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Fuzzy logic based modeling for Resistance Spot Welding Process

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Abstract

In this paper, a fuzzy logic based model for the Resistance Spot Welding (RSW) process, which is capable to predict RSW responses the nugget size, tensile shear strength, and peel strength. Welding current, weld cycle and electrode pressure are taken as the process variables for RSW process. The experimental results were used to construction a fuzzy logic model to predict the effect of the input variables on the responses. The fuzzy model was validated by number of test cases to establish its adequacy. The error in predicting the outputs for the input data was within acceptable limits indicating the adequacy of the model to be used for complex processes like RSW.

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*Keywords:*RSW welding, Fuzzy Logic Controller, Nugget size, tensile shear strength, tensile peel strength.

1. Introduction

Resistance Spot Welding (RSW) process is widely used in aerospace and other application. RSW have many advantage over the another one such as a no filler material is required, a low heat input, a small heat affected zone, low welding distortion and requires relatively low levels of skill from an operator. In resistance spot welding process to produce good weld quality depend upon welding parameter such as welding current, weld time and electrode face. In resistance welding process it is very different to find out optimal resistance spot welding process parameter.

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All three parameters need to control to produce good weld quality. Resistance welding process is complete with 4 stages. Squeeze time, weld time, hold time and off time. The metal sheet to be joined is brought together under pressure by a pair of electrodes and high welding current. Weld nugget is formed at faying surface of sheet metal due to contact resistance and joule heating, Wang, Y. et al. [1] Due to interaction between thermal, electrical, mechanical, Metallurgical phenomena during the RSW process, deformation, stress and strain will developed in the weld metal, O'Brien, R. L. [2]. Over the last few years numerical method is a power full tool for simulate the interaction between thermal, electrical, mechanical, metallurgical phenomena and structural fields during the resistance spot welding by one, two and three-dimensional finite element models, Khan, J. A .et al. [3] and Richard, D. et al. [4].

Fuzzy logic modeling method is one of the artificial intelligence (Al) techniques which have been in use for the modeling of manufacturing process such as machining and welding [5-6]. The fuzzy logic model had developed for select drilling speeds for different material. [7]. Decision-making fuzzy control and Stability analysis of fuzzy systems are proposed in [8]. General treatments of fuzzy set theory, fuzzy logic, and fuzzy systems can be found in several [9]. Rule base fuzzy inference system had developed to study the hardness of sintered high-speed steel [10]. Podrzaj. P. et al. [11] introduced the fuzzy logic based controller for detecting the expulsion during and stopping the welding process when it occurs to avoid unnecessary electrode degradation. Naso D. et. al. [12] developed fuzzy logic model to implement an intelligent algorithm for online weld quality monitoring of GMAW processes with optical sensors. Model also predicts the weld quality and weld defect in real time. Chatterjee, D. et. al. Introduced fuzzy rule based model for predicting the hardness of sintered high-speed steel (HSS).

The aim of this study is to obtain experiment data & construct rule base fuzzy logic model for predict the RSW response (Nugget size, tensile shear strength and Tensile peel strength) with respect to process parameters such as welding current, weld cycle and electrode pressure.

2. Experimental details

In the literature, it is observed that electrode wearing occurred during the resistance welding of galvanized steel sheets. Because of zinc having a low melting temperature which results in it evaporating thereby affecting the surface quality of the electrode. Also, zinc fumes spoil the boundaries of the electrode tip. Each spot welding gives rise to the possibility of electrode wear. Hence the electrode diameter was checked each time before start welding operation. The electrode was ground, cleaned of scales and made to the desired diameter before each welding. A set of electrodes were kept ready with similar diameter to be used for welding. A schematic of the process shown Fig. 1. The electrode was cooled by circulating water during the entire period of the welding process. The thickness of the galvanized steel sheet used in the experiments was 0.8mm. The resistance spot welding was carried out using a constant-alternating current resistance welder (AK-54) having 150 kVA capacity, with full digital set-up parameter (F.D.S.P) controlled by micro-computer and pneumatic application mechanism.

The specimens were prepared with 100 X 30X 0.8 mm in size. Sheet surfaces were cleaned with a dry air jet before RSW. Pilot experiments were initially conducted for spot weld to find out the range and levels of input process parameters such as welding current, weld cycle and electrode pressure. These parameters were set in the microcomputer for welding. Overlapped sheets were placed between the two electrodes center which was marked on the specimens to set the electrode face for producing spot welds at the center. Experiments were conducted for 27 test samples for each response to obtain data for building the fuzzy logic model. Test case study was done with same experimental procedure expect the values of process parameters used in the design matrix.

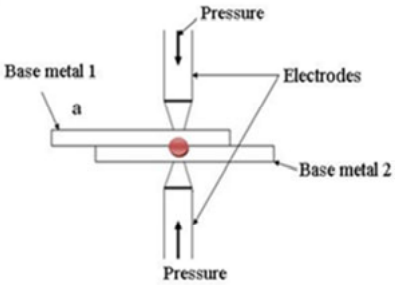

Fig. 1 Schematic view of the process