DISTORTION ANALYSIS OF BUTT JOINT BY FEM AND EXPERIMENTAL STUDY USING MIG WELDING FOR MILD STEEL

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DECLARATION

I hereby declare that this thesis, submitted to Universiti Malaysia Sabah as a partial fulfilment of the requirement for the Degree of Bachelor of Mechanical Engineering. This work has not previously been submitted for any degree or diploma in any university. I also certify that the work described herein is entirely my own, except for quotations and summaries of sources which have been duly acknowledged.

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ABSTRACT

The metal inert gas (MIG) welding technique is the most commonly used welding technology in the industry. Welding distortion in manufactured goods or parts is one of the main problems in the manufacturing industries since correcting the distortion would be more expensive and time-consuming. A deviation from the desired or initial shape and size is referred to as distortion. This research looks at several welding parameters for Metal Inert Gas (MIG) welding and the effect to the welding distortion in both simulation and experimental work and determining the best welding parameters that promotes the least amount of distortion. With welding settings are identical in both simulation and experimental works. ANSYS software is used to construct a three-dimensional and two step transient thermo mechanical finite element model research to examine and assess the distortion behavior. The experiment will be analyzed using Design of Experiment (DOE) approaches, which will include both a computational and physical experimental approach. In order to establish the optimal parameter for minimizing distortion in mild steel welded joints, the results of both computational and physical testing methodologies will be investigated. From both the experimental and simulation analysis, both method suggest that lower voltage and wire feed rate promotes lower distortion and the simulation shows a similar trend to past research in term of voltage and wire feed rate effects on distortion. The experimental result does have a fluctuation of data due to incompetent technical equipment and methodology if compared to past research and simulation where both has more control and are done in a near perfect condition.

ABSTRAK

Kajian Input Haba Terhadap Distorsi Pada Bahan Dikimpal Untuk Kimpalan MIG Pada Keluli Ringan

Pengunaan kimpalan Metal Inert Gas (MIG) adalah cara yang paling diguna pakai dalam teknologi kimpalan dalam industri. Distorsi kimpalan dalam penghasilan barang industri adalah masalah utama dalam teknologi industry disebabkan pembetulan distorsi adalah lebih mahal dan memakan masa yang banyak. Perubahan dari bentuk dan ukuran asal adalah contoh distorsi. Kajian ini bertujuan untuk melihat beberapa parameter kimpalan untul kimpalan Metal Inert Gas (MIG). Tujuan penyelidikan ini adalah untuk mengkaji kesan parameter kimpalan terhadap pengeluaran distorsi dalam kerja simulasi dan experiment, dan juga untuk mencari nilai parameter kimpalan terbaik untuk mendorong jumlah distorsi paling sedikit. Dengan parameter kimpalan yang sama dengan kerja eksperimen, kajian kaedah unsur terhingga menggunakan perisian ANSYS digunakan untuk membina penyelidikan kajian model unsur terhingga mekanik tiga dimensi dan dua langkah untuk mengkali dan menilai tingkah laku distortion. Metodologi Reka Bentuk Experimen (DOE) akan digunakan untuk menganalisis project yang akan menggabungkan pendekatan eksperimen komputasi dan fisikal. Hasil dari pendekatan eksperimen komputasi dan fizikal akan diperiksa untuk menentukan parameter terbaik untuk meminimumkan distorsi pada sendi kimpalan keluli ringan. Daripada pendekatan eksperimen dan komputasi, kedua pendekatan tersebut mencadangkan untuk menggunakan voltan dan kadar suapan wayar yang lebih rendah bagi menghasilkan distorsi yang lebih rendah dan pendekatan komputasi menunjukan hasil data yang hampir sama dengan hasil kajian lepas dari segi kesan voltan dan kadar suapan wayar terhadap distorsi. Data dari pendekatan eksperimen mempunyai sedikit kecatatan disebabkan peralatan dan cara pendekatan eksperimen yang kurang lengkap jikalau di

bandingakan dengan kajian lalu dan pendekatan komputasi yang mempunyai kondisi eksperimen yang hampir sempurna.

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LIST OF ABBREVIATIONS

MIG	Metal Inert Gas
et al.	and others
DOE	Design of Experiment
FEM	Finite Element Method
GMAW	Gas Metal Arc Welding
AWS	American welding society
FE	Finite Element
ASTM	American Society for Testing and Materials

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CHAPTER 1

INTRODUCTION

1.1 Overview

The manufacturing business, in particular, is becoming increasingly competitive as the industry moves toward Industry 4.0. Steel is used for the majority of parts in the creation of new machines, automation, and even buildings due to its qualities. This is due to steel's widespread availability and inexpensive cost, as well as its inherent features such as strength, durability, adaptability, and safety, as well as its recyclability, which allow for superior environmental performance throughout its full life cycle. Steel comes in a variety of shapes and sizes, and its use necessitates specific fabrication processes that must be precisely calibrated. One of the fabrication methods is welding, which has its own set of applications, benefits, and drawbacks. Mild steel has good weldability and machinability, which could lead to an exponential expansion in its use. Mild steel has become a popular material in a variety of industries due to its great qualities.

The metal inert gas (MIG) welding technique is the most commonly used welding technology in the industry. MIG welding uses an electrode all of the time, which is why a trigger regulating device is utilized to control the wire feed and wire bob in this type of soldering procedure. MIG solding is commonly used in manufacturing operations where output rates are high and there is a high risk of arc/shape gas loss due to wind. MIG welding has a faster rate of advancement than TIG welding, but TIG soldering produces a cleaner weld since TIG is less speculated (Madavi et al., 2022).

Due of the highly localised heating process used in welding, residual stress and deformation will undoubtedly develop after cooling. Because of their low rigidity, thin-plate constructions are prone to substantial out-of-plane deformation. Welding distortion is bad for the weldment because it not only reduces the dimensional correctness of the manufactured structure, but it also causes complications during assembly. Meanwhile, residual stress is a significant element that causes cold cracking during the welding process and reduces service fatigue life. As a result, precisely predicting and controlling welding distortion as well as residual stress is critical (Li et al., 2022)

1.2 Problem Statement

One of the primary issues in the manufacturing business is welding distortion in manufactured products or parts, as fixing the distortion would cost extra money and effort. Distortion is a generic phrase that refers to a divergence from the desired or initial shape and size. In welding jargon, distortion refers to the local residual deformation caused by welding that changes the dimension and shape of the linked work piece. The effect of heat supply on welded material will be investigated. The analysis necessitates repeating the experiment in order to verify the process by comparing the distortion produced. Welding distortion is divided into three categories: longitudinal shrinkage, transverse shrinkage, and angular distortion, all of which are influenced by the heat input. The basic calculation for heat input is based on voltage, amperage and travel speed.

$$H = \frac{60\ EL}{1000\ S}$$

Where,

H is the heat input (kJ/mm)

E is the arc voltage (volt)

I is the current (amps)

S is the travel speed (mm/min)

1.3 Objectives

The key objectives of this research project are to analyse the distortion effect on a butt joint weld by FEM and experimental study using the MIG. As a result, the research project's specific objectives can be met by putting out the following effort:

i. To analyse the difference of the effect of welding parameters towards formation of distortion occur in both simulation and experimental.
ii. To find the optimum value of welding parameter that promote the least amount of distortion.

1.4 Scope of the project

MIG welding will be used to complete this project. Welding is done using mild steel with a maximum thickness of 4 mm. The welding travel speed, the welding voltage, welding current, and method of cooling are the process parameters involved in MIG welding. Design of Experiment (DOE) methodologies will be used to analyse the project, which will comprise both a computational and physical experimental approach. Both the theoretical and physical testing outputs will be compared and analysed in order to determine the best parameter for minimising distortion in mild steel welded joints.

1.5 Research Methodology

The methodology of this project is divided into 3 phase which will be conducted accordingly.

Phase I (Design)

1. Problem Statement
2. Background Research

Phase II (Analysis)

3. Material Selection
4. CAD Simulation and Analysis

Phase III (Investigation)

5. Experimental Work
6. Result and Discussion
7. Documentation

1.6 Research Contributions

This project's contribution aims to reduce the cost of repair for industries that rely on welding processes for their products or services, such as construction and infrastructure, automotive, aerospace, shipping, and manufacturing, which all use MIG welding as their standard for joining two or more metals for precision work.

1.7 Summary

The goal of this study is to analyse the distortion effect on a butt joint weld by FEM and experimental study using MIG welding. Metal Inert Gas (MIG), also known as Gas Metal Arc Welding (GMAW), is a welding technique that fuses two base materials together by feeding a continuous solid wire through a welding cannon into the weld pool. Welding parameters, as well as the mechanical properties of the weld, are vital in generating a high-quality weld. Voltage, current, travel speed, welding filler type and size, electrode angle, welding method, and cooling method are all important welding characteristics.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

Previously, the distortion analysis on butt joint by FEM and experimental study using MIG is briefly examined. The study of influence of welding settings on the mechanical characteristic in MIG welding was the one of the main objectives for this paper. All of the research in this study relies on standard guidelines from journals, papers, theses, handbooks and other published materials as a support and to further reinforce the observed effect of heat supply on the material distortion cause by the MIG welding process. As a result, each procedure is further discussed in this literature review chapter in order to gain a better knowledge of the influence of heat supply and cooling method to the distortion of a welded material using MIG and to control them effectively.

2.2 Metal Inert Gas Welding (MIG)

MIG welding is a method that generates heat between a consumable metal electrode and the work piece by using an electric arc. To protect the molten pool from contamination by the atmosphere, an external shielding gas is given in the form of inert gases such as argon, helium, or their mixture. A variety of ferrous and non-ferrous metals can be connected using this method. This welding technology has gained popularity in the general light and heavy fabrication sectors because of its versatility, capacity for all position welding and ability to be semi or entirely automated including robot welding (Verma et al., 2021)

2.2.1 Principle of Operating a MIG

MIG welding requires three parameters: heat electricity, an electrode to fill the gap between metals, and gas pollution protection. MIG welding uses a small electrode that is continually fed by a skilled operator during the welding operation.

In MIG welding, a shielding gas is commonly used to assist protect the weld joint from contamination. Inert gas metal welding does not use shielding, as the name implies. MIG welding is impossible without hydrogen shielding. The MIG welding method is another reason for the shielding gas choking the weld. This makes it easier to deal with welding, fusion arcs, and fusion wire in a clean environment (Madavi et al., 2022)

While selecting the appropriate shielding gas is important, it is equally important to have the appropriate equipment for the job. The MIG gun consumables, which include a diffuser, contact tip, and nozzle, are critically in ensuring that the welding pool is suitably insulated from the surrounding air. If the nozzle is too tiny or narrow for the application, or the diffuser is blocked with spatter, the volume of shielding gas entering the weld pool may be insufficient. This situation might allow air pockets to infiltrate the shielding gas, contaminating spatters, porosity, and welds. As a result, the criteria for picking MIG gun consumables should include those that can assure proper shielding gas coverage by avoiding spatter build up and having sufficiently big nozzle diameter. This suggestion may be utilized to get the MIG