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Micro-Array, a Physics Based Solution to the Challenges of Real-Time Spot-Welding Evaluation

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Resistance spot welding employs the Joule heating effect to form a localized molten pool between two or more metal sheets, which upon solidification forms a solid bond. This process is widely used in automotive and other industrial sectors due to its low cost and ease of automation. Quality assurance of such joints is primarily done using offline inspection with a multi-element ultrasonic transducer to allow for 2D measurements of the weld size to occur. Due to the high number of spot welds in automotive applications, averaging about 5000 welds per car, this inspection is performed only on critical welds, or periodically on select samples. Currently, the novel in-process inspection, which monitors during welding, employs a single-element ultrasound transducer built into the welding electrode. A series of pulses are then used to form a time evolution signature from which size is estimated based on the penetration of the weld into the sheet. For this reason, adoption has been hindered in applications where the physical diameter of the welding zone is required by safety standards.

To overcome this, current techniques in the field such as muti-element matrix and phased array have been explored. Although both offer the possibility for diameter measurement, the increased size of the transducer requires a significantly larger welding electrode and makes integration difficult. Phased array also employs electronic focusing, increasing both the complexity and cost of the system by an order of magnitude.

In order to allow for imaging to occur, a radical alternative was required. By using a series of point-like sources, we propose a novel approach implementing a built-in lens cut into the welding electrode, as a result, a 2D image of the welding process can be performed using a transducer that is a fraction of the size of even single-element solutions. After theoretical and numerical validation, a prototype was fabricated for experimental study.

The primary drawback of this technique results from the drastically smaller size, resulting in approximately 5 orders of magnitude lower signal.

This talk covers the current results and state of development, future approaches to overcome implementation challenges, and the potential for new advanced solutions based around this innovative approach.

Keyword-1

Ultrasound

Keyword-2

Imaging

Keyword-3

Spot-Weld

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