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Effect Of Welding Current On Hardness Of Heat Affected Zone İn Shielded Metal Arc Welding Process Using Different Electrodes

Indra Jeet Yadav[1], Rudra Pratap Singh[2]
[1]PhD Scholar, Department of Mechanical Engineering, GLA University, Mathura, India
[2]Associate Professor, Department of Mechanical Engineering, GLA University, Mathura, India

Abstract

Several structural members require hardness with joints. Heat affected zone changes its microstrure, hence its mechanical properties are changed. The required value of hardness should not be more than the hardness of the material. The shielded metal arc welding process is a popular arc welding process. 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 hardness of the heat affected zone. The three different electrodes as E 6013, E 7016 and E 7018 and the varying currents as 90 A, 100 A and 110 A were used. Total 18 pieces were used to obtain 9 different welds which were used to analyze the effect of current and the electrode on hardness of the heat affected zone. The dimensions of the work pieces were taken as 75 mm x 50 mm x 5 mm. The hardness values in each heat affected zone were written in a table and respective diagrams were drawn to make clear the effect of welding current on hardness of heat affected zone for the three different electrodes. It was found that hardness of the heat affected zone decreased with increase of current for all the three types of electrodes

Keywords: *Electrode, Current, Structure, Hardness, HAZ, Arc*

1 Introduction:

Resistant to indentation is very important in all the structures of the industries during relative motions of the contacting parts. This is why the maximum value of hardness is searched by optimizing welding input and output values. Applied welding current in shielded metal arc welding process is directly proportional to the net heat generated. The welding current has large effect on structure and properties of the weld. Any arc welding process needs heat to melt the work piece and the welding electrode which can be generated by applying suitable welding current and voltage in the welding process. Any welding process requires heat with or without pressure and with or without filler materials to weld several metallic or non metallic structural parts in any industry. The welding is a highly reliable joining method which produces lighter, stronger and economical joints, this is why the process is highly preferred [1]. Due to welding some of the properties of the weld reduce but the properties can be improved by adding some extra materials in the coating of the electrodes. Shielded metal arc welding (SMAW) is a very simple and highly popular arc welding process. The operation of the shielded metal arc welding can be performed manually by human welder. For this reason this process is popularly known as manual metal arc welding process [2]. There are several types of electrodes which are developed to use in shielded metal arc welding process. A welding electrode is made of the same material from which the base material is made. A bare core wire of the same material coated with some other suitable materials is used in the SMAW process. This electrode after burning mixes with the parts of the weld and improves the structures and mechanical properties of the joint. Many gasses are developed during burning of the filler material which is used to protect the produced red hot weld from the harmful gasses [3]. Many types of welding fluxes are applied in the coating of the electrode which reacts in the weld with the impurities of the base metal and can form slag. The slag has very low density and floats on the surface of the pool of the weld, which is chipped off the weld just after it is solidified [4]. In SMAW process a cable is used to connect workpiece with electrode to form an electric circuit. In this process very high temperature of the order of

50000 C is developed, which can supply sufficient heat to melt properly the base material and can mix with the molten electrode material [5]. For the alternative current in which the arc extinguishes 100 times in a second, requires some special electrodes which can re establish the arc. To re-establish the arc in a very small time, some special properties of electrode are essential. There are mainly three electrodes which are commonly applied in shielded metal arc welding process. These electrodes are E 6013, E 7016 and E 7018 which are generally used in this process. These electrodes can provide the essential mechanical and structural properties to the weld. The E 6013 electrode is used to develop soft arc, low spatter, medium depth of penetration with removable slag. The electrode E 7016 is normally used when welding the structures require medium and high tensile strength. E 7018 is used if hydrogen embrittlement is dangerous for the structures. [6]. Hardness provides capability to any material to bear indentation which is generally required by materials used in the machines and structures. This indicates that optimum value of hardness is important for our industries. The heat affected zone is situated near the weld region and changes its properties due to micro-strural change in this region. This region should have sufficient hardness so that structure does not fail during operation.

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.

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. The values of hardness of weld 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 the help of a mixture of 2 % nitric acid and 98 % ethyl alcohol solution. The hardness of heat affected zone was measured for every welded work-piece with the help of Vickers hardness testing machine and arranged in table 5. The effect of welding current and electrode on the hardness 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)

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 Hardness (Vickers) of Heat Affected Zone with Welding Current using Different Electrodes

SN	Electrode	Current (A)	VH (HAZ)
1	E 6013	90	195
2		100	187
3		110	180
4	E 7016	90	232
5		100	224
6		110	219
7	E 7018	90	245
8		100	240
9		110	233

3.1 Variation of Hardness of HAZ with Welding Current using E 6013 Electrode

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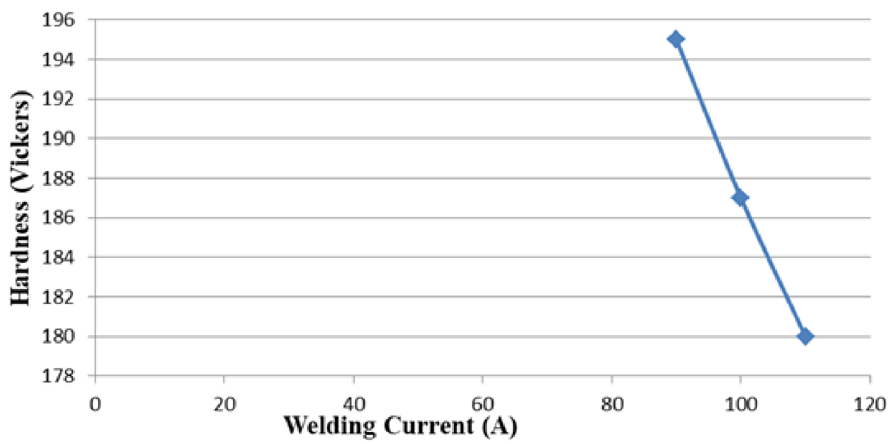

Figure 1: Variation of Hardness of HAZ with Current using E 6013 Electrode

The hardness for heat affected zone for welded plates using electrode E 6013 decreases with increase in current for the whole experimental range as shown in figure 1. At 90 A current the Vickers hardness for heat affected zone was found to be 195, when the current was increased to 100 A the Vickers hardness for heat affected zone decreased to 187 and when the current was again increased to 110 A the Vickers hardness for heat affected zone also again decreased to 180. With the increase of the current the net heat input increases and the heat affected zone also receives more heat, the region gets time for re-crystallization hence coarse grains are formed which reduces hardness at increase of current.

3.2 Variation of Hardness of HAZ with Welding Current using E 7016 Electrode

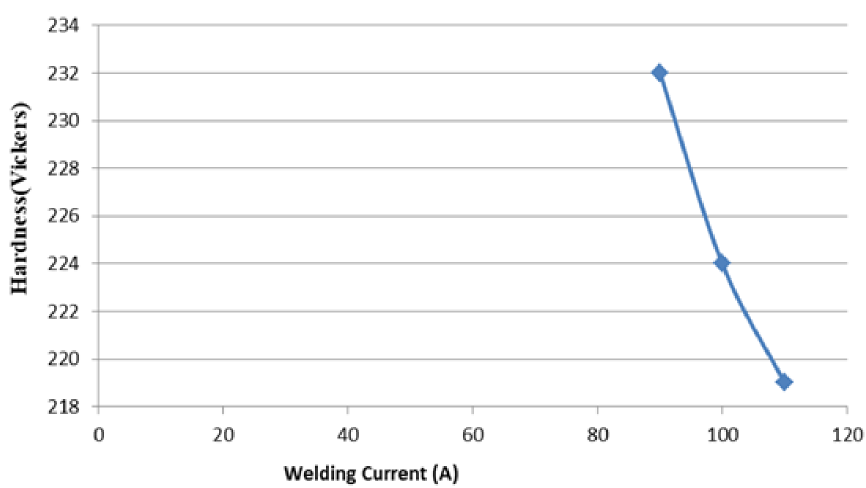

Figure 2: Variation of Hardness of HAZ with Current using E 7016 Electrode

The hardness for heat affected zone for welded plates using electrode E 7016 decreases with increase in current for the whole experimental range as shown in figure 2. At 90 A current the Vickers hardness for heat affected zone was found to be 232, when the current was increased to 100 A the Vickers hardness for heat affected zone decreased to 224 and when the current was again increased to 110 A the Vickers hardness for heat affected zone also again decreased to 219. With the increase of the current the net heat input increases and the heat affected zone also receives more heat, the region gets time for re-crystallization hence coarse grains are formed which reduces hardness at increase of current.

3.3 Variation of Hardness of HAZ with Welding Current using E 7018 Electrode

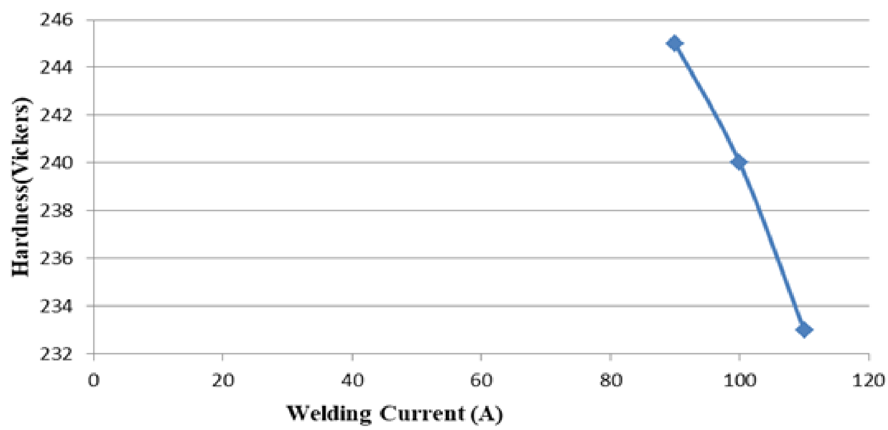

Figure 3: Variation of Hardness of HAZ with Current using E 7018 Electrode

The hardness for heat affected zone for welded plates using electrode E 7018 decreases with increase in current for the whole experimental range as shown in figure 3. At 90 A current the Vickers hardness for heat affected zone was found to be 245, when the current was increased to 100 A the Vickers hardness for heat affected zone decreased to 240 and when the current was again increased to 110 A the Vickers hardness for heat affected zone also again decreased to 233. With the increase of the current the net heat input increases and the heat affected zone also receives more heat, the region gets time for re-crystallization hence coarse grains are formed which reduces hardness at increase of current.

4 Conclusions

Following conclusions can be drawn from the experiments performed.

(1) The hardness of heat affected zone depends upon the welding current and electrode used for welding.

(2) As the current is increased the hardness decreases for whole range of experiments for all types of electrodes applied in the experiments.

(3) The maximum value of hardness was found to be 245 using E 7018 electrode at 90 A welding current.

(4) The minimum value of hardness was found to be 195using 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 hardness 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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