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Experimental analysis of tensile strength in Stainless Steel-304 and Mild Steel-1144 on various process parameters of gas metal arc welding by using Taguchi technique

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Abstract : The aim of this study is to analyse the tensile strength and to develop conditions for improvement of the quality and appearance of weld beams formed by SMA welding processes through variation of welding parameters and using different electrode. The comparative study tests is based on the tensile strength of the selected material (Stainless Steel-304 and Mild Steel-1144) as a consequence of applying different welding parameters i.e. different welding current, variation in welding voltage, welding speed and using different electrodes E-6010 cellulosic ,E6012 rutile.

***Key words* : gas metal arc welding (GMAW), Process parameters different welding current, variation in welding voltage, welding speed.**

I. INTRODUCTION

Welding is a fabrication process that joins materials permanently, usually similar or dissimilar metals by the use of heat causing fusion with or without the application of pressure. Arc welding among these welding processes is the most popular welding process the world over. Arc welding in its present form appeared on the industrial scene in 1880's. Arc welding however, was not accepted for fabrication of critical components till about 1920. However, the demand for large scale production of heavy items like ships, pressure vessels, construction of bridges etc. provided the necessary impetus for welding to come of age and the Second World War firmly established it as the major fabrication process.

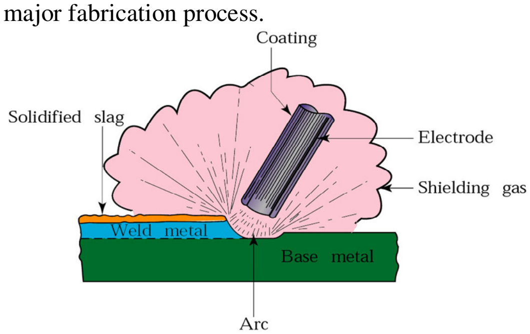

Fig 1.1: Principal Of Metal Arc Welding.

The figure 1.1 shows the principal of Metal Arc Welding process. In arc welding processes an electric arc between an electrode and a workpiece or between two electrodes is utilized to heat the joint to be welded. Most of these processes use some shielding gas while others employ fluxes or coatings to protect the weld pool from ill effects of the atmosphere. Welding processes widely used in industry include oxy-acetylene, manual metal arc or shielded metal arc (SMAW), submerged arc (SAW), gas metal arc (GMAW), gas tungsten arc (GTAW), resistance and thermit welding.

Lu and Kou (Ref. 3) measured power and current density distributions using a split copper block. Based on the analysis by the Abel inversion method, the shape of power and current distribution were found out to be Gaussian density functions, so the arc shape could be described by the total magnitudes (i.e., total heat input and current) and Gaussian distribution parameters. the shape of the weld pool and bead shape are also strongly affected by the flow of plasma in the welding arc. The forces exerted by the arc plasma jet on the weld pool are the arc stagnation pressure and drag force. Arc pressure acts on the weld pool surface in the normal direction, depressing the molten deposit. Arc pressure density distribution on the weld pool surface has also been investigated for GTAW.

The mechanism was studied by Heiple and Roper. They proposed that the final weld shape can be significantly altered by variations of the surface active elements (e.g., sulfur) that changes the direction of surface tension gradient induced flow (Marangoni flow) in GTA welding conditions. Based on understanding the well known forces and heat input in the weld pool, many researchers simulated arc welding processes and studied weld pool convection, the formation of the weld pool and molten droplets, droplet transfer, and solidified weld bead shape. The idea of solving for the shape of the free surface of a fluid volume as a static energy minimization problem. Wang and Tsai investigated the dynamics of periodic filler droplets impinging onto weld pool and phase change,

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using VOF technique that can handle a transient deformed weld pool surface and the continuum model (Kuk et al. 2004, Murugan and Parmar, 1994).GMAW welding process overcome the restriction of using small lengths of electrodes and overcome the inability of the submerged-arc process to weld in various positions. By suitable adjusting the process parameters, it is possible to weld joints in the thickness range of 1-13 mm in all welding position . (Jang et al. 2005, Praveen and Yarlagadda, 2005).The American Welding Society refers to the process Gas Metal Arc Welding process to cover inert as well as active shield gasses. GMAW is basically a semi automatic process arc lengths of electrode and the feeding of the wire are automatically controlled. The welding operator’s job is reduced to positioning the gun at a correct angle and moving it along the seam at a controlled travel speed. Hence less operator skill is required with this process as compare to TIG and manual metal arc process. Yet basic training is required in the setting up of the equipment and manipulation of the gun must be provided to the operator to ensure quality GMAW welding. Lowke *et ul.* simplified the model by putting boundary conditions for elrctric potentiai into the rod electrode. In their model, they solved the mas cmtinuity and consemation equations for momentum and energy only They neglectcd the cathode sheath between the electrode and the arc. Although in this model thcre is no need to pre-define the cathode çurrent density. the rcsults are dependent to some extent on the cathode surfxe temperature.

II. METHODOLOGY ADOPTED

A.Taguchi Technique: Taguchi method is applied for the current study for Experimental analysis of tensile strength in Stainless Steel-304 and Mild Steel-1144 on various process parameters of gas metal arc welding by using Taguchi technique. Professor Taguchi developer of robust designs and advocates a philosophy of quality engineering that is broadly applicable. The fundamental principle of robust design is to improve the quality of a product by minimizing the effect of the causes of variation without eliminating the causes.Professor Genichi Taguchi introduced his approach using experimental design for

- Designing products or processes so that they are robust to environmental condition.
- Designing/developing products so that they are robust to component variation.
- L-9 orthogonal array is selected for the current research work.

B. Material Used

In the present study Stainless Steel-304 and Mild Steel-1144 is selected as a workpiece for working on Gmaw The Electrode Used Is E-6010 cellulosic ,E6012 rutile. Welding is performed on Stainless Steel and Mild Steel flat plate of 100*75*8 dimension By using(Uttam arc welding transformer) Welding machine. The different electrodes use for the process is arc of diameter 3mm.

2. Experimental set up

The purpose of this study is analysing the effect of tensile strength on GMAW in Stainless Steel-304 and Mild Steel-1144. Tensile testing, also known as tension testing, is a fundamental material test in which a sample is subjected to uniaxial tension until failure. The results from the test are commonly used to select a material for an application. The pieces welded by welding machine using different electrodes.is as shown in the figure below.

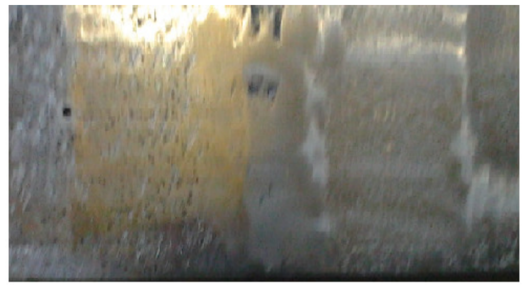


Fig. 1.2 Typical SMAW Welded with E-6012(Rutile)

Electrode

The different electrodes use for the process is arc of diameter 3mm. eighteen no. of pieces welded by welding machine using different electrodes. In the present study, three 3-level process parameters i.e. Arc current, Arc voltage and welding speed are considered. The values of the welding process parameters are listed in Table .L-9 orthogonal parameters are selected for the present research work.anova is also performed and is as shown in below discussion.

Table 1: Parameters & their levels

Parameters	Code	Level 1	Level 2	Level 3
Welding Current (Amp)	A	85	95	110
Arc Voltage (Volt)	B	30	32	34
Welding Speed (mm/sec)	C	3.57	3.82	5.74

After using this value on minitab software design of experiment i.e L-9 Orthogonal array is prepared which is shown as below :-

Table 2 : Design of Experiments

RUN	CURRENT (amp)	VOLTAGE (volt)	SPEED(mm/SEC)
1	85	30	3.57
2	85	32	3.82
3	85	34	5.74
4	95	30	3.82
5	95	32	5.74
6	95	34	3.57

7	110	30	5.74
8	110	32	3.57
9	110	34	3.82

Table 1.2: analysing the tensile strength on various process parameters

Sr. No	Current	Voltage	Speed	Tensile Strength Kgf /mm^2
1	85	30	3.57	422.11
2	85	32	3.82	423.37
3	85	34	5.74	424.63
4	95	30	3.82	425.71
5	95	32	5.74	424.89
6	95	34	3.57	425.93
7	110	30	5.74	427.01
8	110	32	3.57	428.51
9	110	34	3.82	431.73

In this study we noticed that how tensile strength vary by changing the above parameter i.e. welding current etc. E6010 electrode coating by 40% cellulose 25% titanium oxide, 20% mg silicon, 15% Fe-Mn bonded with sodium or potassium silicate.

III. RESULTS AND DISCUSSIONS

Experimental set up show the effect of the three control factors on tensile strength. The S/N ratio response table and response graphs are shown for S/N ratio for tensile strength is shown Fig.3.

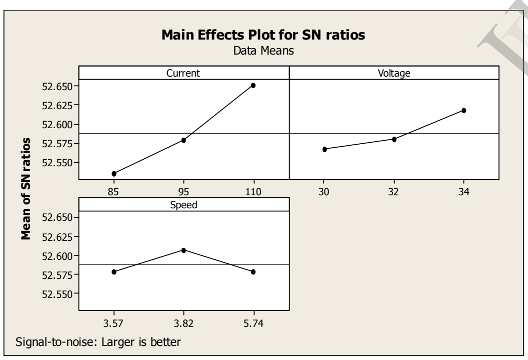


Fig 3 : Effect of control factors on tensile strength for s/n ratio

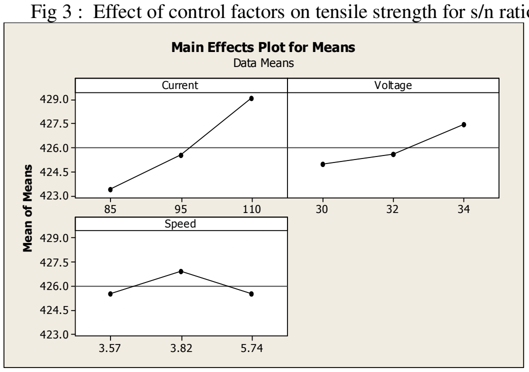
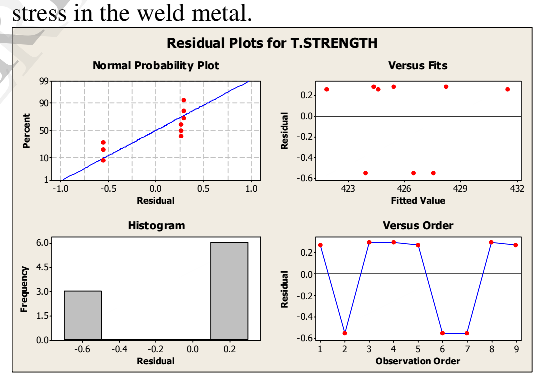


Fig 4 : Effect of control factors on tensile strength for means

As we obtained from the minitab software that according to the design of experiment the value of tensile strength is for (424.63 N/mm^2) at(85 Amp) current & (431.77 N/mm^2) at (110amp). The behavior can also be represented on mean graph as shown in the figure above . The value of tensile strength increases with increase the current and elongation percentage is also increase. On increasing the voltage supply the tensile strength goes on increasing and reach to maximum value at 428.32 at higher value of voltage this is due to the fact that as we increase the voltage supply the current increases that is used in SMAW welding, the bigger the Al materials produced especially on weld metal area. However in HAZ area, the dense material produced on 110 A. The other influencing factor on tensile strength is current in SMAW. There is close relation between the welding current and mechanical proper-ties of weld metal on one hand and normalising temperatures and mechanical properties on the other hand. In general, The current variables used are 85,95,110 effect so much on the base metal as the current increase hardness also increase. As the heat input increases the temperature gradient of the solidifying weld metal in-creases. Also, the shape and size of weld pool is signifi-cantly affected by heat input, the weld pool becomes elongated as the heat input increases. formation of columnar dendrites in the weld metal and also increases the level of residual stress in the weld metal.



The residuals plots vs tensile strength is given in the figure above in very first figure process parameters are randomly distributed on the straight line which shows the goodness of fit.

IV. CONCLUSION

In this paper influence of process parameters on tensile strength was investigated. The parameters affecting the response were obtained using ANOVA and the graph was plotted. From the analysis, it is concluded that:

a) From the above discussion it is concluded that tensile strength is increased with the increasing of current and voltage
b) Secondly as the weld speed is increasing

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The tensile strength first increase upto a limit of 428 bt then rapidly goes on decreasing mode.

c) For wire crater depth (*d*), µm, weld speed rate is the most significant parameter with 3.57 to 3.82 contribution.

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