Strength Analysis of Weld in Mild-Steel Square Bar with Variable Arc Gap using Semi-Automatic Shielded Metal Arc Welding Machine

Aditya Nayak[1], Chandra Shekhar Nagendra[2]

[1]M. Tech. Scholar, Mechanical Engineering, Shri Shankaracharya Technical Campus - Shri Shankaracharya Engineering College, Bhilai, India
nayakadi4725[at]gmail.com

[2]Assistant Professor, Department of Mechanical Engineering, Shri Shankaracharya Technical Campus - Shri Shankaracharya Engineering College, Bhilai, India
nagendra24587[at]gmail.com

Abstract: ***Welding processes are widely used throughout industry to perform a range of fabrication tasks. Of the various welding techniques available, stick-electrode welding, more formally known as Shielded Metal Arc Welding (SMAW) is one of the most common. SMAW is a consumed electrode welding technique, i.e. the electrode not only supplies the filler-metal, but also acts as the consumable material. Currently the electrode feed rate is carefully controlled during the welding process to ensure that the arc length remains constant. The obtained results will give the Tensile Strength & Compressive Strength of the weld, and Weight of Specimen used. These two parameters viz. Tensile Strength & Compressive Strength will help to conclude the result obtained. The strength of the welded work-piece will be tested and recorded with the help of Tests to be performed in Universal Testing Machine viz. tensile test & compression test. This will be helpful in confirming the values of process parameters in SMAW. Later on, Hardness Test can be performed to determining the hardness of the weld by Rockwell Hardness Testing Machine.***

Keywords: SMAW – Shielded Metal Arc Welding, **RHT Machine** - Rockwell Hardness Test Machine, **UTM** - Universal Testing Machine, **Process Parameters** – Arc Gap

1. Introduction

Welding processes are widely used throughout industry to perform a range of fabrication tasks. Of the various welding techniques available, stick-electrode welding, more formally known as Shielded Metal Arc Welding (SMAW) is one of the most common. SMAW is a consumed electrode welding technique, i.e. the electrode not only supplies the filler-metal, but also acts as the consumable material. Currently the electrode feed rate is carefully controlled during the welding process to ensure that the arc length remains constant. At present SMAW (Shielded Metal Arc Welding) process is done at fixed Voltage, fixed welding speed & fixed arc gap. This research work focuses light on measuring, recording and analyzing the variations in the weld strength and hardness of the weld if the fixed parameters would be changed within a given range. In this research, three process variable parameters are taken into account viz. arc voltage, welding speed & arc gap. This can be done by varying one of the process variable parameters and making the other two constants. Figure 1 illustrates the above statement diagrammatically. Result will be obtained for each and every varying process variable parameters and will be recorded. The obtained results will give the Tensile Strength & Compressive Strength of the weld, and Weight of Specimen used. These two parameters viz. Tensile Strength & Compressive Strength will help to conclude the result obtained. The strength of the welded work-piece will be tested and recorded with the help of Tests to be performed in Universal Testing Machine viz. tensile test & compression test. This will be helpful in confirming the values of process parameters in SMAW. Later on, Hardness Test can be performed to determining the hardness of the weld by Rockwell Hardness Testing Machine for measuring bead width & penetration. This will be helpful in determining and confirming the exact and accurate values of process parameters in SMAW.

2. Literature Review

Patnaik et. al. (2007) [15] established a relationship between the controlling factors and performance outputs by means of Non-linear Regression Analysis and developed a valid mathematical model and Genetic Algorithm (GA) to optimize the welding parameter and performance output.

S Kumanan et. al. (2007) [16] worked on the application of Taguchi Technique and Regression Analysis to determine the optimal process parameters for SAW. They have carried out an experiment on a semi automatic submerged arc welding machine and the signals to noise ratios have been computed to determine the optimum parameters. The percentage contribution of each factor has been validated by ANOVA technique. Multiple regression analysis has also been carried out using SPSS software to develop mathematical models to predict the bead geometry for the given welding conditions. They also predicted the bead geometry from the developed model from the corresponding input data.

Chandel and Seow [17], presented the mathematical prediction of the effect of current, polarity used, electrode diameter and its extension on the melting rate, bead height, bead width and weld penetration in SAW**.** They concluded that for a given current (heat input) the melting rate can be increased by using electrode negative polarity, longer electrode extension, and smaller diameter electrodes. There are two other ways to increase the deposition rate without increasing the heat input; these are: (i) using a twin-arc mode and (ii) adding metal powders.

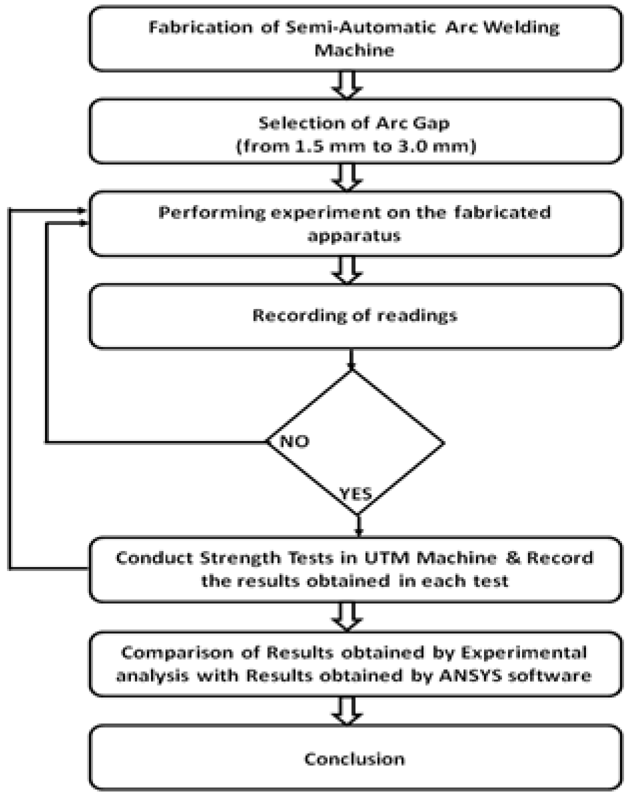
Chandel, Yang and Bibby [18] while investigating the effects of process variables on the bead width of submerged-arc weld deposits concluded that bead width is affected by the electrode polarity, electrode diameter, electrode extension, welding current, welding voltage and welding speed. A positive electrode polarity, a large electrode diameter, a small electrode extension and a high welding voltage encourages a large bead width in most cases. The bead width is not affected significantly by the power source used (i.e. constant voltage or constant current) when an acidic fused flux is used. However, when a basic fused flux is used, constant-current operation gives somewhat larger bead widths.

Mostafa and Khajavi [19], described the prediction of weld penetration as influenced by Flux Cored Arc Welding process parameters like welding current, arc voltage, nozzle-to-plate distance, electrode-to-work angle and welding speed. The optimization result shows penetration will be maximum when welding current, arc voltage, nozzle-to-plate distance and electrode-to- work angle are at their maximum possible value and welding speed is at its minimum value. Increase in welding current (I) increases the depth of penetration (P). Increase in welding speed (S) causes a decrease in depth of penetration (P). Increase in arc welding voltage (V) resulted in an increase in depth of penetration (P), Increase in electrode-to-work angle from 90° to 120° (i.e. for normal to backhand) had resulted in increase of depth of penetration. Increase in nozzle-to-plate distance (N) also causes an increase in depth of penetration (P). Based on this investigation it can be concluded that the developed model can be used to predict adequately the weld bead penetration within the specified range of the process parameters. The optimization method can also be used to find optimum welding conditions for maximum weld bead penetration. Their results are in agreement with the results of Chandel at. el. [17]

3. Problem Identification

The present situation in the field of SMAW (Shielded Metal Arc Welding) is that the whole welding process is done at fixed arc gap. This research work focuses light on what will happen if the fixed arc Voltage would be changed within a given range. In this research, the process variable parameter is taken into account is Arc Gap. This can be done by varying process variable parameter i.e. the Arc Gap and keeping Welding Speed and Arc Voltage at constant i.e. Welding Speed is kept constant at 5 mm.s-1 and Arc Voltage is kept constant at 30 Volt. Result will be obtained for each and every values of the process variable parameter ranging from 1.5 mm to 3.0 mm and will be recorded. The results will give the best possible values of Arc Gap at which welding can be performed with best possible Tensile Strength and Compressive Strength of the weld.

4. Methodology



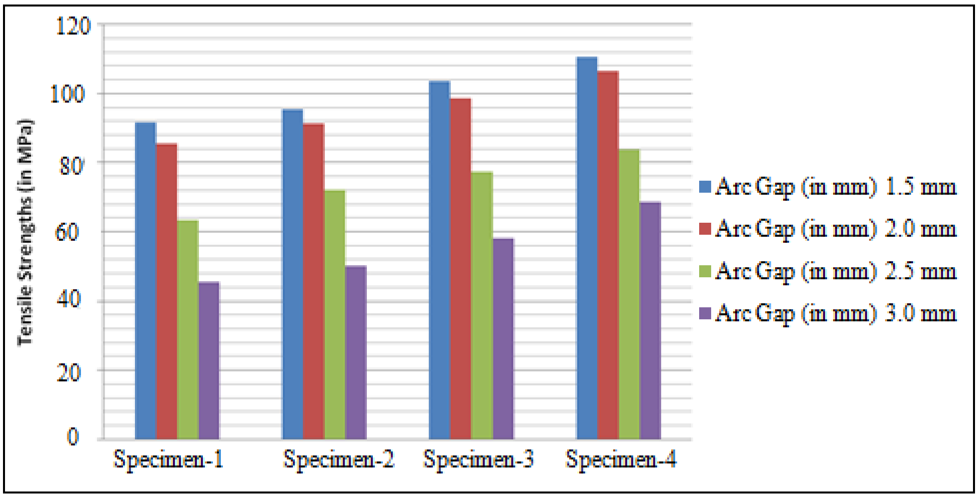
5. Result & Conclusion

The welded work piece will be tested for tensile test, compression test & shear test with the help of Universal Testing Machine (UTM) to obtain the best Arc Gap at which Welding can be performed thus keeping the Welding Speed and Arc Voltage at constants i.e. Welding Speed is 5 mm.s-1 and Arc Voltage is 30 Volt, so that the Tensile Strength and Compressive Strength is at its best. Thus, when the results will be obtained, one will be able to find out the best possible Arc Gap for performing welding at which the Strength of the work-piece will be at its best. Individual Strength Charts are generated using the results obtained by experimental analysis. This will be helpful for comparing the Strengths among them at a given Arc Gap. Thus at each Arc Gap values considered for experimental analysis, Strength analysis is done and a Strength Chart is generated for the same so that the comparison among the strengths for a particular arc gap may be easily made.

The result obtained by experimental analysis is as shown below:

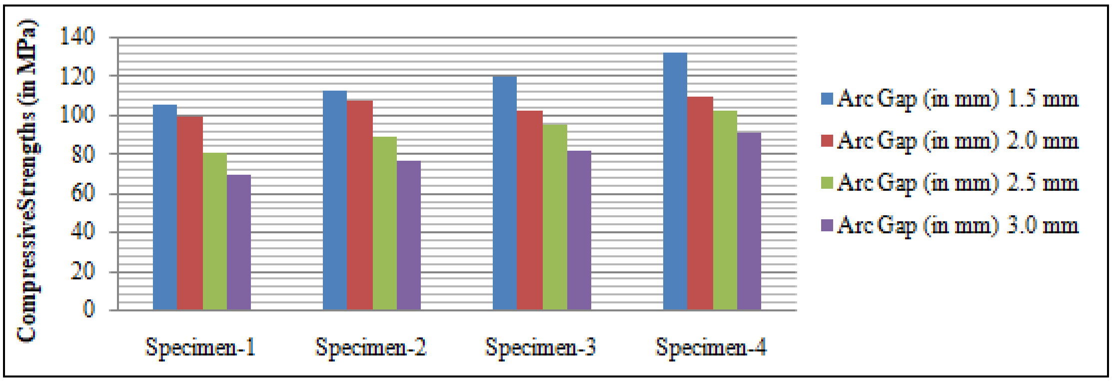
Tensile Strengths of four specimens for Arc Gap Ranging from 1.5 mm to 3.0 mm :

		Tensile Strengths (in MPa)			
		Specimen-1	Specimen-2	Specimen-3	Specimen-4
Arc Gap (in mm)	1.5 mm	91.5	95.3	103.5	110.5
	2.0 mm	85.4	91.1	98.6	106.2
	2.5 mm	63.2	72	77.4	83.6
	3.0 mm	45.5	50.2	58.2	68.7



Compressive Strengths of four specimens for Arc Gap Ranging from 1.5 mm to 3.0 mm

		Tensile Strengths (in MPa)			
		Specimen-1	Specimen-2	Specimen-3	Specimen-4
Arc Gap (in mm)	1.5 mm	105.4	113.4	120.2	132.4
	2.0 mm	99.2	107.5	102.2	109.5
	2.5 mm	81	89.6	95.8	102.8
	3.0 mm	69.3	76.4	82.3	91.3

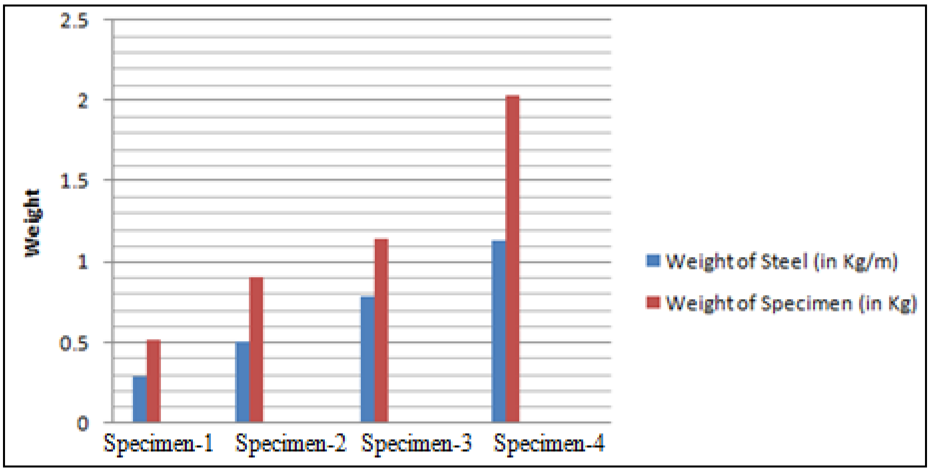


From the above result and graph obtained by comparing the four specimens Tensile and Compressive strengths for Arc Gap ranging from 1.5 mm to 3.0 mm, made by welding Mild Steel Square Bar (Specimen Thickness x 150 mm Length) x 2 Nos. welded at the centre; it can be concluded that the Tensile and Compressive Strength increases when thickness of material increases from 1.5 mm to 3.0 mm whereas Tensile and Compressive Strength decreases when thickness of material is reduced from 3.0 mm to 1.5 mm.

Calculation of Weight of Specimen used in Kilogram:
Source:
https://sites.google.com/site/standardbasicengineering/home/weights-of-round-square-hexagon-steel-brass-bars

Calculation of Weight of Specimens (in Kg)

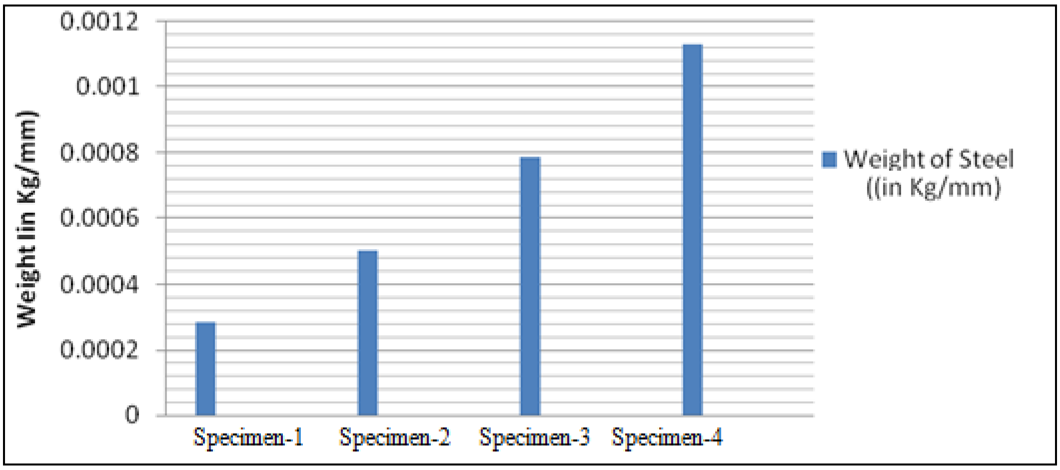
Specimen No.	Weight of Steel (in Kg/m)	Weight of Steel (in Kg/mm)	Thickness of Specimen (in mm)	Length of Specimen (in mm)	No. of Parts	Weight of Specimen (in Kg)
Specimen-1	0.283	0.000283	6	150	2	= 0.000283 x 6 x 150 x 2= 0.5094
Specimen-2	0.502	0.000502	8	150	2	= 0.000502 x 8 x 150 x 2= 0.9036
Specimen-3	0.785	0.000785	10	150	2	= 0.000785 x 10 x 150 x 2= 1.143
Specimen-4	1.13	0.00113	12	150	2	= 0.001130 x 12 x 150 x 2= 2.034



Weight of Specimens (in Kg)

Weight of Steel (in Kg/mm)

Specimen No.	Weight of Steel ((in Kg/mm)
Specimen-1	0.000283
Specimen-2	0.000502
Specimen-3	0.000785
Specimen-4	0.00113



Weight of Steel (in Kg/mm)

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