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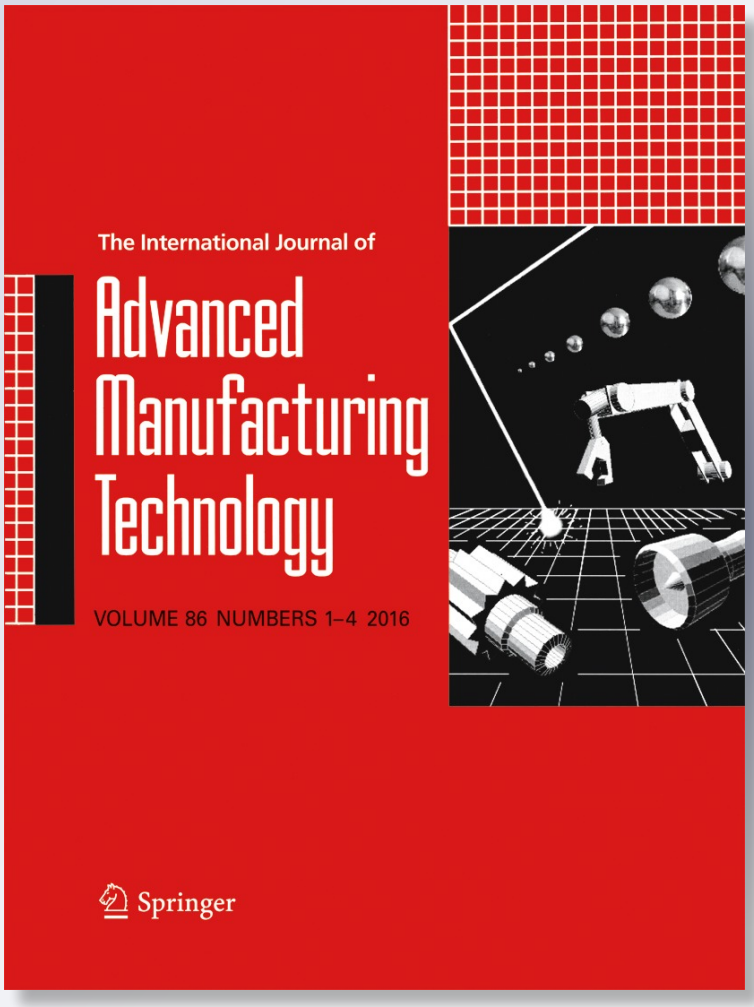

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ORIGINAL ARTICLE

Interpreting the weld formations using acoustic emission for the carbon steels and stainless steels welds in servo-based resistance spot welding

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Abstract Acoustic emission reveals certain characteristic in resistance spot welding process as it exists due to the variation of electromagnetic ties between atomic bounds. So, the objective of this study is to analyse the acoustic patterns of resistance spot welding in a servo-based electrode actuation system. Time and frequency domains' representations are interchangeably applied to analyse such matters as those behaviours are captured via electronics means. More than one type of weldable materials (carbon steels and stainless steels) is purposely used to analyse the dissimilarity conditions as well as the individual material's welding processes. The interpreted waveform shows that the welding processes can be significantly put into classes for their behaviour (weld formation) based on acoustic emissions. A best weld formation will have perfect acoustic pattern, while a better one will have more than one main lobe in frequency domain. Moreover, a dissimilar weld formation will have inter-transient spike waveform, while an expulsion welding process will have a rapid drop of signal in acoustic pattern. All these observations have been revealing dissimilar characteristic of welding processes to certain degrees when the fusion process is concerned in resistance spot welding.

Keywords Spot welding emission · Acoustic emission · Servo welding emission

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1 Introduction

Atoms in crystalline structures are naturally tied by electromagnetic forces between them within the covalent bonds [1, 2]. So, whenever the crystalline structures are stretched or forced in coherent or in random pattern, then the equivalent gyrating electromagnetic waves are transpired accordingly and soon after spontaneously balanced among themselves [3, 4]. In resistance spot welding, the fusion process leads to the entire recrystallisation of atomic structures and releases the corresponding electromagnetic waves [5–7]. Such phenomena yield the electromagnetic waves as acoustic emission due to the adequate amplitudes in periodic alternating current (AC) waveforms, especially in AC waveform-based spot welder [8]. Thus, the atomic compounds of solid or liquid metal will be vibrating in bidirectional ways during the flow of high AC current as it stretches their electromagnetic ties relatively [9, 10]. If this is a natural occurrence, then the unleashing acoustic emission (AE) should be able to be noticed through the spectrum of sounds [11]. As to challenge this empirical notion, an AC, 75 kVA apparent power, C-type pedestal high-capacity machine frames were tested for reality. Since the input frequency of AC waveform of spot welder is about 50 to 60 Hz on the primary side of welding transformer and thereby, the secondary side will be expectedly to have an equivalent frequency spectrum. Hence, the low-voltage electrode terminals (typically below 3 V) with high current (between 1 and 25 kA) that paved ways for AC current flow (50 to 60 Hz of frequency (1 cycle is one complete waveform of welding current) were predominated to these acoustic investigations. Naturally, the human threshold of hearing is 20 Hz, and therefore, these acoustic waveforms should be easily listenable during the welding process because it emits the electromagnetic waves within