO_2 arc welding, and submerged arc welding. Submerged arc welding (SAW) is an arc welding process that uses a consumable wire as an electrode. It has significant advantages of higher productivity, more stable arc, and no spatters compares with other welding processes.

Although, these welding processes have been developed and applied to increase the deposition rate, and productivity. It can achieve higher efficiency than the conventional arc welding process. They still have the problems, such as difficulty in optimizing welding conditions, small tolerances in welding conditions on an actual construction site, which affected to secure joint strength from a decrease in HAZ toughness and is difficult to control the join properties.

In the proposed welding process, hot-wire CO_2 arc welding technology was developed for the high-efficiency and low-heat-input CO_2 arc-welding process for thick steel plates of 20 and 36-mm. The butt joint was welded by the combinations of hot-wire feeding speed and welding current. It was investigated the stabilities within the molten pool for determining the optimum condition and founding the main factor which affected the molten metal precedence. For hot-wire double lasers welding method was performed with the thick steel plate of 20-mm. It was able to decrease the deposition rate of weld metal using the stable laser combination with total laser power of 12 kW.

Firstly, the development of the high-efficiency welding process for 20-mm thick steel plate using hot-wire CO_2 arc welding method was performed in two passes that were completely fulfilled. Sound beads without any defects were achieved under the conditions with a deposit ratio above 1.0 (Fulfilled weld). The deposition capability for each combination of the welding current and hot-wire feeding speed depended on the stable arc molten pool from feeding the total filler wire of hot wire and its. Therefore, obtained conditions were the welding current of 350 A and hot-wire feeding speed of 7.5 m/min, 400 A and 5 m/min, 450 A and 5 m/min, and 500 A and 5 m/min, respectively. The dilution ratio and HAZ width became smaller due to molten pool temperature deduced by the hot-wire feeding, and the welding current decreased. The Vickers hardness average of weld metal was reduced when heat input was increased from adjusting the step welding current up increased. The sound beads were evaluated the mechanical properties, which were performed by Charpy impact test, tensile test, and bending test. Those test results complied with the standard value and without any defects when they were investigated.

Second part, hot-wire CO_2 arc welding process was applied with 36-mm thickness for finding the optimized conditions in each pass. The total volume of the combination of CO_2 wire and hot wire could be filled on the bead width, which was determined after finishing the previous pass. Therefore, filling the weld metal on each pass achieved under the appropriately groove-shape size and stability of molten pool. The obtained conditions of the butt joint can increase the high-efficiency welding by feeding the higher hot wire in welding with the wider bead width. The mechanical properties were evaluated

by Charpy impact, tensile, and bending test. The results found that the welded joint properties met the standard requirements. Also, adjusting the welding speed could increase the welding time. Still, it cannot improve the hardness and toughness of weld metal due to the decreased heat input from changing the welding speed, which affected to cooling rate within the molten pool.

Finally, to study the hot-wire laser welding method for narrow-gap joint of 20-mm thickness, in the first part was researched using both of stable laser beams with tatal laser power of 12 kW. The optimal condition, the molten pool formation and joint creation were generated by using the stable laser beam combination of 32x2 mm and 26x2 mm, beam position arrangement on the bottom side, and welding speed of 0.4 m/min. The welded joint properties, the tensile strength met the requirement of the specification. The results of Charpy impact tests, the absorbed energy of weld metal and fusion line zone showed adequate values over 47 J at 0°C. For the second part, the optimum welding condition used for investigating the molten pool formation using the weaving head system was the combination of laser beam of 32x2.5 mm and 25x2.4 mm, and angle of fixed and weaving head as 30º and 10º. While weaving width of 0.65 mm was used. The achieved weld bead was evaluated of joint property with Charpy impact test according to the standard requirement. In some cases, the Charpy impact test result still had some lack of fusion from investigating the fracture surface and directions of the test specimen. The toughness results of notch location at weld metal and fusion line zone showed a low mean value even though it was used the weaving head system. An essential idea of this problem, using a high laser power on the bottom side of the weld groove can troubleshoot the occurred imperfection.