UNIVERSITI TEKNOLOGI MARA

MODEL DEVELOPMENT OF RESISTANCE SPOT WELDING ON LOW CARBON STEEL AND ADVANCED HIGH STRENGTH STEEL USING MULTIRESPONSE DOE AND FEM

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ABSTRACT

This project investigated the development of the weld zone in resistance spot welding (RSW) on similar and dissimilar material using various statistical methods and numerical simulation approach. Demands placed on dissimilar material joints have increased from various viewpoint such as lightweight vehicle structure, energy saving, high performance and cost saving. Due to steadily increasing price of material, a combination between DP 600 and low carbon steel can be seen as an alternative especially for the section which is not fully exposed to external load. Therefore, the RSW process on dissimilar material of DP 600 and low carbon steel is necessarily to be observed for mass production. For comparison purpose, this research was conducted for plate thickness of 1.2 mm of low carbon steel and 1.0 mm of DP600. In order to reduce the trial and error experiments, statistical methods were used throughout the investigation. An experimental design was started using a general 2^4 factorial design to determine which of the various parameters were important in response surface study. The significance of the welding parameters was obtained using Analysis of Variance (ANOVA) to evaluate the relations existing between the important parameters and the response (radius of weld nugget and radius of HAZ). Optimization of the welding parameters (weld current, weld time and electrode force) to normalize weld nugget and to minimize HAZ size was then conducted using Central Composite Design (CCD) in Response Surface Methodology (RSM) and the optimum parameters were determined. Experiments were conducted according to the selected experimental design, followed by data analysis which included regression analysis and model adequacy checking. A quadratic model for radius of weld nugget and radius of HAZ as a function of the significant parameters were developed for all the combined metal sheets. A second order models were found fitted and can be effectively used to predict the size of weld zone within the factors domain study. Further, the optimization of multi-response (nominal-the-best for radius of weld nugget and smaller-the-better for radius of HAZ) were obtained simultaneously using desirability approach. The confirmation tests validated the use of multi-response optimization for enhancing the welding performance and optimizing the welding parameters in RSW process. The experimental obtained under the optimum operating conditions and the predicted one was found to agree satisfactorily with each other. The optimum parameters obtained from multi-response optimization was applied in the simulation process. A two dimensional axis-symmetric finite element model using customized electrode meshing was chosen to develop the thermal-mechanical-electrical characteristic of the RSW based on the actual electrode dimension. The development of the weld zone was investigated using finite element method (FEM) of SYSWELD and the results were compared with experimental measurement. It was found that the result of FEM presents a theoretically accurate correlation with that of experiments in terms of radius weld nugget as well as HAZ developed.

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CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF STUDY

Resistance spot welding (RSW) is a key technology in automotive assembly production. The welding process is efficient, flexible and can easily weld many dissimilar material combinations that are difficult to join by other welding techniques. The operational cost is generally low, as no shielding gas or filler metal is required. These advantages are originating from its operating principle which employs the electrical resistance concept. The metal to be joined is placed between two water-cooled electrodes and then pressure applied and current turned on [1] [2] [3].The RSW process fundamentally consists of four stages which are squeeze cycle, weld cycle, hold cycle and off cycle. Major factors controlling this process are weld current, weld time, electrode force, contact resistance and sheet material.

The determination of appropriate welding parameters for RSW is a very complex issue in which a small change of one parameter will affect all the other parameters. As a consequence, a prediction on welding parameters for different circumstances is difficult in order to obtain the best quality of weld. Hence, to overcome this problem, Design of Experiment (DOE) was applied to define the desired output variables through developing mathematical models so as to specify the relationship between the input parameters and output variables.

Nowadays, there is an increasing demand for advanced high strength steel (AHSS) sheets in the automotive industry in order to improve the fuel efficiency, safety performance and reduction of auto body weight. The application of AHSSis widely used in automobile industry as it has good formability, ability to resist fatigue and capacity to absorb crash energy [4] [5]. Due to the combination of excellent strength and formability, AHSS offer potentials for improvement in vehicle crash performance without the addition of excess weight. Dual phase 600 (DP 600) steel is one of the most common AHSS and it is good candidates for making light-weight vehicles [6]. Considering the development and commercialization of DP 600 steels for application in automotive bodies, it is necessary to study the welding parameters as well as how they interact to obtain the acceptable weld joint for this steel.