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Effect of Welding Current and Electrodes on Impact Strength of Weld in Shielded Metal Arc Welding Process

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Abstract

In several operations in our industries the joining of materials is the need. The shielded metal arc welding process is one of the most popular and commonly used arc welding processes. The impact strength of any structural member becomes important in several cases where the shock loading is involved. 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 impact strength. 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 different welds which were used to analyze the effect of current and the electrode on impact strength. The dimensions of the work pieces were taken as 150 mm x 50 mm x 10 mm. The values of impact strength in each weld were written in a table and respective diagrams were drawn to make clear the effect of welding current on impact strength for the three different electrodes. It was found that impact strength of weld decreased with increase of current for all the three types of electrodes.

Keywords: *Electrode, Current, Structure, Impact Strength, Arc.*

1.Introduction

Any arc welding process requires heat of fusion which is generated by welding current and voltage of the process. Heat and pressure are very important and are used to join two or more metallic or non metallic structural parts in any industry. Two or more structural parts can be joined by several methods but the welding process provides highly reliable, stronger, lighter and cost effective joint, hence it is preferred over many other joining processes [1]. Welding process can add some positive value to the welded parts and can increase the life of overall structures where the process is used. Shielded metal arc welding (SMAW) is one of the most preferred arc welding processes in the world. The operation of this process is easy and also the process is performed manually by human welder, for which reason the process is also known as manual metal arc welding process [2]. A metallic wire surrounded by some coatings containing some required materials is used as an electrode in SMAW process. This electrode contains filler metals and non metals both within the coatings, which after melting becomes the part of the weld and increases the properties of the joint. The filler material also produces some gasses when the material is burnt, which are used to shield and protect the weld from the surrounding atmospheric gasses [3]. Some flux is also used in the coating of the electrode which in the weld reacts with the impurities of the base metal and forms slag. The slag has very low density and hence floats on the upper layer of the molten weld, which can be removed from the surface of the weld after itis solidified [4]. In SMAW process a cable is used to form a circuit which connects the coated electrode and the work piece. The temperature developed in between the tip of the electrode and the work-piece is of the range of f 50000 C. This temperature is sufficient to melt the base material which mixes with the molten electrode material [5]. For the alternative current having a frequency of 50 Hz, the arc extinguishes 100 times per minute. Tore-establish the arc spontaneously, some special properties of electrode are required. There may be several electrodes which can serve this purpose. In these electrodes E 6013, E 7016 and E 7018 are important which provide required mechanical properties to the weld. The E 6013 electrode produces normally a soft arc having minimal spatter. It offers moderate penetration and provides an easily-removable slag. These electrodes should only be used to weld a clean and new sheet metal. E 7016 is hydrogen controlled basic coated electrode which is normally utilized for welding medium and high tensile structures like grey cast iron components and low and medium carbon steel products. The deposits are generally of radiographic quality with very impressive mechanical properties. E 7018 is a low-hydrogen type electrode which reduces hydrogen embrittlement in the weldment [6]. Impact strength provides any material to bear shock loads, and in our industries shock loads are common on machine elements. This indicates that optimum value of impact strength is essential for our industries.

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 as shown in figure 1. 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 10 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 150 mm x 50 mm x 10 mm. V groove angle of 22.5 degree in piece was made on one side of length so that the welded length is 150 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 specimens for impact testing were 55 mm long 10 mm wide and 10 mm thick and cut from the central part of the welded piece in such a way that weld centerline comes in the centre. It contains The standard thickness can be taken any one value from 10 mm, 7.5 mm, 6.7 mm, 5 mm, 3.3 mm and 2.5 mm and we have selected 10 mm. Standard notch for charpy impact strength was made with the help of files which is 22.5 degree in each piece to make total 45 degree. The depth of cut was 2mm and the root radius was taken as 25 mm The measurement of impact strength by Charpy impact strength testing machine is shown in figure 2.

Figure1 Welded Specimen

Figure 2 Measurement of impact strength by Charpy Testing Machine

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 impact strength for every weld were recorded in table 5.

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

Table4 Chemical Composition of E 7018

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

Table5. Variation of Impact Strength with Welding Current for Different Electrodes

SN	Electrode	Current (A)	Impact Strength (J/mm^2)
1	E 6013	90	0.950
2		100	0.725
3		110	0.622
4	E 7016	90	1.815
5		100	1.700
6		110	1.495
7	E 7018	90	1.921
8		100	1.834
9		110	1.699

3.1 Variation of Impact Strength with Welding Current for E 6013 Electrode

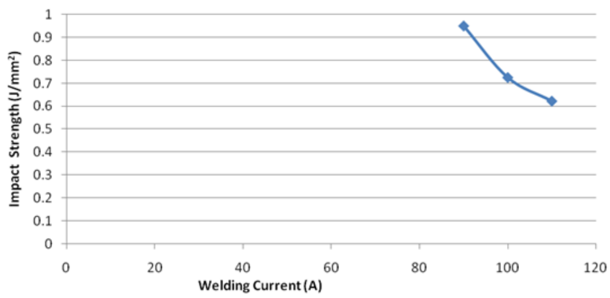

Figure 1: Variation of Impact Strength with Current for E 6013

The impact strength for weld 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 tensile strength for weld zone was found to be 0.950 J/mm2, when the current was increased to 100 A the impact strength for weld zone decreased to 0.725 J/mm2 and when the current was again increased to 110 A the impact strength for weld zone also again decreased to 0.622 J/mm2. With the increase of the current the net heat input increases and the weld zone also receives more heat, and temperature becomes high resulting in high cooling rate hence less time is available for re-crystallization hence fine grains are obtained to decrease the impact strength with increase of current.

3.2 Variation of Impact Strength with Welding Current for E 7016 Electrode

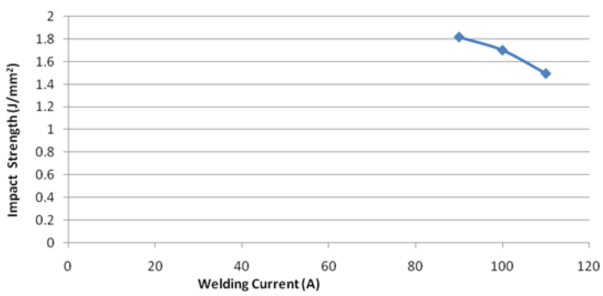

Figure 2: Variation of Impact Strength with Current for E 7016

The impact strength for weld 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 tensile strength for weld zone was found to be 1.815 J/mm2, when the

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current was increased to 100 A the impact strength for weld zone decreased to1.700 J/mm2 and when the current was again increased to 110 A the impact strength for weld zone also again decreased to 1.495 J/mm2. With the increase of the current the net heat input increases and the weld zone also receives more heat, and temperature becomes high resulting in high cooling rate hence less time is available for re-crystallization hence fine grains are obtained to decrease the impact strength with increase of current.

3.3 Variation of Impact Strength with Welding Current for E 7018 Electrode

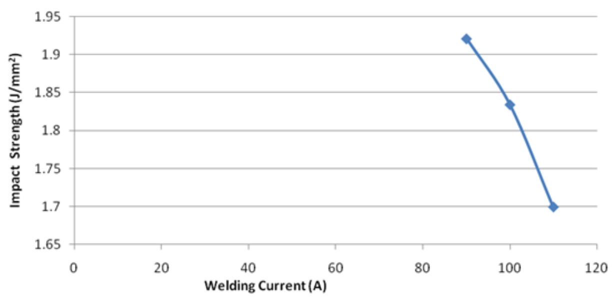

Figure 3: Variation of ImpactStrength with Current for E 7018

The impact strength for weld 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 tensile strength for weld zone was found to be 1.921 J/mm2, when the current was increased to 100 A the impact strength for weld zone decreased to 1.834 J/mm2 and when the current was again increased to 110 A the impact strength for weld zone also again decreased to 1.699 J/mm2. With the increase of the current the net heat input increases and the weld zone also receives more heat, and temperature becomes high resulting in high cooling rate hence less time is available for re-crystallization hence fine grains are obtained to decrease the impact strength with increase of current.

4. Conclusions

Following conclusions can be drawn from the experiments performed.
The impact strength of weld zone depends upon the welding current and electrode used for welding.
As the current is increased the impact strength decreases for whole range of experiments for all types of electrodes applied in the experiments.
The maximum value of impact strength was found to be 1.921 J/mm2 using E 7018 electrode at 90 A welding current.
The minimum value of impact strength was found to be 0.622 J/mm2 using E 6013 electrode at 110 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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