THE SUMMARY OF Ph.D. DISSERTATION

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Title

Automatic Penetration Control in Welding by Monitoring Oscillation of Molten Pool

Abstract

In recent years, the intelligent welding robots with monitoring systems have been developed to obtain high quality welded joints for reliable constructions. However, it is difficult to obtain a sound penetration weld with back bead in thin plate welding, pipe welding or root welding of thick plates. In order to realize the stable penetration welding, several welding control systems with a visual sensor or an arc sensor have been proposed. In the arc sensing system, the molten pool is oscillated by pulsed welding current, and the penetration is estimated by the natural frequency of the molten pool. However, the miss-judgments concerning penetration sometimes occurred in the welding process using these sensors.

Therefore, two new monitoring systems are proposed to construct more reliable penetration control systems. One is an arc sensing system called ‘back assist gas oscillating method’, in which the molten pool is oscillated by the pulsed gas flow. Using the oscillating method, it is possible to detect the natural frequency stably because of the higher oscillating force. Another system is a hybrid sensing system, in which the arc sensor and the visual sensor are employed in a control system. Then, the welding control experiments are performed and effectiveness of these systems are discussed.

Chapter 1 describes the background and objectives of this study.

Chapter 2 introduces the fundamental theory of the molten pool oscillation and the image processing.

In Chapter 3, the experimental system including power source, welding torch, PC, arc sensor system with A/D converter and visual sensing system are described.

In Chapter 4, the algorithm to detect natural frequency of the molten pool oscillation with FFT analysis is proposed.

In Chapter 5, a molten pool oscillating method by the back assist gas is proposed and the optimum condition for oscillation was studied. the penetration control system to obtain the sound penetration weld by detecting the natural frequency of the molten pool was constructed. Furthermore, the validity of the penetration control system was confirmed by welding control experiments.

In Chapter 6, a new algorithm to detect the contour of the molten pool by analyzing the pool image acquired by a CCD camera was proposed. From the processed image, the shape parameters of the molten pool are measured. the reliable penetration control system with an arc sensor and a visual sensor was constructed. In this system, the artificial neural network was used to consider synthetically the natural frequency and the shape parameters of the molten pool and to output the optimum welding current.

In Chapter 7, penetration control experiments were executed using the welding control system with the hybrid sensing system combined with arc sensor and visual sensor in TIG arc welding of stainless steel plates. As a result of the experiments, the validity and practicability of the system constructed in this study were confirmed.

Chapter 8 summarizes the conclusions of this study.