Several types of welding applications engineering essay



INTRODUCTION

Background of Study

Over the past decades, the importance of welding process especially in a wide range of industrial applications such as ships, railroad equipments, building construction, boilers, pipelines, nuclear power plants, aircraft and automobiles becomes more advance. Today, Flux Cored Arc Welding (FCAW) is one of the most popular welding methods, especially in industrial environments to join metals and alloys. FCAW was first introduced in the early 1950s as an alternative to Shielded Metal Arc Welding (SMAW). In 1965, it represented less than 5 percent of the total amount welding done by using FCAW. The rapid rise in the use of FCAW increasingly continued in 2005 when it passed 50 percent mark and still rising.

C: UserssahaDesktopUntitled. pngC: UserssahaDesktop2071602_f520. jpgC: UserssahaDesktop1114_D77. jpg

Figure 1. 1: Several types of welding applications.

Among the processes employed for welding such as Gas Metal Arc Welding (GMAW), Gas Tungsten Arc Welding (GTAW), Plasma Arc Welding (PAW) and Electroslag Welding (ESW), FCAW is more accepted in different industries to join metals and alloys [1] due to the following features.

High deposition rates.

More tolerant of rust and mill scale than GMAW.

Less operator skill required than GMAW.

High productivity than SMAW.

Good surface appearance.

Recently, automated robotic welding systems have received a great deal of attention, since they are highly appropriate both to increase production rate and quality as well as to decrease cost and production time [2, 3]. The process parameters for FCAW such as welding current, arc voltage and welding speed should be well recognized and categorized to enable automation and robotization of arc welding. The welding parameters are the most important factors affecting quality, productivity and cost of welding joint. Therefore, it is essential to properly select welding parameters for a given task to obtain the adequate bead geometry and shape relationship of a weldment based [4]. Furthermore, occurrence of various weld defects such as incomplete penetration, excess penetration, hollow bead and undercut are also affected by all of these parameters.

The relationship between welding process parameters and bead geometry began investigation in the mid 1900s and researchers were applied the regression analysis in 1987. Numerous attempts have been made by researchers using various types of software and analysis tools relating process variables and bead geometry to generate optimal welding output. Palani and Murugan [4] have built mathematical models using five level factorial technique to predict weld bead geometry for 317L flux cored stainless steel wire with IS: 2062 structural steel as base plate. In addition, the performance of weld can be predicted by Genetic Algorithm method [5], Multiple Regression and Neural Network [6] and Taguchi and Particle Swarm Optimization [7].

The result from these researches show that the mathematical models derived can be used to predict bead geometry accurately. However, these analysis tools are costly and welding industries generally do not use them in production. Thus, the aim of this project is to develop the prediction calculator based on mathematical formulas that match the graphical profiles and represent the correlation between welding parameter and weld bead geometry.

Problem Statement

The bead geometry and welding parameter has to be given before welding start, but this input parameter cannot be easily guessed. Therefore, the quantitative relationship between welding parameter and bead geometry require reference to large number of experimental welding. Meanwhile, the selection of welding parameter for production based on trial and error is costly and time consuming. Hence, the cost of development of Welding Procedure Specification (WPS) will increase by many folds unless the welding parameter is optimal for welding.

Objective of Project

The main purpose of this project is to study the correlation between Flux Cored Arc Welding (FCAW) welding parameter and weld bead geometry in 2F position. Besides that, the aim of this study is to establish the limit of welding parameter that produces acceptable weld quality. In addition, the results from the experiment will be used to develop a calculator that can predict the welding parameter and weld bead geometry for FCAW in 2F position, then validate the accuracy of predicting calculator by experimental measurement.

Significance of Project

This project is intent to build a correlation between the FCAW welding parameter and weld bead geometry in 2F position based on experimental welded coupons. Hence, the result on this project can accurately predict the deposition profile using robotic FCAW process through a map which showing the range of welding parameter in 2G position that will produce good quality weld. As addition, the FCAW bead geometry in 4G position could be predicted based on selected welding parameter by using a validated calculator.

Scope of Project

The welding process is done by employing the robotic welder to perform the FCAW welding in 2F position. The material used is low carbon steel with a thickness of 9mm with T-fillet design. The quality of welding shall be evaluated based on the requirement of AWS D1. 1 code of practice.

Project Methodology

In order to achieve the objectives and the scope of work that to get the good correlation between FCAW welding parameter and bead geometry in 2F position, several methods have been set:

To prepare fillet joint between two plate coupon on 9mm low carbon steel, in

2F position

https://assignbuster.com/several-types-of-welding-applications-engineering-essay/

To employ the robotic welder to weld by the FCAW process by varying one parameter at a time

To measure the weld bead geometry for all good quality bead geometry

To develop a mathematical formula that matches the correlation. Create the predicting calculator for FCAW welding in 2F position

To validate the accuracy and reliability of the calculator with measurements taken from an actual welded sample.

CHAPTER II LITERATURE REVIEW

Introduction of Welding

Welding can be defined as a permanent joining process that produces coalescence of materials by heating them to the welding temperature, with or without the application of pressure or by the application of pressure alone, and with or without the use of filler metal [8]. Ibrahim [10] defined welding as a process of permanent joining two materials usually metals through localised coalescence resulting from suitable combination of temperature, pressure and metallurgical conditions. Most welding processes use heat to join parts together and the equipment used to generate the required varies, depending on the welding process.

Welding is used extensively for the manufacture and repair of farm equipment, construction of boilers, mining and refinery equipment, furnaces and railway cars. In addition, construction of bridges and ships also commonly requires welding. The application of welding process depends on https://assignbuster.com/several-types-of-welding-applications-engineeringessay/ the requirements of the weld, accessibility of the weld area, economic considerations and available welding equipment [9]. The strength and the integrity of a weld depend on the material properties of the metal being welded, as well as on a great many other factors. These factors include the shape of the weld, temperature of the heat sources, the amount of heat produced by the source and even the type of power source used.

Overview of Flux Cored Arc Welding (FCAW)

In recent years, pressure to increase productivity and reduce costs by the manufacturers has been the main driving force behind the adoption of flux cored wires. Productivity, quality and ease of use are the three main factors on which the increasing popularity of FCAW.

FCAW is an arc welding process that uses an arc between a continuous filler metal electrode and the weld pool [8]. The flux is used as a protection for molten metal from the atmosphere contaminations during welding operation. It will improve strength through chemical reactions and produce excellent weld shape. FCAW is very similar to GMAW in principle of operation and equipment used. In FCAW, weld metal is transferred as in GMAW globular or spray transfer. However, FCAW can achieve greater weld metal deposition and deeper penetration than GMAW short circuiting transfer [9]. The effects of electrode extension, nozzle angle, welding directions, welding speed and other welding manipulations are similar as GMAW.

The FCAW are welding process introduced in early 1950s with the development of an electrode that contained a core of flux material. However, an external shielding gas was required even with the flux cored electrode. After that, the flux cored electrode that did not require an external shielding gas was developed in 1959. Shielding gas is important in FCAW-G process for increased penetration and filler metal deposition [9]. FCAW can be applied automatically or semi-automatic. Most FCAW process is semi-automatic, which is the wire feeder continuously feeds the electrode wire and the welder must manually positions the torch into the weld. However, it can transform to fully automatically with a computer driven robot manipulating the torch along a preset path. FCAW is widely used for welding large sections and with materials of great thicknesses and lengths, especially in the flat position.

FCAW actually comprises two welding processes. The two variations for applying FCAW are self-shielded flux cored arc welding (FCAW-S) and gasshielded flux cored arc welding (FCAW-G). The difference in the two is due to different fluxing agents in the consumables, which provide different benefits to the user. FCAW-S is a variation of FCAW in which the shielding gas is provided solely by the flux material within the electrode. The heat of the welding arc causes the flux to melt, creating a gaseous shield around the arc and weld pool. FCAW-S is also called Innershield and it is a flux cored arc welding process developed by Lincoln Electric Manufacturing Company [9]. On the other hand, shielding in FCAW-G is obtained from both the CO2 gas flowing from the gas nozzle and from the flux core of the electrode. FCAW-G is widely performed in flat and horizontal position. However, FCAW-G also can be performed for vertical and overhead position by using small diameter electrodes.

C: UserssahaDesktopfcaws. png

https://assignbuster.com/several-types-of-welding-applications-engineeringessay/

Figure 2. 1: Self-Shielded Flux Cored Arc Welding (FCAW-S). [11]

C: UserssahaDesktopfcawS. png

Figure 2. 2: Gas-Shielded Flux Cored Arc Welding (FCAW-G). [11]

FCAW requires more electrode extension than GMAW. It is because electrode extension will affect the vapour-forming ingredients to generate enough arc vapour for adequate shielding [11]. Inadequate arc vapour will cause porosity in the weld. Besides that, the deposition rates and current density in FCAW are also higher than GMAW. The increased current density occurs due flux cored electrodes are tubular rather than solid, and the flux core has less density and current-carrying capacity than metal [11]. FCAW has a wide range of applications in industry. FCAW combines the production efficiency of GMAW and the penetration and deposition rates of SMAW. FCAW also has the ability to weld metals as thin as that used in vehicle bodies and as thick as heavy structural members of high rise buildings. The most common application of FCAW is in structural fabrication. High deposition rates achieved in single pass make FCAW more popular in the railroad, shipbuilding and automotive industries.

Advantages of FCAW

FCAW has many advantages over the manual shielded metal arc welding. It is more flexible and acceptable in varies industry compared to other welding operation such as gas metal arc welding, submerged arc welding and oxyacetylene welding. These advantages of FCAW [9, 10] are as follows: High quality weld metal deposit

Produces smooth and uniform beads with an excellent weld appearance

Produce less distortion than SMAW

Welds a variety of steels over a wide thickness range

High operating factor

High deposition rate with high current density

Economical engineering joint design

Limitations of FCAW

The limitations of FCAW regarding its applicability [12] are as follows:

Confined to ferrous metals which is primary steels

Removal of post weld slag requires another production step

Electrode wire is more expensive on a weight basis than solid electrode wires

Equipment is more expensive and complex than required for SMAW

Ventilation system need to be increased to handle added volume of smoke and fume

Robotic Welding Technology

Over the past decades, the importance of robot in a wide range of industrial

and nonindustrial applications such as measurements, robotic manipulator

and handling of hazardous materials becomes more advanced. These

applications have to perform in high precision speed and accurate execution in order to achieve outstanding result. Nowadays, most of welding processes could be done in automated applications. With these automated applications, the welding process then called as robotic welding. Robot welding is the use of mechanized programmable tools, which completely automate a welding process by both performing the weld and handling the part. Figure 2. 3

shows the comparison between robotic production setups that exhibit the best " cost per unit" performance if compared with manual work and hard automated setups [15].

C: UserssahaDesktopind rbtc zone. png

Figure 2. 3: Industrial robotic zone. [15]

Robots can be defined as a programmable, self controlled device that perform task to move material, parts, tools or specialized devices through various programmed motions. The term ' robot' has the origination in the Czech dictionary word ' robota', meaning forced work or compulsory service [13]. The term of ' robot' has been created in Karel Capek's play Rossum's Universal Robots (R. U. R) in 1921 and also the term ' robotics' was first used within the short stories written by Isaac Asimov in the 1940s [14].

Robotic welding is one of the most successful applications of industrial robot manipulators. There are lot of products require welding operations in their assembly especially in automation industry. Robotic welding application in production can lead to cheaper products since productivity and quality can be increased, and costs and manpower can be decreased. However, the limitations of automatic welding is it ability to equilibrate for variations in welding joints in any but simplest welding design [8]. When a robot is added to a welding setup, the problems increase in number and in complexity. Robots are still difficult to use because it complexity and have limited remote facilities, program environments and software interfaces [15]. Nevertheless, there are a lot of advantages in robotic welding applications [8] include the following:

Increased productivity through higher operator factor and higher welding speeds

Good uniform quality that is predictable and consistent

Strict cost control through predictable weld time

Minimized operator skill and reduced training requirements

Better weld appearance, consistency of product and heavier-duty welding procedures can be done

FCAW robotic welding is widely used in industrial applications due to its numerous advantages. It can weld a variety of metals in a large range of thickness and effective in all position. It also can weld the material without having to stop frequently to change electrodes compared to other welding processes. In addition, high skill operator is not required because electrode wire is fed automatically and it can perpetuate the arc length approximately constant. However, this process is sensitive to the wind effects which can disperse the shielding gas [15]. In automatic welding, the welding device is programmed to provide the exact tough motion patterns and preset welding

parameters. Inherent tolerance of welding process to accommodate minor https://assignbuster.com/several-types-of-welding-applications-engineering-essay/

variations will result good quality welds. An automatic or automated welding system consists of at least the following [8]:

Welding arc

It requires a welding power source and its control, an electrode wire feeder and its control, welding gun assembly and interfacing hardware.

Master controller

It acts as overall controller which controls all system functions. It can be robot controller or a separate controller.

Arc motion device

It can be the robot manipulator, a dedicated welding machine or a standardized welding machine which involve several axes.

Work motion device

It can be a standardized device such as tilt table positioner, a rotating turntable or dedicated fixture.

Work holding fixture

It must be customized or dedicated to accommodate the specific weldment to be produced which mounted on the work motion device.

Welding program

It requires the development of the welding procedure and the software to operate the master controller to produce weldment.

Welding Position

Welding must be done in the position in which the part will be used. In this project, the scope is to study and investigate the correlation between welding parameter and bead geometry in 2F position. 2F position indicates welding operation for fillet weld in horizontal position. According to the American Welding Society (AWS), horizontal fillet welding is the position in which welding is performed on the upper side of an approximately horizontal surface and against and approximately vertical surface [8].

C: UserssahaDesktop2f position. png

Figure 2. 4: Schematic diagram of horizontal welding 2F position. [8]

The official AWS diagrams for welding positions are precise. They utilize the angle of the axis of the weld which is a line through the length of the weld perpendicular to the cross section at its center of gravity. Figure 2. 4 shows the fillet weld and its limits of the various positions. It is necessary to consider the inclination of the axis of the weld as well as the rotation of the face of the fillet weld [8].

C: UserssahaDesktoppics report2. png

Table 2. 1: Tabulation of position of fillet welds. [20]

TABULATION OF POSITIONS

OF FILLET WELDS

POSITION

DIAGRAM REFERENCE

INCLINATION OF AXIS

ROTATION OF FACE

FLAT

Α

00 TO 150

1500 TO 2100

HORIZONTAL

В

00 TO 150

1250 TO 1500

2100 TO 2350

OVERHEAD

С

https://assignbuster.com/several-types-of-welding-applications-engineeringessay/

00 TO 800

00 TO 1250

2350 TO 3600

VERTICAL

D

150 TO 800

1250 TO 2350

Е

800 TO 900

00 TO 3600

Welding parameter

Weld quality and weld deposition rate are influenced very much by the various welding parameters and joint geometry. Essentially a welded joint can be produced by various combinations of welding parameters as well as joint geometry. These parameters are the process variables which control the weld deposition rate and weld quality. Welding variables can be divided into three classifications which are primary adjustable variables, secondary adjustable variables and distinct level variables [8]. The primary adjustable variables are those most usually used to change the characteristics of the weld namely arc voltage, welding current and travel speed. These primary variables control formation of the weld by influencing the depth of penetration, bead width and bead height. They also affect deposition rate, arc stability and spatter level.

The secondary adjustable variables are consist of tip-to-work distance (stickout) and electrode or nozzle angle. Secondary adjustable variables do not directly affect bead formation and they are more difficult to measure and accurately control. The third class of variables also known as distinct level variables are include electrode size, electrode type, welding current type and its polarity, shielding gas composition and flux type. These variables are selected depends on the type and thickness of the material, joint design, welding position, deposition rate and appearance. In this research, the effects of various welding parameters by robotic FCAW were investigated. The welding current, arc voltage and welding speed were chosen as variable parameters.

Welding current

In welding process, welding current is the most influential variable in welding process because it many factors such as the electrode melting rate, deposition rate, the depth of fusion and geometry of the weldments. Among all welding parameters, welding current intensity has the greatest effect on melting capacity, weld seal's size and geometry and depth of penetration [2]. It must be well determined especially for thin parts because excessive amount of welding current will cause high penetration depths. Otherwise, very low welding current causes insufficient penetration on base metal. Karadeniz et. al [2] were investigated the effect of welding parameters on penetration in Erdemir 6842 steel having 2. 5mm thickness welded by robotic gas metal arc welding. The result showed that the change in depth of penetration was increase with increasing welding currents. Shahfuan et. al [16] also proved in their research that the increasing welding current increases the penetrative power of the arc but reduce the leg size, face width and width of arc due to magnetic pinch. They also demonstrated that the throat size increases toward a maximum with welding current.

Welding voltage

The other most important parameter in welding process is welding voltage. Welding voltage can be defined as electrical potential difference between the surface of the molten weld pool and the tip of welding wire [17]. The primary function of voltage is to control the shape of the bead cross section and its outward appearance. Increasing the arc voltage will produce wider and less deeply penetrating welds than low welding voltages. The relationship between arc voltage and welding penetration is not a straight-line relationship [8]. The smoothest welding arc only can be obtained by certain voltage with constant welding current. Thus, the arc voltage is not suggested as a control for penetration.

C: UserssahaDesktopvol effct. png

Figure 2. 6: Effect of arc voltage variations on weld bead shape. [10]

The arc voltage depends on arc length and type of electrode. However, arc voltage is much easier to be controlled than arc length in order to obtain a

quality welding. An increase in arc voltage tends to cause welding defects such as porosity, spatter and increase weld width [10]. In previous research, Shahfuan et. al [16] was investigated the correlation between welding arc voltage and fillet bead geometry. In this research, the values of arc voltage vary from 23V to 31V, while the current and welding speed are fixed at 250A and 7mm/s. The result shows that the leg size and face width increase with welding arc voltage after minimum at 24V. Besides that, increasing arc voltage increases the arc length but decreasing penetration power. They also concluded that the arc voltage only have small effect on welding bead geometry.

Welding speed

Welding speed is also particularly important variable because it control the actual time that directly effect on the production cost and also weld deposition rate and quality of weld. Welding speed also known as travel speed and can be defined as linear rate at which the arc moves along the weld joint. The relationship between travel speed and weld penetration is relatively straight line relationship [8]. Increasing travel speed will reduce the weld penetration. Welding speed is not recommended to be used as a major welding control if economical reason is emphasized because it is desired to weld at a maximum speed possible. Besides that, increasing the travel speed while maintaining constant arc voltage and welding current will reduce the bead width [17].

Figure 2. 7: Effect of travel speed variation on weld bead size and the penetration. [9]

Travel speed is one of the most important parameters affecting weld quality such as penetration and bead size. High welding speeds will decrease weld penetration but increase tendencies for undercut, porosity and arc blow. Previous researches have shown that the weld penetration was increased by increasing the value of welding speed [1, 2, 3]. Besides that, the changes of welding speed will affect the weld bead geometry such as leg size, weld width and throat size. By increasing welding speed while maintaining constant value of welding current and arc voltage, the leg size, weld width and throat size will decrease on fillet weld [16].

Welding consumables and electrode requirements

The flux cored electrode wires also can be known as inside-outside electrodes because of the fluxing and alloying compounds are on the inside rather than on the on the outside as with a covered electrode [8]. The FCAW electrodes are consist of a metal outer sheath filled with a combination of mineral flux and metal powders which perform same function as the coating on covered electrode. Alternative configuration may be produced by lapping or folding the strip or the consumable may be made by filling a tube with flux followed by a drawing operation to reduce the diameter. Typical finishing wire diameter is range from 3. 2 to 0. 8 mm [18].

Figure 2. 8: Alternative configuration for flux cored wires (a) Outer Sheath, (b) Flux powder. [18]

Flux cored wires offer a lot of advantages in welding process. The deposition

rate will be substantially higher than that normally achieved with Manual https://assignbuster.com/several-types-of-welding-applications-engineering-essay/

Metal Arc Welding (MMAW) and solid wire GMAW. This increase in deposition rate is attributable to the increased current density that carried by the sheath but it also depend on the thickness, polarity and electrode stickout [18]. Besides that, the solidification quality of the slag may be adjusted or designed to provide additional shielding than control the bead shape. The minimum slag generated by flux cored wires will make it possible to use narrower weld joints and fewer required weld passes especially in heavier base metals.

2. 6. 1 FCAW electrode wire classification

The system for identifying flux cored electrodes is complicated. The most common system is shown in Figure 2. 9, which shows the numbering systems for electrodes for carbon steels. However, the electrode numbering system for low-alloy steels, corrosion-resisting steels and for welding cast iron are slightly different. For carbon steel electrode wires, the "E" indicates an electrode which is common for all specifications. The next digit is stands for the minimum tensile strength, as welded, in 10 ksi. The next digit is represents welding position which is "0" indicates flat or horizontal position welding while "1" indicates all position welding. After that, the "T" indicates a tubular or flux cored electrode and last digit following a dash designates the external shielding medium and welding power to be employed. There are four options which is "1" indicates use of CO2 gas as shielding and direct current with electrode positive (DCEP), " 2" indicates use of argon plus 2% oxygen for shielding and DCEP, " 3" indicates no external gas shielding and DCEP, and "G" indicates that the gas shielding and polarity are not specified.

https://assignbuster.com/several-types-of-welding-applications-engineeringessay/ Tubular or Flux Cored

Shielding medium and power

Welding position

Minimum tensile 10 ksi

Designates an electrode

EXXT-X

Figure 2. 9: American Welding Society (AWS) designation for tubular electrode wire for carbon steel. [8]

2. 6. 2 Type of flux cored consumable

Flux cored wire have been developed by following group:

Plain carbon and alloy steel

Hardfacing and surfacing alloys

Stainless steel.

2. 6. 2. 1 Plain carbon and alloy steel

In this group, there have several type of consumable such as

Rutile gas shielded

Basic gas shielded

Metal cored gas shielded

Self shielded

```
https://assignbuster.com/several-types-of-welding-applications-engineering-
essay/
```

Rutile Gas Shielded

Rutile gas shielded wire have extremely good running performance, excellent positional welding capabilities, good slag removal and provide mechanical properties equivalent to or better than those obtained with a plain carbon steel solid wire [18]. Rutile which is a form of titanium dioxide became a popular base for stick electrode coatings in 1930s. It allowed the melting point and viscosity of the slag to be controlled. After that, the presence of sodium and potassium titanates in rutile wires was noticed with the new generation of E71T-1 all positional wires. The toughness of this electrode was good because of the residual impurities in the steel strip were getting lower all the time than improved the positional welding capability [19].

Basic Gas Shielded

Basic gas shielded wire give reasonable operating performance, excellent tolerance to operating parameters and very good mechanical properties. Alloyed formula for welding low alloy and high strength low alloy steels are available. The positional performance of these wires, particularly in the larger diameter, is not as good as that of the rutile consumables [18].

Metal Cored Gas Shielded

Metal cored wires contain very little mineral flux, the major core constituent is iron powder or a mixture of iron powder and ferrous alloys. These wires give very smooth spray transfer in argon/ CO2 gas mixture, particularly at currents around 300 A although they may also be used in the dip and pulse modes at low mean currents. They generate minimal slag and are suitable for mechanized applications [18].

Self Shielded

Self shielded wires are available for general purpose downhand welding and positional welding and a limited range of wires are available for applications which required higher toughness. As in the rutile wires, the higher toughness requirements are usually met by alloying with nickel [18].

2. 6. 2. 2 Hardfacing and surfacing alloys

A wide range of hardfacing and surfacing alloys are produced in the form of flux-cored wire. These include plain carbon steel, austenitec stainless steels, alloying containing high chromium and tungsten carbide and nickel and cobalt based consumables. Many of these wires are self-shielded and intended primarily for site use [18].

2. 6. 2. 3 Stainless steel

Stainless steels flux core wire have also been introduced and matching consumables are available for most the common corrosion resistant materials. Both gas shielded metal cored and rutile based formulation are available with the latter giving exceptionally good operating characteristics, wide process tolerance, low spatter and excellent surface finish [18].

Weld quality

The quality of welded joints is very important aspect especially in critical applications such as building construction, boilers and nuclear power plants where the failure will result into a catastrophe. Thus, the inspection methods should be carried out according to acceptance standards. Acceptance standards stand for the minimum weld quality and are based upon test of welded specimens containing some dis