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Effect of Welding Current and Electrodes on Reinforcement Height in Shielded Metal Arc Welding Process

Indra Jeet Yadav, Rudra Pratap Singh

Abstract :*Joining of materials is the need of modern industries and stuctures. Shielded metal arc welding process is one of the most popular and commonly used method of joining materials. The weld reinforcement height should be optimum for mechanical properties of the weld. If the reinforcement height is less or negative, it is not recommended considering strength of weld as surface area will be reduced and if the reinforcement height is more, it will produce stress concentration which is not recommended. In the present work the investigation of the effect of three different types of electrodes at three different welding currents in shielded metal arc welding process utilizing Low Carbon Steel plate of API 5L Grade X 52, was done for reinforcement height. The three different electrodes as E 6013, E 7016 and E 7018 and the varying currents as 90 A, 100 A and 110 A. Total 18 pieces were used to obtain 9 welds which were used to analyze the effect of current and the electrode on reinforcement height. The dimensions of the work pieces were taken as 75 mm x 50 mm x 5 mm. The values of reinforcement height in each weld were written in a table and respective diagrams were drawn to make clear the effect of welding current on reinforcement height for the three different electrodes.*

Keywords: Electrode, Current, Structure, reinforcement height, Arc.

I. INTRODUCTION

The heat of welding is produced by welding current and voltage of the system. There are several arc welding processes in which the shielded metal arc welding is a promising joining process and is used by several small scale industries for making products. The process is very simple whereas the overall working is cheap and can be operated by human welders in limited working area. Heat and pressure both simultaneously or any one alone can be applied to join structural parts in any welding process. There are several processes by which two or more parts of any structure can be joined but the welding process has high reliability. With the help of this method, cost effective, strong and light joint can be produced this is why this process is preferred over many other joining processes [1].

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***** Correspondence Author
Mr Indra Jeet Yadav, PhD Scholar, Department of Mechanical Engineering, GLA University, Mathura, India. E-mail: yadavindrajeet636@gmail.com
Dr. Rudra Pratap Singh, Associate Professor, Department of Mechanical Engineering, GLA University, Mathura, India. E-mail: rudra.singh@gla.ac.in

The life of any welded parts can be increased with the addition of some special materials in the weld matrix through electrode.

The shielded metal arc welding process is applied manually hence termed as manual metal arc welding process [2]. A filler metal to improve the properties of the weld is added with the help of specially designed electrodes. An electrode has a core wire surrounded by some coatings having suitable materials for the SMAW process.

The electrodes contain different types of filler material and are manufactured having different length and diameter. At very high temperature the electrode and the added materials melt and become the part of the weld to improve the properties of the joint. Due to burning of filler material some useful gasses are produced which are utilized to shield and protect the highly heated molten weld from the surrounding atmospheric gasses [3]. Some fluxes are also utilized in the coating of the electrode which has a chemical reaction with the found impurities of the base metal to form light slag. The slag floats on the surface of the molten weld, which can be removed from the surface of the weld after solidification [4]. In shielded metal arc welding process an electric circuit is formed to connect electrode and the work piece with the help of cables. The temperature produced in this process is of the range of about 5000 degree centigrade in between the tip of the electrode and the work-piece. This produced intense heat is capable to melt the work piece and electrode to form the weld [5]. In our country the alternative current extinguishes 100 times per minute. The re-establishment of the arc can be done by some specially designed electrodes. There may be several electrodes in industries which serve this purpose, but in these electrodes E 6013, E 7016 and E 7018 are very common and important. E 6013 electrode produces a soft arc and the spatter is limited. It develops medium penetration and creates an easily-removable slag. E 7016 is hydrogen controlled and base coated electrode to weld medium and highly tensile structures. The deposits have excellent mechanical properties. E 7018 is a low-hydrogen electrode hence by using this electrode hydrogen Embrittlement is reduced in the weldment [6]. The reinforcement height is a very important macro-structural property of the weld which indirectly indicates the mechanical properties of the weld and increases the life of the product if properly designed.

II. 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 5000^0 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 work pieces were polished using polishing machines as shown in figure 1. The measurement of bead dimensions by metallurgical microscope is shown in figure 2. 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 voltages, 6.35 mm/s as feed rate and welding speed as 1.44 mm/s. the measurement of current was done with the help of a clamp meter as shown in figure 3

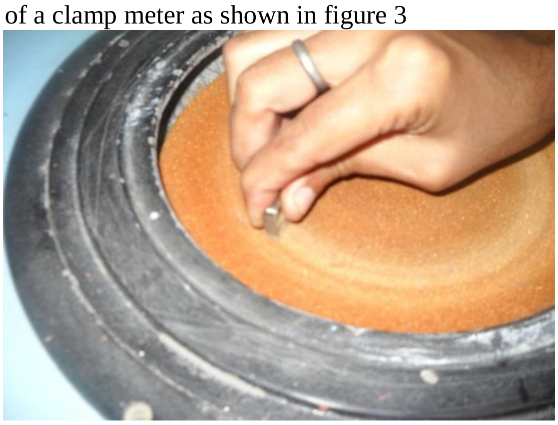

Figure 1 Preparation of Work piece by polishing

Figure 2: Measurements of Weld Bead Dimensions with Metallurgical Microscope

Figure 3: Current Measurement by Clamp-meter

The values of reinforcement height for every weld were recorded in table 5. 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 98 % ethyl alcohol solution. The values of reinforcement height were 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 reinforcement height can be easily analyzed with this table. It was found that for all the electrodes if the current was increased, the value of reinforcement height of the welds increased.

III. RESULT AND DISCUSSIONS

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

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

Chemical Composition of E 6013

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

Chemical Composition of E 7016

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

Chemical Composition of E 7018

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

Table 1: Variation of Reinforcement Height with Welding Current using Different Electrodes

SN	Electrode	Current (A)	RH (mm)
1	E 6013	90	2.63
2		100	2.71
3		110	2.75
4	E 7016	90	3.10
5		100	3.19
6		110	3.25
7	E 7018	90	2.59
8		100	2.63
9		110	2.69

3.1 Variation of Reinforcement Height with Welding Current using E 6013 Electrode

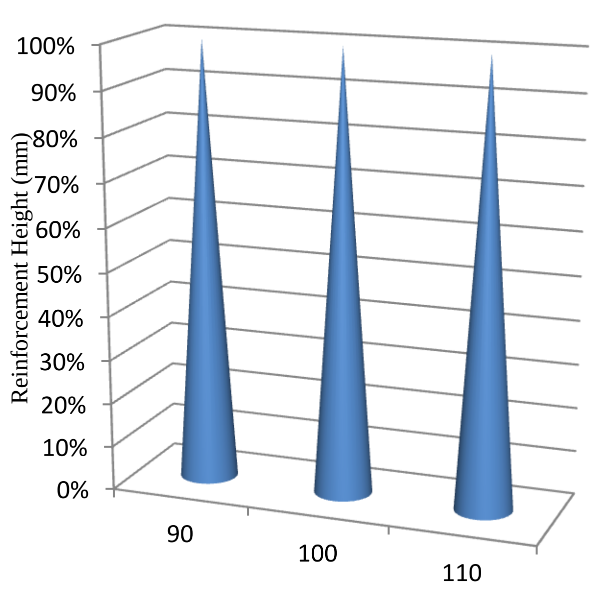

Figure 1: Variation of Reinforcement Height with Current using E 6013 Electrode

The reinforcement height 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 2.63 mm, when the current was increased to 100 A the reinforcement height increased to 2.71 mm and when the current was again increased to 110 A the reinforcement height also again increased to 2.75 mm. The reinforcement height 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 reinforcement height 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 Reinforcement Height with Welding Current using E 7016 Electrode

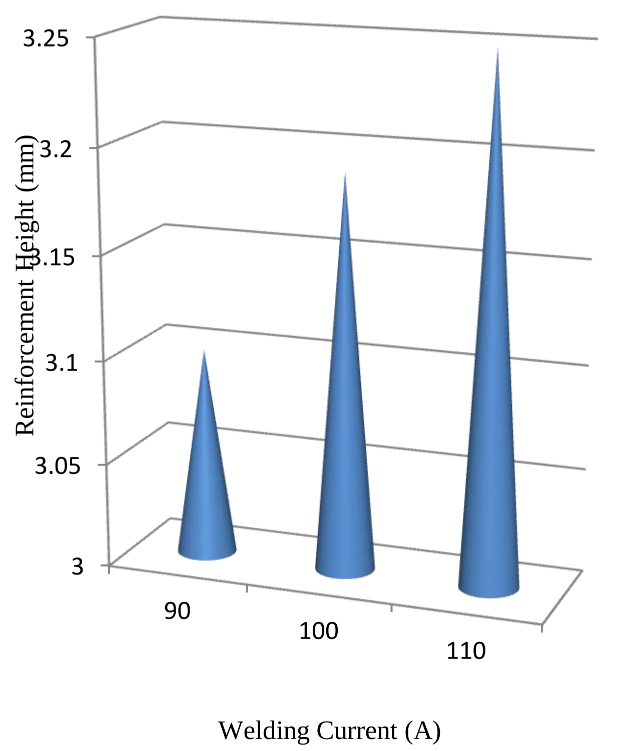

Figure 2: Variation of Reinforcement Height with Current using E 7016 Electrode

The reinforcement height for electrode E7016 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 3.10 mm, when the current was increased to 100 A the reinforcement height increased to 3.19 mm and when the current was again increased to 110 A the reinforcement height also again increased to 3.75 mm. The reinforcement height 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 reinforcement height 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 Reinforcement Height with Welding Current using E 7018 Electrode

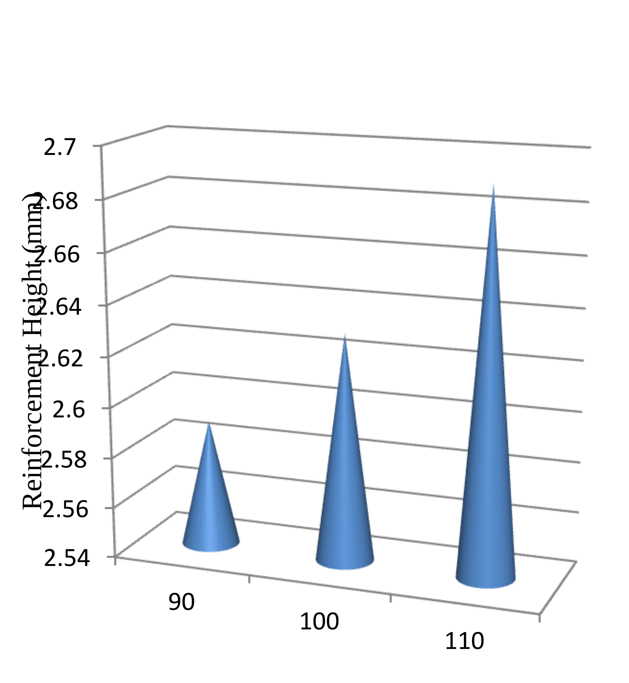

Figure 3: Variation of Reinforcement Height with Current using E 7018 Electrode

The reinforcement height 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 2.59 mm, when the current was increased to 100 A the reinforcement height increased to 2.63 mm and when the current was again increased to 110 A the reinforcement height also again increased to 2.69 mm. The reinforcement height 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 reinforcement height 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.

IV. CONCLUSIONS

Following conclusions can be drawn from the experiments performed.

(1) The reinforcement height depends upon the current used for welding.
(2) As the current is increases the reinforcement height also increases for whole range of experiments for all types of electrodes applied in the experiments.
(3) The maximum value of reinforcement height was found to be 3.25 mm using E 7016 electrode at 100 A welding current.
(4) The minimum value of reinforcement height was found to be 2.59 mm using E 7018 electrode at 90 A welding current.

V. 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.

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AUTHORS PROFILE

Mr Indra Jeet Yadav was born in Azamgarh Uttar Pradesh in 1992. He completed his Bachelor degree on Mechanical engineering in 2015, completed his Mater Degree in Production Engineering in 2018 and PhD degree in Mechanical Engineering from Department of Mechanical Engineering GLA University Mathura Enrolled in 2019. He is currently working as Head of Department Mechanical Engineering, Satyadev Institute of Technology Ghazipur Uttar Pradesh . His main research interests in welding Technology. Email id yadavindrajeet636@gmail.com

Dr. Rudra Pratap Singh Associate Professor Institute of Engineering and Technology Department of Mechanical Engineering GLA University Mathura Email id – rudra.singh@gla.ac.in TEACHING EXPERIENCE**:** More than Twenty One years teaching experience in engineering field from 02-03-1999 to till date in GLAITM (now GLA University) Mathura. (a) Lecturer from 02-03-1999 to 30-06-2004,(b) Senior Lecturer from 01-07-2004 to28-02-2009 (c) Reader from 01-03-2009 to 31-08-2014(d) Associate Professor from 01-09-2014 to till date RESEARCH PAPERS AND CONFERENCE PAPERS: 60 International and National paper published in Scopus and SCI Journals