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Variation of Tensile Strength of Welds with Welding Current for Different Electrodes in Shielded Metal Arc Welding Process

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Abstract

Tensile strength of structural members is very important for any industry. In several operations the joining of materials is the essential. The shielded metal arc welding process is a very important arc welding processe. The tensile strength of any structural member is important in several cases where the bending and twisting types of 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 tensile 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 tensile strength. The dimensions of the work pieces were taken as 150 mm x 50 mm x 10 mm. The values of tensile strength in each weld were written in a table and respective diagrams were drawn to make clear the effect of welding current on tensile strength for the three different electrodes. It was found that tensile strength of weld decreased with increase of current for all the three types of electrodes.

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

1.Introduction

Welding current is proportional to the heat generated in the welding process. It affects the structure and properties of the weld. The tensile strength is very important for many structures. Any arc welding process requires heat of fusion which is generated by using suitable welding current and voltage of the process. Heat with pressure or any one in heat and pressure are used in welding of two or more metallic or non metallic structural parts in any industry. Two or more parts of any machine-parts can be joined by several procedures but the welding methods provide very much reliable, lighter, stronger and cost effective joint, this makes the process to be preferred to many other joining processes [1]. The welding processes can add many positive values to the welded parts and can increase the life of different parts of the structures. Shielded metal arc welding (SMAW) is a popular arc welding processes in the world. The operation of this process is very easy and also the welding process is done manually by human welder. Due to this reason the process is also named as manual metal arc welding process [2]. Different types of electrodes can be used for welding. An electrode is consisted of a core wire coated with suitable materials in the SMAW process. This electrode contains required filler materials within the coatings, which after burning becomes the part of the weld and enhances the structure and properties of the joint. Many gasses are developed during burning of the filler material which can be utilized to shield and protect the produced weld from the air and harmful gasses. [3]. Many fluxes are also included in the coating of the electrode which react in the weld with the impurities present in the base metal and form slag. The slag is lighter than the molten metallic part and hence floats on the pool of the weld, which can be removed from the weld after it is solidified [4]. In SMAW process a suitable cable is utilized to form an electric circuit which connects the electrode and the work piece. The temperature developed in this process is of the order of 5000^0 C which develops sufficient heat to melt the base material which after melting mixes with the molten electrode material [5]. For the alternative current having a frequency of 50 Hz, as used in India, the arc extinguishes 100 times in one minute. To re-start the arc spontaneously, some properties of electrode are required. There may be several types of electrodes which can be used in this purpose. In these electrodes E 6013, E 7016 and E 7018 are generally used which can provide required mechanical and structural properties to the weld. The E 6013 electrode produces soft arc having low spatter. This electrode offers moderate depth of penetration providing an easily-removable slag. These electrodes should only be used to weld a clean and new sheet metal plate. The electrode E 7016 is a hydrogen controlled basic coated which is normally utilized for welding structures having medium and high tensile strength. The deposits have very good quality and properties. E 7018 is a low-hydrogen type electrode and is if hydrogen embrittlement is dangerous for the structures. [6]. Tensile strength provides any material to bear direct and bending loads, and in our industries bending loads and direct compressive and tensile direct loads are common on machine elements. This indicates that optimum value of tensile 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 52having 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 150 mm x 50 mm x 5 mm. V groove angle of 22.5 degree in piece was made on one side of 50 mm length so that the welded length is 50 mm making total length of tensile test specimen as 300 mm and width as 50 mm with thickness as 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 specimens for tensile testing were 55 mm long 10 mm wide and 5 mm thick. The measurement of tensile strength is done by a UTM which is shown in figure 2.

Fig.1 Welded Specimen

Fig.2 Universal Testing Machine (Ref 3)

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

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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 tensile strength for every weld were recorded in table 5.

3. Result and Discussions

Table1: 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)

Table2: Chemical Composition of E 6013

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

Table3: 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

Table 5. Test Results for Tensile Strength in the

SN	Electrode	Current (A)	Tensile Strength (MPa)
1	E 6013	90	551.5
2		100	506.5
3		110	465.5
4	E 7016	90	615.0
5		100	600.5
6		110	585.5
7	E 7018	90	584.5
8		100	566.0
9		110	550.5

3.1 Variation of Tensile Strength with Current for E 6013

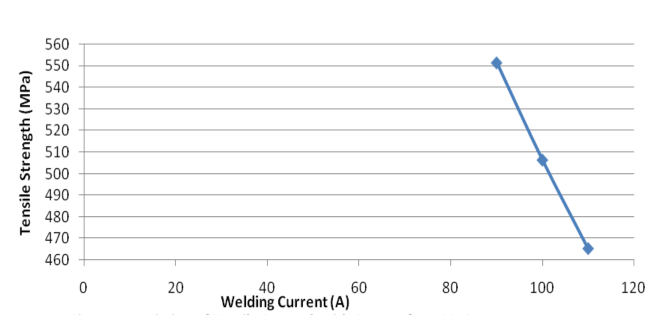

Figure 1: Variation of Tensile Strength with Current for E 6013

The tensile 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 551.5 N/mm^2, when the current was increased to 100 A the tensile strength for weld zone decreased to 506.5 N/mm^2 and when the current was again increased to 110 A the tensile strength for weld zone also again decreased to 465.5 N/mm^2. 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 tensile strength with increase of current.

3.2 Variation of Tensile Strength with Current for E 7016

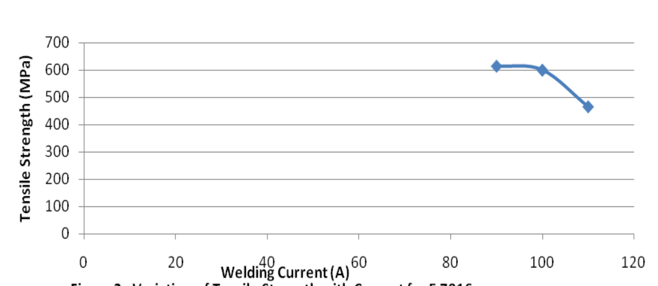

Figure 2: Variation of Tensile Strength with Current for E 7016

The tensile 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

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weld zone was found to be 615.5 N/mm^2, when the current was increased to 100 A the tensile strength for weld zone decreased to 600.5 N/mm^2 and when the current was again increased to 110 A the tensile strength for weld zone also again decreased to 585.5 N/mm^2. 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 tensile strength with increase of current..

3.3 Variation of Tensile Strength with Current for E 7018

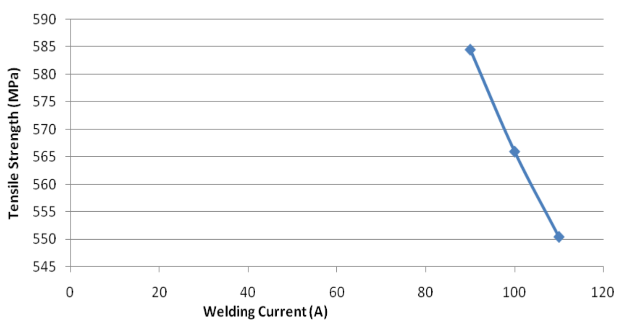

Figure 3: Variation of Tensile Strength with Current for E 7018

The tensile 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 584.5 N/mm^2, when the current was increased to 100 A the tensile strength for weld zone decreased to 566.0 N/mm^2 and when the current was again increased to 110 A the tensile strength for weld zone also again decreased to 550.5 N/mm^2. 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 tensile strength with increase of current..

4. Conclusions

Following conclusions can be drawn from the experiments performed.

(1) The tensile strength of weld zone depends upon the welding current and electrode used for welding.

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

(3) The maximum value of tensile strength was found to be 615.0 N/mm^2 using E 7016 electrode at 90 A welding current.

(4) The minimum value of tensile strength was found to be 465.5 N/mm^2 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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