論　文　の　要　旨

題　目　Development of High-Controllability Hot-Wire Welding Process for Enhanced Joint Properties and Weldability
（継手特性と溶接性の制御を可能とするホットワイヤ溶接技術の開発）

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The hot-wire gas metal arc welding (GMAW) process offers several advantages, including high deposition volume and reduced power consumption, reduced number of weld passes required, and increased process tolerance. Based on these benefits, this dissertation aims to achieve three main objectives.

First, the aim is to develop a single-pass welding method using hot-wire GMAW on 15-mm thick steel plate square butt joints without edge preparation. The author investigates the limitations of conventional GMAW and the effect of hot-wire fraction on the quality of the welded joints. The results demonstrated that the new approach yielded promising results when optimized conditions were applied. Specifically, a single-pass condition using a welding current of 450A, a hot-wire feeding speed of 15 m/min, and a travel speed of 0.6 m/min. Notably, this condition reduced power consumption by 81.25% and a remarkable saving of arc time by 91.67% compared to conventional GMAW.

Second, the aim is to determine the optimal hot-wire fraction and maximize deposition efficiency in GMAW. The author used hot-wire to compensate for the total deposition rate instead of relying solely on high welding current as in conventional GMAW. The hot-wire fraction was varied to identify its limitations. The findings showed that a hot-wire fraction of up to 41% of the total deposition rate provided a soundness condition. Beyond this threshold, issues such as molten metal precedence or lack of fusion will occur. By optimizing the ratio between hot-wire and GMAW fractions, a single-v butt joint on a 20-mm thick steel plate was achieved, resulting in a substantial 62% decrease in power consumption compared to conventional GMAW.

Last, the aim is to enhance joint properties through selective hot-wire filler metal during GMAW. The author used different filler wires with varying nickel (Ni) content to evaluate their impact on microstructure evolution, material characteristics, and fracture behavior. The results showed that increasing the Ni content increased the fraction of acicular ferrite in the weld metal, improving joint properties such as hardness and absorption energy. Hot-wire gas metal arc welding resulted in a 7% increase in hardness and a remarkable 45% increase in toughness compared to conventional GMAW. The hardness and toughness values of the weld metal varied based on the Ni content in the hot-wire filler metal. The findings highlighted the critical role of Ni content in determining the microstructure and mechanical properties of the weld metal. The addition of Ni through hot-wire insertion enabled the superior performance of the weld joint. Hot-wire insertion expands the process tolerance of GMAW sustainably, contributing to its ongoing development.