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Monitoring weld pool oscillation using reflected laser pattern in gas tungsten arc welding

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Abstract: A single laser vision method was proposed to carry out real-time sensing of the oscillation signal from the reflected laser pattern. A robust algorithm based on the image centroid of reflected laser pattern was developed to extract the oscillation frequency of weld pool and fluctuation amplitude of centroids of laser pattern ΔH_{cen}. The correlation between fluctuation amplitude of centroids of laser pattern ΔH_{cen} and oscillation amplitude of weld pool surface Δh_{act} were simulated based on the law of reflection. Several experiments were conducted in stationary and traveling welding processes with different penetration status. The oscillation frequency and ΔH_{cen} were extracted. An abrupt transition mode of oscillation frequency and Δh_{act} exists from partial to full penetration status in stationary welding process. By contrast, an abrupt transition occurs in Δh_{act} in the case of traveling welding process. Two transition modes of oscillation frequency, continuous and abrupt change mode, occurred with different welding speeds, which correlated with the oscillation behavior of weld pool surface.

Keywords: weld pool oscillation; single laser vision method; image centroid; weld penetration

1. Introduction

In recent years, trends in high productivity and high-quality welding leaned toward process automation, which has stimulated the increased use of automation and associated systems. As one of the major arc welding processes, gas tungsten arc welding (GTAW) has been widely used in the production of high-quality components for reactor pressure vessels and aerospace structures due to its high weld quality and easy automation. Incomplete penetration is the main and long-standing issues affecting the weld quality in automatic GTAW welding process. Manual GTAW is still applied in many situations to obtain consistent and complete penetration. Hence, sensing and controlling weld penetration in the GTAW welding process have been key issues to developing next-generation intelligent automatic weld machines.

Numerous works were conducted to find the feature signal that can be used to sense and control