Investigating the Effect of Welding Current on the Tensile Properties of SMAW Welded Mild Steel Joints

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Abstract: **- The objective of the present investigation is to realize the effect of process parameter like welding current on tensile strength of mild steel weldment by using welding current as varying parameter. In this work mild steel alloy plates were joined by Shielded Metal Arc Welding (SMAW) process which is also known as manual metal arc welding used to examine optimum welding current. Welding specimen tensile strength was investigated using Tensile Testing Machine to characterize weld strength by determining ultimate tensile strength. The experimental results have shown that optimum current out of the four welding current used (100amp, 110amp, 120amp, 130amp & 140amp) is 120amp. In this study mild steel plates of 12mm thickness of AA10119 specification have been used which is most commonly used in fabrication of steel structures.**

Keywords: - Shielded Metal Arc Welding (SMAW), Tensile Strength, Welding Current, Mild Steel.

INTRODUCTION:

Welding is a process of joining two or more pieces of metals by heating them to their melting temperature and causing the molten metal to flow together. The welding process is used to metallurgic ally join together two metals pieces to produce essentially a single piece of metal. The advantages of this method are that it is the simplest of the all arc welding processes. The equipment is often small in size and can be easily shifted from one place to the other. Cost of the equipment is also low. This process is used for numerous applications because of the availability of a wide variety of electrodes which makes it possible to weld a number of metals and their alloys.

The welding process finds widespread applications in almost all branches of industry and construction. Welding is extremely employed in the fabrication and erection of steel structures in industrial construction and civil engineering, for example, structural members of bridges and buildings etc.; vessels of welded plate construction (steel reservoirs, boilers, pressure vessel tanks and pipelines etc.) and concrete reinforcement [1]. Due to versatile nature of demand for welding /joining it is must know the optimized situations under which most desired properties would be attained by the weldment. To consistently produce high quality of welds, arc welding requires experienced welding personnel. One reason for this is need to properly select welding parameters for given task to provide good weld quality which identified by its microstructure and the amount of spatter and relied on the correct bead geometry size. Therefore the use of the control system in arc welding can eliminate much of the “guess work” often employed by welders to specify welding parameters for a given task [2]. The study on prediction of heat effected zone characteristics in submerged Arc welding of structural steel pipes concluded that heat input and wire feed have a positive effect. But welding speed has negative effect on all HAZ characteristics. [3].

The effect of submerged arc welding parameters and fluxes on element transfer behavior and weld-metal chemistry concluded that welding current and voltage have an appreciable influence on element transfer, as well as on weld composition. Weldments properties such as strength, toughness and solidification cracking behavior are affected by chemical composition [4]

Present study has been framed keeping in view to obtained optimal welding current value for mild steel weldment by SMAW process. Mild steel which is most frequently used in fabrication and erection of steel structure are used for this purpose. The different process parameters which affect the weld quality in Arc welding are classified as:-

Welding Current:
Welding current is the most influencing parameter in welding process which controls the depth of fusion; the electrode feed rate and depth of penetration. The amount of heat developed during welding depends upon the current used for given size of electrode and filler wires. It is therefore essential that a correct current is used to produce good quality of weld and reduce the distortion problems on the job.

Welding Voltage:
This is the electrical potential difference between the tip of the welding wire and the surface of the molten weld pool. It determines the shape of the fusion zone and weld reinforcement. High welding voltage produces wider, flatter and less deeply penetrating welds than low welding voltages. Depth of penetration is maximum at optimum are voltage.

Welding Speed:
Speed of welding is defined as the rate of travel of the electrode along the seam or the rate of the travel of the work under the electrode along the seam. Some general statements can be made regarding speed of travel. Increasing the speed of travel and maintaining constant arc voltage and current will reduce the width of bead and also increase penetration until an optimum speed is reached at which penetration will be maximum increasing the speed beyond this optimum will result in decreasing penetration

Heat Input Rate:
Heat input is a relative measure of the energy transferred per unit length of weld. It is an important characteristic because it influences the cooling rate, which any affect the mechanical properties and metallurgical structure of the weld and the HAZ. Heat input or energy is calculated from mathematical formula.

$$\text{Heat I/p} = \frac{60VI}{S} \quad \text{in joule/mm}$$

Where
H I/p = heat input (joule/mm)
V = arc voltage (volts)
I = current (amps)
S = welding speed (mm/min)

Wire Feed Rate:
Wire feed rate is a measure of the rate at which the electrode is passed through the welding torch and delivered to the arc. The deposition rates are directly proportional to wire feed speed and directly related to current. When all other welding conditions are maintained constant, an increase in wire feed rate will directly lead to an increase in current. For slower wire feed rates, the ratio of wire feed rate to current is relatively constant and linear.

Experimental Procedure:
The welding of all the specimens was done at Bent Joints Industry Govindpura Industrial Area Bhopal M.P with the following set up “Warp Engineering’ Model-WS-400 Time Inverter, MMA/TIG Welding Machine with a 400A capacity. In this investigation Mild steel alloy plates of dimension 150mm × 50mm × 12mm (figure 1) were taken for SMAW welding technique. These plates are cleaned from dirt, grease and other foreign materials and were cut into the required dimension by power hacksaw. Edge preparation is carried out where single V edge is prepared for a bevel angle of 37.5^0. The mild steel plates are placed on welding table and in order avoid the undesired distortion to the minimal; the right size of stiffeners was provided at critical locations where the welding process is carried out.

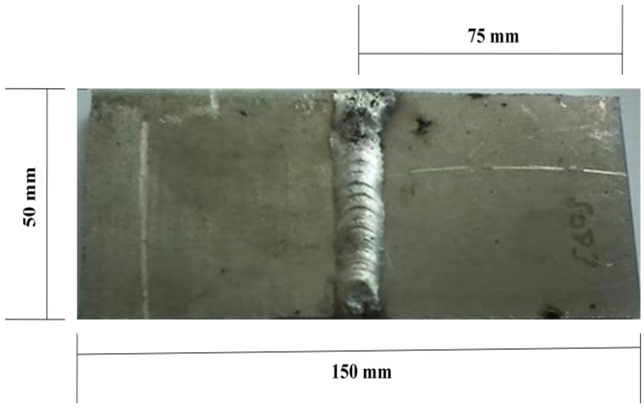


Figure 1: Pictorial View of Single V Butt Joint Welded Specimen

In this process all the various welding parameters such as the arc voltage, number of passes, welding speed, wire feed rate, arc time and welding current where recorded during the welding of each specimen only welding current was varies during the welding of specimens, to study the effect of welding current on the tensile strength of the weldments. Having finished the welding of the joints in order to measure the tensile strength, welded plates were cut using power hacksaw and then machined to the required dimensions (150 mm X 16.5mm X 12mm) to make the tensile test pieces with the help of shaper and lathe machine. The dimensions of tensile test specimen shown in figure no.2

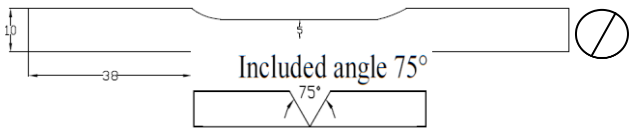


Figure2: Tensile test specimen

Figure3: Testing Samples of Mild steel Before Tensile Tests

The round/circular smooth tensile specimens were prepared to evaluate tensile properties of the joints such as yield strength and ultimate tensile strength. After machining operation the specimen was tested in tensile testing machine at CIAE, Bhopal to record the reading of different tensile test specimens which was made at varying welding current input. The tested broken samples were shown in figure 4.

Figure4: Broken Test Samples after Tensile Tests

The chemical composition of AA10119 mild steel plate which is used as base metal were given in table no.1

Table 1- The Chemical Composition of the Base Metal

Material	C	Mn	Si	S	P
AA110119	0.17	0.95	0.22	0.010	0.015

E6013L electrodes were used to weld the specimen using Shielded Metal Arc Welding process. The chemical composition E6013L electrode were given in table no.2

Table -2 Chemical Composition of Electrode

Material	C	Mn	Si	S	P
E6013L	0.08	0.40	0.25	0.02	0.02

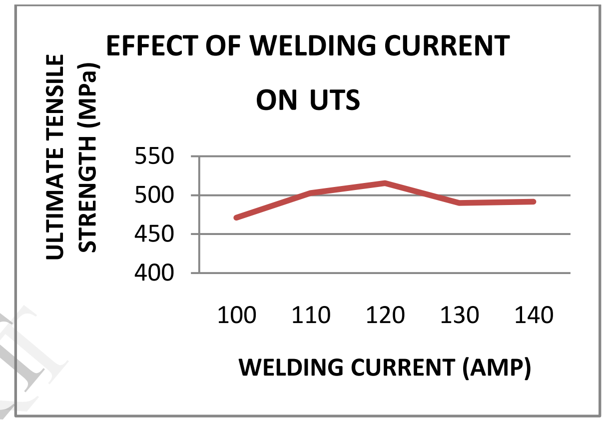
Experimental Results and Discussions**:**

The tensile strength of the joints was evaluated. The specimens were tested and the results were presented in table no.3

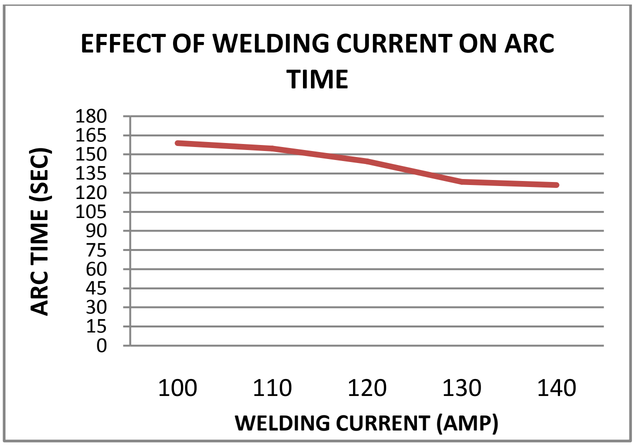
Table 3- Effect of Welding current on Ultimate Tensile Strength

Current ampere	**Arc time second**	**Welding speed mm/min**	**Wire Feed Rate mm/sec**	**Ultimate Tensile Strength (MPa)**	**Percentage Elongation**
100	159.08	132.0	4.40	470.780	14.71
110	154.6	135.83	4.49	502.293	16.40
120	144.52	145.30	4.72	515.185	19.57
130	128.57	140.0	4.85	489.77	20.21
140	125.95	119.09	5.12	491.152	19.57

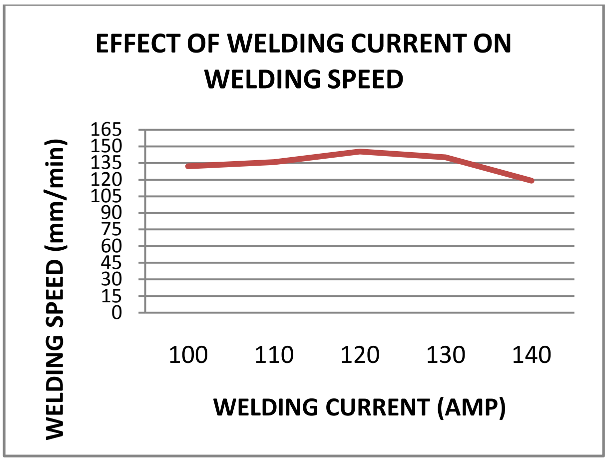
Effect of Welding Current on Ultimate Tensile Strength:
From the values of UTS (ultimate tensile strength) obtained for 100amp, 110amp, 120amp,130amp,140amp it is observed that 120amp weldment depicted maximum ultimate tensile strength when compare to weldment of 100amp, 110amp, 130amp and 140amp.The tensile strength increases with increase in current up to 120 amp which was optimum value to obtain maximum ultimate tensile strength, it means that the rate at which the welding electrode is melted, the amount of base metal melted, dilution, depth of fusion, the amperage(the amount of current flowing through the electrode and the work),the deposition rates, the depth of penetration was good at this value and optimum weldability can be achieved as welding current 120 amp, arc time 144.52sec, welding speed 145.30 mm/min, wire feed rate 4.72 mm/sec. Increasing welding current beyond this optimum value increases the amount of wire feed rate and penetration.



Effect of Welding Current on Arc Time:
The effect of welding current on arc time which help to analyze the arc time with respect to varying welding current was that by increasing welding current the arc time decreases. It is clear from figure that describes the arc time decreases by increasing welding current.

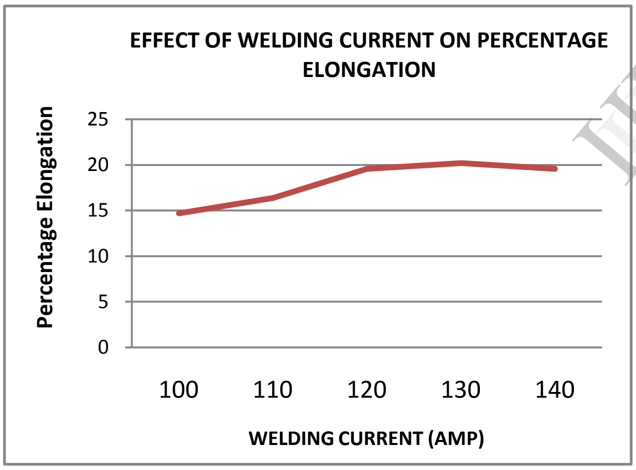


Effect of Welding Current on Welding Speed:
From the above graph it can be observed that there is a increase in welding speed up to 145.30 mm/min which was optimum value to obtain maximum UTS and after this when increasing welding current the welding speed is starts decreasing and also the UTS.



Effect of Welding Current on Percentage Elongation:

From the above graph it can be evaluated that the percentage elongation increases with increase in welding current. It seems that due to increase in welding current the ductility of the weldment increases up to optimum value at certain value of current and start decreasing by further increment of current it means the weldment became brittle. So the percentage elongation increases when the ductility increases and decreases when ductility decreases.



CONCLUSION:

The following conclusion has been derived from this experimental investigation. The tensile strength has been maximum at welding current of 120amp in comparison with weld carried out of 100amp, 110amp, 130amp and 140amp. With increase in welding current which was taken as a varying parameter the ultimate tensile strength 515.185MPa was recorded. Maximum/optimum value of tensile strength was obtained when welding speed was 145.30mm/min. The maximum UTS was obtained when heat input rate was 1236.94 J/mm. Hence it can be concluded that with increase in welding current the UTS will increase until an optimum value. Increasing the current beyond this optimum value will result in decreasing UTS.

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