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The Effect of Flux Core Arc Welding (FCAW) processes on different parameters

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Abstract

Flux Core Arc Welding (FCAW) is an arc welding process that using continuous flux-cored filler wire. The flux is used as a welding protection from the atmosphere environment. This project is study about the effect of FCAW process on different parameters by using robotic welding with the variables in welding current, speed and arc voltage. The effects are on welding penetration, microstructural and hardness measurement. Mild steel with 6mm thickness is used in this study as a base metal. For all experiments, the welding currents were chosen are 90A, 150A and 210A and the arc voltage is 22V, 26V and 30V respectively. 20, 40 and 60 cm/min were chosen for the welding speed. The effect will studied and measured on the penetration, microstructure and hardness for all specimens after FCAW process. From the study, the result shown increasing welding current will influenced the value depth of penetration increased. Other than that, the factors that can influence the value of depth of penetration are arc voltage and welding speed.

Keywords: Depth of penetration, Hardness, Welding speed, Microstructure, Robotic welding

1. Introduction

In a welding world, Flux-Cored Arc Welding (FCAW) process commonly used in different industries to join the metals and alloys. It has a few numbers of benefits such as high deposition rates, more tolerant of rust and mill scale than GMAW, simpler and more adaptable than SAW, less operator skill required than GMAW, high productivity than SMAW and goo surface appearance [1]. For the repairs industry they are performed by used the manual metal arc welding (MMAW), however the flux cored arc welding (FCAW) process are more benefits and have been appreciated by the industry for many years [2].

The process parameters for FCAW should be well recognized and categorized to enable automation and robotization of arc welding. The selection of welding procedure must be specific to ensure the good quality in bead. To obtain the needed quality welds, it is important to have complete control over the relevant process parameters to obtain bead geometry and shape relationship of a weldment based [3].

The result from the study on relationship between process parameters, weld bead geometry and tensile properties in low carbon steel joints by robotic FCAW-G shown that the increase in arc voltage or welding current in FCAW-G decrease clearly the ultimate tensile strength and yield strength of weldment . When the welding speed increase, the weld strength also increase [4].

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2. Experimental

For the base metal, the mild steel having the 100mm x 100mm x 6mm sizes were use for the experiment. The spectrometric analysis of the base metal was done by using Optical Emission Spectrometer Machine to obtain the chemical compositions of the metal were given in the Table 1.

FCAW operations were performed by the OTC Almega AII-B4 series articulated robot welding. 1.2mm diameter of electrode wire (K-71T AWS A5.20) were used, 100% of CO_2 was used as a shielding gas protected, , nozzle to work distance is 12mm, the torch angle is 5° and only one pass on the weld plate. The variables that choose in this study are arc voltage, welding current and welding speed. The arc voltage and welding current were chosen as 22, 26 and 30 V and 90, 150 and 210 A approximately. The welding speed was chosen as 20, 40 and 60 cm/min.

Table 1: The composition of the base metal used, wt (%)

Element	C	Si	Mn	P	S	Cr	Ni	Cu	Al
Wt (%)	0.204	0.231	0.65	0.0085	0.012	0.143	0.081	0.309	0.0024

After finished the welding process, the specimens will cut perpendicular to the welding direction by using a cut-off machine to cut the specimens, grinding and polished. Then, the specimens will etch using 2% or 10% nital for clearly the metal zone of welding. The depth of penetration will measured and microstructural will observed on the etched specimens by optical microscopy 10x magnification. Lastly, for the Vickers Hardness values for HAZ, the 1kg load applies up to 20 second on the specimens [4], [5], [6].

Figure 1.The OTC Almega AII-B4 articulated robot welding

3. Result and discussion

The 27 FCAW process on the base metals with the variables in welding parameters which are welding speed, arc voltage and current were complete and the microstructure observation, deep of penetration measured and hardness for all cases. As a result, the parameters will affect the penetration, microstructure and also hardness.

3.1 The effect of welding current on penetration

The effect of welding current on penetration was present in figure 2 below. The entire graph shows the penetration versus welding current on three various arc voltages with the constant welding speeds 20cm/min, 40cm/min and 60cm/min.

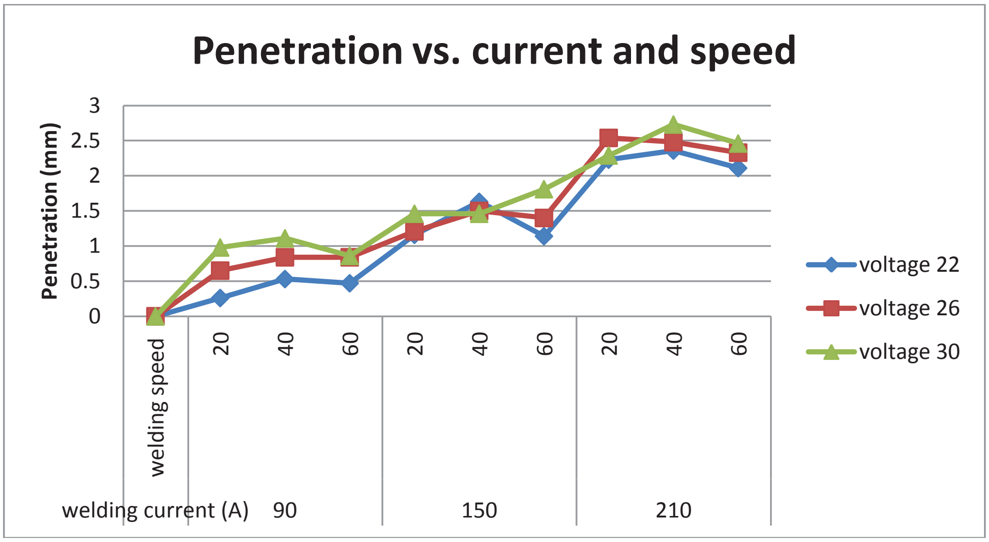


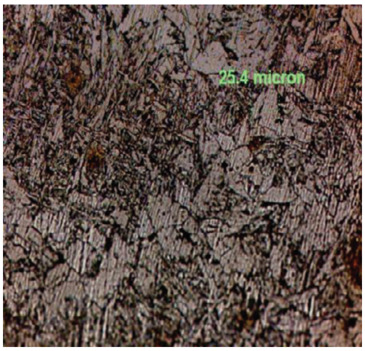
Figure 2. The effect of welding current to the penetration at different arc voltage on a) 20 cm/min welding speed, b) 40 cm/min welding speed and c) 60 cm/min welding speed

In figure 2, arc voltage as constant as 30V and the value of the penetration was increased by increasing the value of welding speed 20, 40 and 60 cm/min. The higher penetration is 2.732 mm at the welding speed 40cm/min, welding current 210A and arc voltage 30V. The lower penetration is 0.26mm at the welding speed 20cm/min, welding current 90 A and arc voltage 22V. From the figure, it showed clearly that the increasing the welding current from 90 to 210A will influence and increase the depth of penetration, at all arc voltages. The graph shows when the welding speeds and welding current increase will affect the penetration become increase.

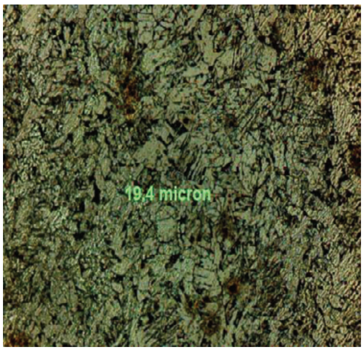
3.2 Microstructural observation

These microstructural changes have been shown in figure 3. The changes in flux core arc welding parameters are influence the affect of the microstructure properties of weld metal. The increased parameters will affected to the grain size of microstructure.

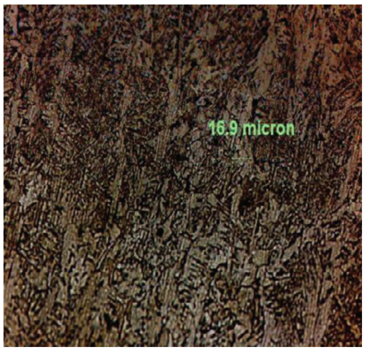
The figure 3 below shown at the arc voltage 210 A, 30 V welding current and different value of welding speed 20 cm/min, 40 cm/min and 60 cm/min present the different phase of grain boundaries. At 20 cm/min, the large grain boundaries with 25.4micron have shown but at 40 cm/min, the grain boundaries (19.4micron) become smaller than 20 cm/min and at 60 cm/min it is smallest (16.9micron) and form more martensite than others.



200x magnification
210 A, 30V, 20cm/min



200x magnification
210 A, 30V, 40cm/min



200x magnification
210 A, 30V, 60cm/min

Figure 3: The microstructure observation on the weld metal

3.3 Vickers Hardness Test

The specimens will cut perpendicular to the welding direction by using abrasive cutter, grinding and polished with different grades of grits. Before going to the experiment, the specimen will etched using 2% natal clearly the metal zone of welding. The Vickers Hardness values for HAZ, the 1kg load applies up to 20 second on the specimens.

The hardness value are determined and performed at figure 4. Usually, the loses of originality strength for the material causes by the strain hardening effect in the fused zone during the solidification. For low carbon steel, the point of the fusion zone that content the formation of bainite or martensite phase and the hardness of material were increased [5].

The effect of welding current to the hardness was present in figure 4 below. The entire graph shows the hardness versus welding current on three various arc voltages with the constant welding speeds 20cm/min, 40cm/min and 60cm/min. The hardness decrease depends on when the welding current and arc voltage are increase.

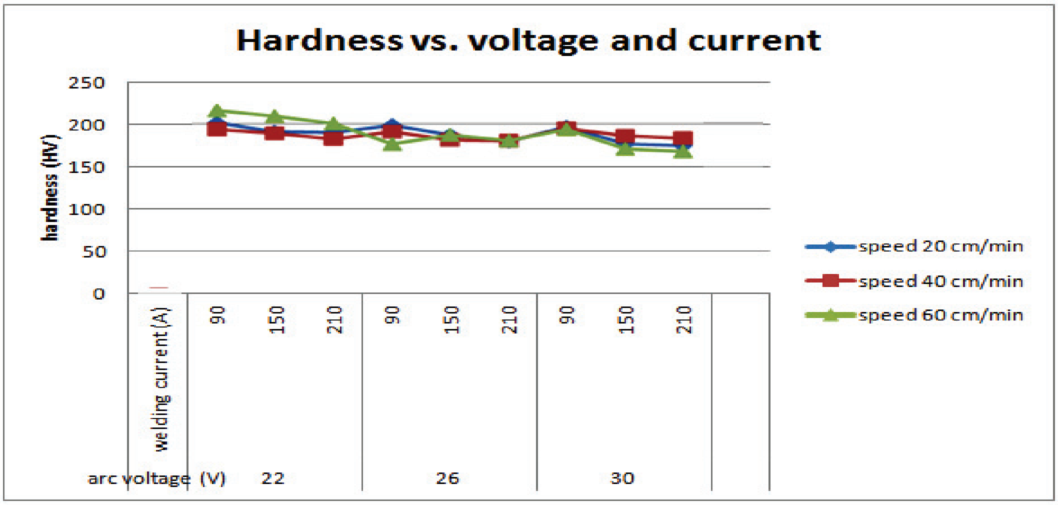


Figure 4. The effect of welding current to the hardness at different arc voltage on a) 20 cm/min welding speed, b) 40 cm/min welding speed and c) 60 cm/min welding speed

Figure 5 below shown that at the certain parameters the hardness value at weld bead metals are higher than the value of Heat Affected Zone (HAZ). The cooling method likes environment temperature influenced the hardness values in the HAZ zone. The hardness values for base metals are lower than weld bead and HAZ. The graph below shows the hardness value of weld bead is higher than HAZ.

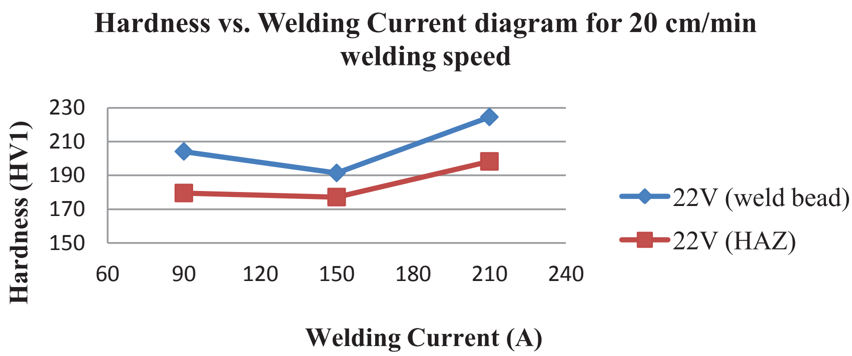


Figure 5. The graph of hardness versus welding current at 20cm/min welding speed (arc voltage 22V)

4.0 Conclusion

Robot welding system are highly appropriate both to increase the production rate and quality as well as to reduce production time and cost for a desired product, due to that it have received a great deal of attention. The conclusion from this study;

1) The increased value of penetration by increasing the value of welding current from 90, 150 and 210 A. Welding current is a factor that influences the penetration. Arc voltage and welding speed also a factor that can influence the penetration. From the graph at the figure 2, the best value of the penetration from three various welding speed is 30V. It plotted the highest value of penetration compare than 22V and 26 V.
2) The sizes grain boundary of microstructure changes from bigger to smaller size when the welding speeds increase.
3) The hardness values for the weld metal are higher than HAZ in FCAW if the base metals are mild steel. The other effects will influence the values of hardness for the weld metals and HAZ. It shown in the several parameters has an HAZ value is higher than weld metals. The hardness will decrease when the arc voltage and welding current are increase because of the change of the sizes grain boundary of microstructure.

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Abstract

The main problem faced in duplex stainless steel cladding is the selection of the optimum combination of process parameters for achieving the
required quality of clad. This paper highlights an experimental study carried out to analyse the effects of various flux cored arc welding (FCAW)
process parameters on important clad quality parameters in duplex stainless steel cladding of low carbon structural steel plates. The experiments
were conducted based on four-factor five level central composite rotatable design with full replications technique and having mathematical models
developed using multiple regression method. The effects of the input process parameters on clad quality parameters have been presented in graphical
form, which helps in selecting welding process parameters to achieve the desired clad quality quickly.

Abstract

The welding heat input plays a significant role in determining the microstructure and composition of the super duplex stainless steel cladding. The welding process is represented in the form of mathematical models developed using response surface methodology. The models were then used to predict the weld bead characteristics with reasonable accuracy. In this work, the models were developed to relate the identified important process parameters like welding voltage, wire feed rate, welding speed, nozzle to plate distance and welding gun angle with bead geometry. The models found to satisfy the adequacy requirements. It was found that reinforcement form factor was influenced by the factors arc length, torch travel speed, melting rate and resistance heating of the electrode. In the same way penetration form factor is influenced by the arc length, torch travel speed and arc force at the weld puddle. Contact angle influenced by the melting rate and resistance heating of the electrode.

Abstract

Weld surfacing with super duplex grade stainless steel found to improve corrosion resistance and functional life of the mild steel components used in the process industries. The properties of the deposited layer were influenced by the process variables that affect the heat input to the process. The influence exerted by the process variables on the responses of super duplex stainless steel claddings were modeled using the response surface models. The response surface models developed by the regression techniques using the data collected from central composite rotatable design of experiments. The data extracted from 32 single bead on the plate welds were deposited by flux cored arc welding process. The developed models can be used to predict and simulate the influence of the process variables on the responses. The insignificant variables found in the full models were removed by the backward elimination technique. Sensitivity analysis performed on the reduced models helps to identify and rank the process variables based on their extent of influence on the responses. Then the ranked variables are closely regulated to tailor the properties of the surfaced layer.

Abstract

Post weld heat treatment (PWHT) is the most common technique employed for relieving residual stresses after general repair welding. Besides,the primary purpose of reducing the effect of stresses induced by welding, PWHT is also intended to temper the metallurgical structure of the heat-affected zone (HAZ). Unfortunately, there are significant difficulties in carrying out post weld heat treatment such as; the complexity of weld geometry, the possibility of distortion in the case of any mechanical loads, difficulty in heating symmetrically, and also PWHT may cause degradation of the material properties (especially creep and tensile strength in the case of multi PWHT cycles). Most of the repairs in industry are performed with manual metal arc welding (MMAW), however, the benefits of the flux cored arc welding (FCAW) process have been appreciated by industry for many years. Guidelines in the current welding standards in addressing the issue of temper bead welding (TBW) when fully automated flux cored arc welding is used are very limited. This paper reports research work carried out to investigate, whether a fully automated flux cored arc welding process with bead tempering can be used in repair welding instead of manual metal arc welding in order to eliminate the use of post weld heat treatment. The paper also examines different percentages of bead overlaps and studies their effects on the mechanical properties as well as the microstructures. The results show that desirable microstructures and hardness values can be obtained using flux cored arc welding when 70% bead overlap is used.