A Study on Automatic Welding System of Fixed Aluminum Pipes Using Vision Sensors

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Abstract

Arc welding processes of aluminum alloys are important in the automotive and maritime sectors, and have potential for high strength aerospace alloys due to lighter and cheaper structures. One of the arc welding processes is Tungsten Inert Gas (TIG) welding that is widely used in the industries for welding of aluminum alloys. Since the arc welding process is nonlinear and multivariable-coupled because it involves many uncertainty parameters, it is very difficult to obtain a practical and useful controllable model of an arc welding process through classical modeling approaches. Therefore, intelligent control systems are necessary to be developed for modeling and controlling the welding process.

In this study, automatic welding system for horizontally fixed aluminum pipe of 6063S-T5 using a vision sensor is proposed. The welding of aluminum pipe is conducted by monitoring the backside image of molten pool and controlling the welding speed using Neural Network and Fuzzy Inference Systems. Furthermore, an omnidirectional camera, which can observe the entire area around the camera, is adopted for monitoring the molten pool. Finally, the optimization of image processing algorithm to search the edge detection range for detecting the edge of molten pool is conducted using Particle Swarm Optimization (PSO) and Genetic Algorithm (GA).

Chapter 1 describes the background, literature review, original contributions and the outline of this work.

Chapter 2 describes the welding penetration control of fixed aluminum pipes by monitoring the backside image of molten pool using vision sensor. Generally, the edge detection of the molten pool is difficult in aluminum welding, because the contrast of the image is much lower compared to steel welding. Accordingly, a new image processing algorithm to obtain the edge detection range for detecting the edge of the molten pool is proposed. Neural Network model for welding speed control is constructed to perform the welding process automatically.

Chapter 3 describes the automatic welding process of aluminum pipe by monitoring the backside image of the molten pool using Fuzzy Inference System. At first, a simulation system of the welding control using Fuzzy Inference System is constructed to confirm the validity of the control algorithm. Then a series of welding control experiments is conducted to evaluate the performance of the fuzzy controller.

Chapter 4 describes the welding penetration control of aluminum pipe using an omnidirectional camera. A new image processing algorithm is constructed to process the omnidirectional image and to recognize the edge of the molten pool. Back bead width data as the result of detection are delivered into the Fuzzy Inference System to control welding speed.

Chapter 5 describes Particle Swarm Optimization (PSO) and Genetic Algorithm (GA) to optimize the image processing algorithm for searching the edge detection range of the molten pool. Finally, the welding control experiments are conducted using the Fuzzy Inference System which controls the welding speed using the input data of the detected back bead width, and the effectiveness of the system is confirmed.

Chapter 6 summarizes the results of this thesis and discusses future research.