DESIGN OF MULTIFUNCTION WELDING JIG FOR BUTT, LAPP AND T-JOINT USING CATIA SOFTWARE

Submitted in accordance with requirement of the University Teknikal Malaysia (UTeM) for the Bachelor Degree of Manufacturing Engineering (Hons.)

By

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DECLARATION

I hereby, declared this report entitled “Design of Multifunction Welding jig for Butt, Lapp and T-join using CATIA Software” is the results of my own research excepts as cited in reference.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirements for the degree of Bachelor of Manufacturing Engineering (Hons.).

The members of the supervisory committee are as follow:

……..

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ABSTRACT

This project is conducted in order to design a multifunction welding jig that able to secure three types of welding joints which are Butt, Lapp and T-joint in form of 2D drafting and 3D assembly design. The material of workpieces that be welding on multifunction welding jig is aluminium alloy material and has a flat surface with a thickness of 6 mm. Meanwhile, multifunction welding jig is made from mild steel. This project not involved in fabrication stage. The application of the multifunction welding jig is design purposely for gas metal arc welding (GMAW). In order to obtain the best design for the multifunction welding jig, the survey was conducted to identify the user's preference and priority. Then, House of Quality (HoQ) was established to see the relationship between the customer requirement and technical critical specification. After that, three design concepts were sketched. The screening method was then conducted to select the two designs out of the three concept designs that have a higher rating. To obtain the best design concept, a scoring method was applied. The concept design 2 was selected. This is because concept design 2 gets the highest rank. After that, the concept design was drawn using CATIA Software. The drawing process, begin from draw the multifunction welding jig in 3D modelling. After the 3D modelling finished, all components of multifunction welding jig were assembled in 3D assembly drawing. To ensure that, the components of multifunction welding jig able to be minimized, Design for Manufacture and Assembly (DFMA) using DFA Product Simplification software was conducted to reduce the assembly process and cost of the final design.

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ABSTRAK

Projek ini dijalankan adalah bertujuan untuk merekabentuk jig kimpalan yang boleh mengapit tiga jenis sambungan iaitu sambungan “Butt”, “Lapp” dan T dalam bentuk “2D drafting” dan “3D assembly design”. Ciri-ciri bahan logam yang boleh diapit oleh jig kimpalan adalah Aloi Aluminium dan mempunyai permukaan yg rata dengan ketebalan 6 mm. Manakala, jig kimpalan diperbuat daripada Keluli lembut. Projek ini tidak melibatkan peringkat fabrikasi. Aplikasi jig kimpalan ini dikhaskan untuk kimpalan gas arka logam (GMAW). Untuk mendapatkan reka bentuk yang terbaik untuk jig kimpalan, soal selidik telah dilaksanakan untuk mengenalpasti pilihan dan keutamaan pengguna. Seterusnya, “House of Quality” (HoQ) dibuat untuk melihat hubungan di antara keperluan pengguna dan keperluan spesifikasi kritikal teknikal. Selepas itu, tiga reka bentuk konsep telah dilakar. Kaedah penyaringan kemudiannya telah dijalankan untuk memilih dua daripada tiga reka bentuk konsep yang mempunyai penarafan yang lebih tinggi. Untuk mendapatkan reka bentuk konsep yang terbaik, kaedah pemarkahan digunakan. Reka bentuk konsep 2 telah dipilih. Hal ini kerana reka bentuk konsep 2 mendapat penarafan yang tertinggi. Selepas itu, reka bentuk tersebut dilukis dengan menggunakan perisian CATIA. Proses lukisan dimulai dengan melukis jig kimpalan dalam “3D Modelling”. Selepas “3D Modelling” selesai dilukis, semua komponen jig kimpalan pelbagai fungsi telah dipasang di dalam “3D Assembly drawing”. Untuk memastikan komponen-komponen reka bentuk jig kimpalan pelbagai fungsi mampu dikurangkan, “Design for Manufacture and Assembly” (DFMA) dengan menggunakan perisian “DFA Product Simplification” telah dijalankanuntuk mengurangkan proses pemasangan dan kos pemasangan untuk reka bentuk akhir.

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DEDICATION

Only,

my beloved father, Jahnes.S

my appreciated mother, Hellen Ann

my bestfriends, Zuhaizah Jasni, Rozie and Saleha

for giving me moral support, cooperation, encouragement and also understandings

Thank You So Much

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LIST OF ABBREVIATIONS

OAW	-	Oxyacetylene Welding
SMAW	-	Shielded Metal Arc Welding
GMAW	-	Gas Metal Arc Welding
GTAW	-	Gas Tungsten Arc Welding
FCAW	-	Flux Cored Arc Welding
TB	-	Torch Brazing
HOQ	-	House of Quality
DFMA	-	Design for Manufacture and Assembly
CATIA	-	Computer Aided Three Dimensional Interactive Application
MIG	-	Metal Inert Gas
HSS	-	High Speed Steel
QFD	-	Quality Function Deployment
DFA	-	Design for Assembly
DFM	-	Design for Manufacture
CAD/CAM	-	Computer Aided Design/Computer Aided Manufacturing
CNC	-	Computer Numerical Control

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CHAPTER 1

INTRODUCTION

This chapter explains about background, objective, problem statement, the scope of research, significant of study and organization of this final year report. Background discusses the welding process, welding jig, type of joining in welding, methods for design selection and the software used. The objective mentions the mission that should be achieved in this project. Further, problem statement, it explains the issue that causes the research to be conducted. Then, the scope of research covers everything that supposed to be performed in this project.

1.1 Background

Welding is a process of joining two pieces of metal together. The utilization of extreme heat or the addition of other gases or metal causes the occurrence of bonding within both metals (Aguilar, 2011). There are various types of welding processes such as oxyacetylene welding (OAW), shielded metal arc welding (SMAW), gas tungsten arc welding (GTAW), gas metal arc welding (GMAW), flux cored arc welding (FCAW) and torch brazing (TB) (Jeffus, 2004). There are certain tools and condition that is compulsory to be considered in order to get a good quality of workpiece joining. One of the considerations is welding jig.

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Welding jig is a large brace that supports and align first and second workpiece before it undergoes welding operation (Ateliers, 2012). There are four types of basic joining in welding which are corner joint, T-joint, butt joint and lapp joint. Corner joint can be made with or without the addition of filler metal. The filler metal is not necessary if the workpieces are tacked together. As for T-joint, it is complex as compared to the other joining process. In order to melt both sheet metals at the same time, it is essential to hold the flame. There is a large percentage of the welding heat that is reflected back on the torch and cause adjusted torch to backfire. Thus, the torch must be angle more to the direction to avoid it from occurring. Then for butt joint, two workpieces are placed together on the table and it both ends are tacked together. When the workpieces have differences in term of size or thickness, the torch must be pointed to it to ensure both of metals melt at a same time. For lapp joint, caution must be exercised when heating the sheets to ensure both sheets melt simultaneously. The flame must be directed on the bottom sheet and away from the metal top-sheet due to its difference in heating rate (Jeffus, 2004). Each joining required one jig, thus, multifunction welding jig will be proposed.

This project implements House of Quality (HoQ), concept selection and Design for Manufacture and Assembly (DFMA) method to do design selection of multifunction welding jig. HOQ is a method that used to do a translation of the customer needs into technical design requirements (Parka, 1998). The relationship between technical aspects and the customer requirements is constructed by the application of HOQ approach (Ismail et al., 2017). As for concept selection, it is a method that used to do a comparison of a number of design candidates leading ultimately to which best meets a set of criteria (Burge, 2009).Concept selection or also known as Pugh matrix is the best way of structuring and representing an evaluation, as they add structure and control to the concept selection process (Gerrit et al., 2014). DFMA method is the last method that will employ to the concept design. According to Kalyun & Wodajo (2012), from the industry point of view, DFMA method can be described as “A system by which ways of efficient manufacture and configuration of smaller parts are planned and made possible for their use in making bigger structures by putting them all together”. The researchers mentioned that the essential consideration when applying the method is the design for the manufacturing process of assembly parts and actual assembly by the process used for the creation final product must be separately considered.

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The software that will be used to design the multifunction welding jig is Computer Aided Three Dimensional Interactive Application (CATIA). Dassault Systemes and IBM boost up and market this software respectively. The software offers a single platform to design, analyze and fabricate a product, thus, the product progress becomes faster and easier. There are various industries that used CATIA to manufacture their product such as automobiles, aerospace, industrial equipment and ship building (Bartlett, 2011). The version of CATIA consists of 5 which are V2, V3, V4, V5 and V6. The version that to will used for this project is CATIA V5. CATIA V5 offers various of a new Window-like features such as Object Linking and Embedding integration, copy and paste functions, contextual and drop-down menus, traditional toolbars, drag-and-drop functionality and keyboard shortcut. As for system feature, it consists of 3 parts which are sketcher, parametric variational modeler and associative functionality (Fred Karam, 2004).

This project focuses on the design the multifunction welding jig, which are combinations of three welding processes; butt joint, T-joint and lapp joint. The design of jig takes various considerations such as the method of holding the workpiece, reference point, the direction of moveable robot welding, HoQ, concept selection and DFMA method implementation in the multifunction welding jig design.

1.2 Problem Statement

The quality of welding assembly was assured by the usage of a great deal body welding jig during all process of the automobile (Xiaoping Xiong et al, 2009). From this statement, the importance of jig can be seen. Users use a jig to hold the workpieces before it undergoes the joining process in order to get a good quality of joining. When users proceed with the different type of joining process, a different jig will be changed as well according to the suitability of the joining process itself. Thus, a plenty of time wasted just to remove the previous jig and to set up the other jig.

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1.3 Objectives

The main objective of this project is to design the multifunction welding jig using CATIA software. To achieve the main objective, three sub-objectives are outlined.

a) To propose a new design of jig that has an advance function compared to the current product.
b) To produce 3D assembly design and 2D drafting design of the welding jig.
c) To optimize welding jig design by using DFMA in order to reduce assembly process and cost.

1.4 Scopes of the Research

The scopes of the research are as follows:

a) To design the multifunction welding jig, only CATIA software will be used.
b) Prepare the 3D drawing, 2D assembly drawing & engineering drawing.
c) Perform optimisation of multifunction welding jig by DFMA (DFA Product Simplification) software.
d) Only three type of joining will be included in this project which is T-joint, Butt joint and Lapp joint.
e) The multifunction jig application only limited to GMAW welding process.
f) Workpiece limited on Aluminum Alloy flat surface with a 6mm thickness only.

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1.5 Significant of Study

The significances of study are as follows:

a) Improve the knowledge of CATIA software. Apply all tools in the software to provide a good quality of jig design.
b) Study the characteristic of the jig in terms of its design, material and fabrication to prevent thermal stress effect so the jig suitable to be used at the workpiece.
c) Develop a good quality of multifunction jig design that can be used for welding industries.

1.6 Organization of Final Year Project

(a) Chapter 1 is an introduction to the project. It begins with research on project background, problem statement and objective which it must be achieved by following the project scope.

(b) Chapter 2 is a Literature Review. It comprises the previous study and research about CATIA software, welding jig and welding joining type. The entire source is taken from journals, books, articles and websites.

(c) Chapter 3 is a Methodology of the project. It describes a method and process that used to prepare a multifunction jig design.

(d) Chapter 4 is a Result and Discussion. This chapter explains the data result that obtained from the survey, HoQ diagram, concept selection matrix, CATIA software and DFA Product Simplification software.

(e) Chapter 5 is a Conclusion and Recommendation of the overall project. It describes the summary of an entire project.

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1.7 Summary

Chapter 1 consist of 6 sub-titles which is the project background, problem statement, objectives, scope, significant of study and the organization of the project. Background describes the welding process, welding jig, type of joining and the software used. As for problem statement, it explains the usage of a different jig for a different type of joining. It required more time to remove the previous jig and to set up the jig. There 3 crucial objectives that compulsory to be achieved in this project. Then, for the scope it will only cover about the software application, 3 joining process and the welding process that suitable for the multifunction jig. The significant of the study explains the important point of this project. Last but not least, the organization describes the overview of each chapter.

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CHAPTER 2
LITERATURE REVIEW

This chapter describes the summarization of all related articles, journal, website and book that has been done by the previous researchers. The sub-topic that included in this chapter includes GMAW, joining process, jig and fixture, welding jig, HoQ, concept selection, DFMA and CATIA software.

2.1 Gas Metal Arc Welding (GMAW)

GMAW or most commonly known as Metal Inert Gas (MIG) process was used at first chiefly for welding aluminium alloy with helium as shielding gas. After the process was introduced by the development of lower cost power source and shielding by carbon dioxide, GMAW able to be used for welding variety of material that consists of both ferrous and non-ferrous. The range of material that able to be welded is almost unlimited. It only restricted by the characteristic of metal transfer from wire to the workpiece. GMAW process critical feature is by feeding the small diameter electrode wire incessantly into arc from the coil (Peter Houldcroft, 1988).

GMAW also called as MIG, Wire Feed welding or Squirt welding. The process begins as the electrode wire part linking tip and the base metal is heated and deposited into the weld. The feed mechanism supplies more electrode wire at a pre-adjusted rate to sustain a stable arc as the wire consumed. Types of metal that can be welded by this process are Aluminium, Carbon Steel, Copper, Low Alloy Steel, Magnesium, Nickel, Stainless Steel and Titanium. Some of its advantages are it can be simply adapted to fully automatic welding process and a metal as thin as 0.5842 mm can be welded (William Galvery, 2007).

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GMAW is one of the conventional fusion-welding processes where an electrical arc established between a continuously fed filler-metal wire-shape consumable electrode and the workpiece components to be joined is used to generate the heat required for the filler-metal melting and the welding process zone is protected from the oxidizing or contaminating environment using an externally supplied shielding gas. There are many advantages of this process such as most of the commercially available metallic materials can be joined using this process. And joints in all common orientations can be fabricated (Grujicic et al., 2013). Figure 2.1 shows the illustration of GMAW process.

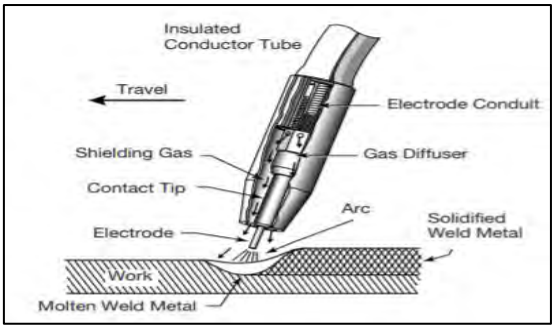

Figure 2.1: GMAW Illustration (Kimbrough et al., 1980)

According to Miller (2012), GMAW is a process of joining metal with electric arc by heating it until reaching its melting point. The arc is between a continuous, consumable electrode wire and the workpiece being welded. The parameter of GMAW is depended on the thickness of workpiece to be welded. Kimbrough et al (1980) mention that GMAW is a process of joining a metal by heating them with an arc between continuously fed filler metal electrode and work. They stated that the range of alloy material that suitable for GMAW includes carbon steel, stainless steel, aluminium, magnesium, copper, nickel, silicon bronze and tubular metal-cored surfacing alloys.

2.1.1 Type of GMAW

Miller (2012) stated there are three different way to perform joining processes which are semi-automatic, machine and automatic welding. Semi-automatic welding also known as hand-held welding. This is because equipment controls only electrode wire feeding, while the welding gun movement is controlled by an operator. As for machine welding, an operator has to persistently set and adjust control that moves the manipulator. While for automatic

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