INTEGRATED ASSESSMENT OF MIG WELDING PARAMETERS ON CARBON STEEL USING RSM OPTIMIZATION

JUNITA BINTI MOHD SAID

MASTER OF SCIENCE

UNIVERSITI MALAYSIA PAHANG
AL-SULTAN ABDULLAH

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis, and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science in Manufacturing System & Optimization.

____

(Supervisor's Signature)

Full Name : Ir. Dr. Faiz bin Mohd Turan

Position : Associate Professor

Date : 31 October 2023

____

(Co-supervisor's Signature)

Full Name :

Position :

Date :

UNIVERSITI MALAYSIA PAHANG AL-SULTAN ABDULLAH

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang Al-Sultan Abdullah or any other institutions.

____

(Student's Signature)

Full Name : Junita Binti Mohd Said

ID Number : MFO21001

Date : 31 October 2023

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JUNITA BINTI MOHD SAID

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ABSTRAK

Kajian ini memfokuskan kepada pengaruh pengoptimuman parameter kimpalan MIG terhadap sifat bahan dan kualiti kimpalan melalui kekuatan lentur dan geometri kimpalan melalui reka bentuk eksperimen. Ujian struktur menunjukkan bahawa kegagalan logam selalunya disebabkan oleh ketidaksempurnaan dalam kolam kimpalan, terutamanya dalam sambungan yang dikimpal. Oleh kerana pemilihan parameter kimpalan yang tidak betul, kebolehkimpalan bahan dan pembentukan logam, ia menyumbang kepada kecacatan dan memerlukan proses pasca rawatan. Jesteru, objektif utama kajian ini adalah untuk meminimumkan kecacatan pada kimpalan dan memaksimumkan kekuatan bahan bahagian yang dikimpal dengan menggunakan model regresi tertib kedua kuadratik sepenuhnya untuk meramal parameter proses optimum yang dipilih. Bahan keluli karbon gelek panas JIS G3131 yang dipilih untuk kajian ini adalah berdasarkan penggunaannya yang meluas sebagai bahagian komponen kereta serta mempunyai nilai ekonomi dan mudah dikimpal. Manakala, jenis kimpalan yang digunakan dalam experimen adalah logam gas lengai kimpal temu dengan merujuk kepada piawaian AWS 1.1. Tahap reka bentuk ujikaji yang dijalankan adalah 3 x 3 mengunakan kaedah metodologi maklum balas permukaan dan parameter proses adalah arus kimpalan, voltan arka dan kelajuan kimpalan. Ujikaji ini adalah untuk merekod nilai ketinggian manik kimpal*,* lebar manik kimpal dan penusukan kimpalan. Ujian tanpa musnah radiografi sinar-X dilakukan untuk melihat kecacatan pada kolam kimpalan. Ketahanan sambungan yang dikimpal kemudiannya ditentukan menggunakan ujian lenturan tiga mata. Eksperimen reka bentuk dilaksanakan untuk mendapatkan gabungan optimum parameter input dengan tahap keyakinan 95%. Reka bentuk eksperimen berdasarkan tatasusunan ortogon dan analisis varians (ANOVA) juga digunakan dalam kajian ini. Sumbangannya kepada setiap faktor dan analisis regresi. Kekuatan lentur yang diramalkan adalah 903 MPa dengan ralat 0.66% berbanding nilai eksperimen 897 MPa. Nilai ramalan tambahan untuk penembusan kimpalan, lebar manik, dan ketinggian manik masing-masing 3.1, 9.45 dan 2.04. Selain itu, dalam ujian pemeriksaan RT, didapati sampel ujian mengikut parameter optimum tidak mempunyai kecacatan pada sambungan kimpalan. Untuk analisis regresi gabungan RSM, nilai parameter optimum ialah 115, 20, dan 18 untuk arus, kelajuan dan voltan, masing-masing. Ujian pengesahan untuk DT dan NDT, juga dilakukan selepas penentuan parameter optimum untuk mengesahkan tetapan parameter optimum. Penyelidikan ini menyimpulkan bahawa penggunaan optimum parameter proses untuk produk yang dikimpal telah meningkatkan geometri kimpalan dan kekuatan lentur, yang mana kaedah pengoptimuman ini digunakan secara meluas dan bernilai dalam fabrikasi logam.

ABSTRACT

This study focused on the influence of parameter optimization of MIG welding on material properties and weld quality through flexural strength and weld bead geometry through experimental design. Structural testing shows that metal failure is often caused by imperfections in the weld pool, particularly in welded joints. Due to incorrect selection of the chosen welding parameters, weldability of the material and metal forming, they contribute to defects and require the post-treatment process. Therefore, the objective of this study is to minimize defects in welds and maximize the material strength of welded parts by using a fully quadratic second-order regression model to predict selected optimal process parameters. The JIS G3131 hot-rolled carbon steel material selected for this study is based on its extensive use as automotive parts, has economic value, and is suitable for welding. The experimental welding process is a MIG butt weld joint according to AWS 1.1 standards. The experimental tests correspond to the 3 x 3 orthogonal array of the RSM design; the process parameters are welding current, arc voltage and welding speed and their responses are bead height, bead width, penetration, and flexural strength. Non-destructive testing X-ray radiography is performed to see the flaw in the weld pool. The durability of the welded connection is then determined using a three-point bending test. Design experiments are implemented to obtain an optimal combination of input parameters with a 95% confidence level. An experimental design based on an orthogonal array and analysis of variance (ANOVA) is also used in this study. Its contribution to each factor and the regression analysis. The predicted flexural strength was determined to be 903.1 MPa with an error of 0.66% compared to the experimental value of 897 MPa. Additional predicted values for weld penetration, bead width, and bead height of 3.01, 9.45, and 2.04, respectively. In addition, in an RT inspection test, it was also found that the test sample by optimum parameter had no defect in the welded joint. For the regression analysis of the RSM combination, the optimal parameter values are 115, 20, and 18 for current, speed, and voltage. Confirmation tests for DT and NDT, were also performed after the optimal parameter determination to validate the optimal parameter settings. This research concludes that the optimal use of process parameters for welded products has improved weld geometry and flexural strength, which this optimization method is widely used and valuable in metal fabrication.

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