TEST Engineering & Management

May – June 2020
ISSN: 0193-4120 Page No. 1151 - 1155

Effect of Welding Current and Electrodes on Depth of Penetration in Shielded Metal Arc Welding Process

Rudra Pratap Singh[1]*
[1]Associate Professor, Department of Mechanical Engineering, GLA University, Mathura, India
**corresponding author e-mail*: rudra.singh@gla.ac.in

Article Info
Volume 83
Page Number: 1151 - 1155
Publication Issue:
May - June 2020

Article History
Article Received*: 11August 2019*
Revised*: 18November 2019*
Accepted*: 23January 2020*
Publication*:10 May2020*

Abstract:

Depth of penetration is a very important macroscopic welding output parameter whch indirectly indicates the mechanical properties of the weld. This work aims at the investigation of the effect of three different types of electrodes at varying welding current in shielded metal arc welding process utilizing Low Carbon Steel plate of API 5L Grade X 52. The three electrodes used were E 6013, E 7016 and E 7018 and the varying currents were used as 90 A, 100 A and 110 A. Total 9 pairs of welds were obtained to analyze the effect of current and the electrode on the depth of penetration. The dimensions of the work pieces were as 75 mm x 50 mm x 5 mm. The values of depth of penetration in each weld were recorded in a table and diagrams were drawn to make clear the effect of welding current on depth of penetration for different electrodes. It was found that depth of penetration increased for all the electrode cases if the value of the current was increased.

Keywords: *Electrode, Current, Structure, Depth of Penetration, Arc.*

1.Introduction

Shielded metal arc welding process is used by several small scale industries for making joints. The process is simple and cheap and can be operated by human welders in small working area. Heat and pressure both can be applied to join structural parts in any welding process. Two or more parts of any structure can be joined by many methods but the welding process is highly reliable. The strong enough, cost effective joint which is light in weight can be produced hence this process is preferred over many other joining processes [1]. The life of welded parts can be increased by adding some special materials in the weld through electrode. The shielded metal arc welding process is performed manually and is also known as manual metal arc welding process [2]. A core wire surrounded by some coatings containing suitable materials is used as an electrode in this SMAW process. This electrode contains different types of filler material and is made in different length and diameter. After melting the electrode and added materials become the part of the weld and improve the properties of the joint. The burning of filler material produces some gasses which are utilized to shield and protect the weld from the surrounding atmospheric gasses [3]. Some flux is also used in the coating of the electrode which reacts with the present impurities of the base metal and forms slag having low density. The slag floats on the upper layers, which is removed from the surface of the weld when it is solidified [4]. An electric circuit is used to connect electrode and the work piece in SMAW process with the help of cables. The temperature of about 5000 degree centigrade is produced in between the tip of the electrode and the work-piece. This heat produced is capable to melt the electrode and base material to form the weld [5]. In India the alternative current has a frequency of 50 Hz and so the arc extinguishes 100 times per minute, the re-establishment of the arc can be done by some special electrodes. There may be several electrodes which serve this purpose, in these electrodes E 6013, E 7016 and E 7018 are very important. E 6013 electrodes produce a soft arc with minimal spatter, offer moderate penetration and have an easily-removable slag. These electrodes should only be used to weld clean, new sheet metal. E 7016 is hydrogen controlled basic coated electrode for welding medium and high tensile structures, grey cast iron components, low and medium carbon steels. The deposits are of radiographic quality

May – June 2020
ISSN: 0193-4120 Page No. 1151 - 1155

coupled with excellent mechanical properties. E 7018 is a low-hydrogen type electrode which means "hydrogen embrittlement" is reduced in the weldment [6]. The depth of penetration is a very important macro-structural property of the weld which indirectly represents the mechanical properties of the weld and increases the life of the product if properly designed. The welding current is in direct relation with input heat so very important for calculating optimum mechanical properties of the weld.

2.Experimental Procedure

The experiments were performed in the welding science and technology lab of the GLA University, Mathura. The welding of specimens was done with the help of a shielded metal arc welding process. Total nine pairs of specimen pieces were cut from a large Low Carbon Steel plate of API 5L Grade X 52 having 50 mm width and 5 mm thickness, with the help of a power hack saw. The chemical composition of Low Carbon Steel plate of API 5L Grade X 52 is shown in table 1. The dimensions of the specimens were taken as 75mm x 50 mm x 5 mm. The specimens were cleaned with the help of rough and hard papers to remove rust, dust and contaminated surface layers. Two pieces forming a pair were welded in butt position to obtain the required bead. The used power source was a shielded metal arc welding machine using transformer, from which the power was supplied to the work pieces with the help of an electrode. An electric arc was developed in between the work piece and the electrode. The energy was supplied through the arc and a column of highly ionized gas and metal vapours. The temperature of about 50000 C was developed in this welding process. The high amount of heat, so developed was used to melt the material and to form the joint. The measurement of bead dimensions by metallurgical microscope is shown in figure 1.

In this work three types of electrodes namely E 6013, E 7016 and E 7018 were used at welding currents of 90 A, 100 A and 110 A. Each electrode has 3.15 mm as diameter and the former has 350 mm length and the other two have the length as 450 mm. The chemical composition of E 6013, E 7016 and E 7018 are shown in tables 2, 3 and 4 respectively. Every electrode was used to weld three pairs of specimens using currents 90 A, 100 A and 110 A, respectively. The other input welding parameters were kept at constant values as 22 V voltage, 6.35 mm/s as feed rate and welding speed as 1.44 mm/s.

Figure 1 Measurement of Weld Bead Dimensions with Metallurgical Microscope

The values of depth of penetration for every weld were recorded in table 1. After welding, all the weld beads obtained were sectioned transversely at two surfaces in such a way that middle portion,1 mm thick containing weld, heat affected zone and base metal were selected for investigation. The welds are generally not proper at start and at end of the work pieces due to several reasons so these portions are removed. The sectioned parts were ground with the help of emery belt grinders of grades 0, 2 and 3 so that weld bead dimensions become clear and visible. The ground portions were polished with double disk polishing machine. Etching process was done to the polished pieces with the help of a mixture of 2 % nitric acid and 98 % ethyl alcohol solution. The depth of penetration was measured for every weld with the help of metallurgical microscope and digital sliding calliper and arranged in table 5. The effect of welding current and electrode on depth of penetration can be easily analyzed with this table.

3. Result and Discussions

Table 1 Chemical composition of Work-piece material as Low Carbon Steel API 5L Grade X 52

Element	C	Mn	P	S	Fe
%age Composition	0.20	1.35	0.025 Max	0.001 Max	Remaining (98.484)

TEST Engineering & Management

May – June 2020
ISSN: 0193-4120 Page No. 1151 - 1155

Table 2 Chemical Composition of E 6013

Element	C	Mn	Cr	Si
%age Composition	0.08	0.5	0.06	0.30

Table 3 Chemical Composition of E 7016

Element	C	Mn	Cr	Si
%age Composition	0.10	0.90	0.14	0.70

Table 4 Chemical Composition of E 7018

Element	C	Mn	Cr	Si
%age Composition	0.90	1.10	0.10	0.60

Table 5. Variation of Depth of Penetration with Welding Current using Different Electrodes

SN	Electrode	Current (A)	DOP (mm)
1	E 6013	90	3.18
2		100	3.27
3		110	3.43
4	E 7016	90	3.76
5		100	3.84
6		110	3.91
7	E 7018	90	3.37
8		100	3.45
9		110	3.50

3.1 Variation of Depth of Penetration with Welding Current using E 6013 Electrode

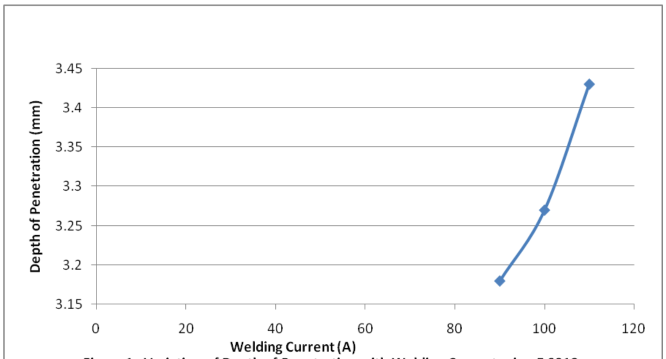

Figure 1: Variation of Depth of Penetration with Welding Current using E 6013 Electrode

The depth of penetration for electrode E 6013 increases with increase in current for the whole experimental range as shown in figure 1. At 90 A current the depth of penetration was found to be 3.18 mm, when the current was increased to 100 A the depth of penetration increased to 3.27 mm and when the current was again increased to 110 A the depth of penetration also again increased to 3.43 mm. The depth of penetration increases with increase of current as due to increase of current the input heat increases which increases the volume of melted material. This heat is spread at affected surface area, hence the depth of penetration increases to compensate the increased volume as volume increases with increase of one or more values of depth of penetration, reinforcement height and weld width.

3.2 Variation of Depth of Penetration with Welding Current using E 7016 Electrode

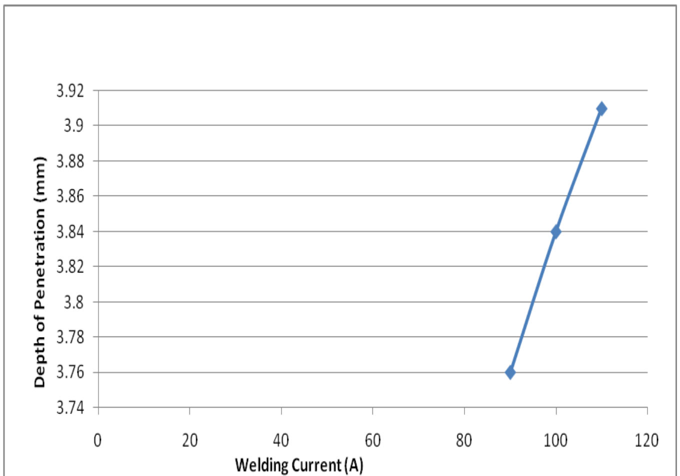

Figure 2: Variation of Depth of Penetration with Welding Current using E 7016 Electrode

The variation of depth of penetration with welding current using E 7016 is shown in figure 2. The depth of penetration for electrode E 7016 increases with increase in current for the whole experimental range as shown in figure 2. At 90 A current the depth of penetration was found to be 3.76 mm, when the current was increased to 100 A the depth of penetration increased to 3.84 mm and when the current was again increased to 110 A, the depth of penetration also again increased to 3.91 mm. The depth of penetration increases with increase of current as due to increase of current the input heat

May – June 2020
ISSN: 0193-4120 Page No. 1151 - 1155

increases which increases the volume of melted material, as the depth of penetration increases to compensate the increased volume as volume increases with increase of one or more values of depth of penetration, reinforcement height and weld width.

3.3 Variation of Depth of Penetration with Welding Current using E 7018 Electrode

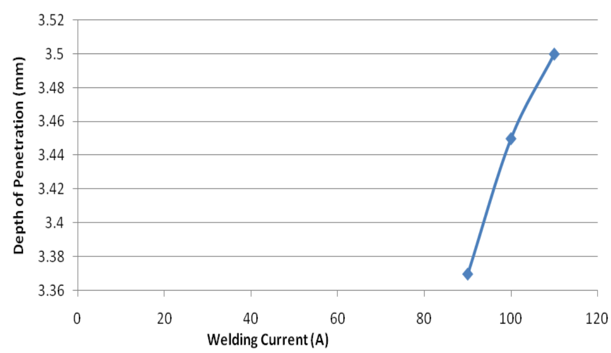

Figure 3: Variation of Depth of Penetration with Current using E 7018 Electrode

The variation of depth of penetration with welding current using E 7018 is shown in figure 3. The depth of penetration for electrode E 7018 increases with increase in current for the whole experimental range as shown in figure 3. At 90 A current the depth of penetration was found to be 3.37 mm, when the current was increased to 100 A the depth of penetration increased to 3.45 mm and when the current was again increased to 110 A, the depth of penetration also again increased to 3.50 mm. The depth of penetration increases with increase of current as due to increase of current the input heat increases which increases the volume of melted material, as the depth of penetration increases to compensate the increased volume as volume increases with increase of one or more values of depth of penetration, reinforcement height and weld width.

4. Conclusions

Following conclusions can be drawn from the experiments performed.

(1) The depth of penetration depends upon the current used for welding.

(2) As the current is increased the depth of penetration also increases for whole range of experiments for all types of electrodes applied in the experiments.

(3) The maximum value of depth of penetration was found to be 3.50 mm using E 7018 electrode at 110 A welding current.

(4) The minimum value of depth of penetration was found to be 3.18 mm using E 6013 electrode at 90 A welding current.

5. Future Scope

Following are recommendations for future study:

(1)The experiment was performed for low carbon steel, using only three types of electrodes, which can be extended to other materials using many other electrodes also.

(2)In this experiment the process of welding utilized was the shielded metal arc welding process, other processes like submerged arc welding and tungsten inert gas welding processes etc. can also be used.

(3)The range of current was limited from 90A to 110A; it can be increased for better exposure of the trend of depth of penetration with the change of welding current.

(4)Artificial neural networks, Taguchi methods etc can be used to make clearer the study.

References

[1] Kim I. S., Son J. S., Park C. E. and Kim I. J., Kim H. H. (2005) An investigation into an intelligent system for predicting bead geometry in GMA welding process. Journal of Materials Processing Technology. 159 (2005) 113 – 118.

[2] Tewari S. P., Ankur Gupta and Jyoti Prakash (2010). Effect of welding parameters on the weldability of materials. International journal of engineering science and technology volume 2(4), 512-516.

[3] Bahman, A.R. (2010). Change in Hardness, Yield Strength and UTS of Welded Joints Reduced in ST 37 Grade Steel. Indian Journal of Science and technology, 1162-1164.

[4] Abson, D. J., & Pargeter, R. J. (2013). Factors influencing as-deposited strength, microstructure, and toughness of manual metal arc welds suitable for C-Mn steel fabrications. International Metals Reviews, 31(1), 141-196.

[5] Maksuti, R. Impact Of The Acicular Ferrite On The Charpy V-Notch Toughness Of Submerged Arc Weld Metal Deposits. International Journal

May – June 2020
ISSN: 0193-4120 Page No. 1151 - 1155

of Scientific & Engineering Research, Volume 7, Issue 8, August-2016. 1149-1155.

[6] Sumardiyanto, D., Susilowati, S. E., & Cahyo, A. (2018). Effect of Cutting Parameter on Surface Roughness Carbon Steel S45C. Journal of Mechanical Engineering and Automation, 8(1), 1-6.