Investigation of Chromium Manganese Stainless Steel using Taguchi Method to Analyse the Mechanical Properties

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***Abstract*—This project deals with 304 SS weldment properties on TIG welding. 304 SS contains 18% chromium and 8% nickel which has higher corrosion resistance. The base metal 304 SS is welded using the process parameters such as current, voltage and welding angle, the influence of these parameters on weld zone is studied. Tensile test is carried out to find the strength of weld. Salt spray test is conducted at weld zone to identify the corrosive resistance of material. Since it widely used in Marine applications.**

Keywords – 304SS, corrosion resistance, salt spray test, tensile test, tig

I. INTRODUCTION

The increased globalization of industry is causing acceleration in the pace of product change. Shorter product development time with Excellency in functionality, quality, cost competitiveness and aesthetics is the order of the day. This trend is forcing the Engineers and Engineering managers to respond with products that have increasingly lower costs, better quality and shorter development times.

Welding is a process of joining similar or dissimilar metals by the application of heat with or without the application of pressure and addition of filler material. The result is a continuity of homogenous material of the composition and characteristics of two parts which are being joined together. The application of welding is so varied and extensive that it would be no exaggeration to say that there is no metal industry and there is no branch of engineering that does not make use of welding in one form or another. In fact, the future of any new metal may depend on how far it would lend itself to fabrication by welding.

Steel is an alloy of iron and other elements, primarily carbon, that is widely used in construction and other applications because of its high tensile strength and low cost. Steel's base metal is iron, which is able to take on two crystalline forms (allotropic forms), body centred cubic and face centred cubic (FCC), depending on its temperature. It is the interaction of those allotropes with the alloying elements, primarily carbon, that gives steel and cast iron their range of unique properties.

II. PROBLEM DEFINITION

Resistance spot welding (RSW) has a very important role as a joining process in the automotive industry and a typical vehicle contains more than 3000 spot welds. The quality and strength of the spot welds are very important to the durability and safety design of the vehicles. The development of the new materials results constantly in the resistance spot welding tasks with new materials or combinations of them.

Low carbon steels are widely used for structural applications because of its ease in fabrication and the moderate strength it possesses. However, its pure corrosion resistance at normal atmosphere is a matter of serious concern.

In this study corrosion rates of aluminium, copper, brass and Stainless Steel 304 (SS 304) in tequila are reported from potentio-dynamic polarization and Electrochemical Impedance Spectroscopy (EIS) measurements. A simple kinetic model is proposed to analyse the polarization data and to establish a comparison with EIS measurements.

Corrosion testing of four PM stainless steel materials (SS-316N1, SS-316N2, SS-316H, and SS-434H) has been conducted under the auspices of the MPIF Standards Committee. Test specimens were subjected to salt spray testing in accordance with ASTM B117. Additional test specimens were tested for corrosion in 5% NaCl solution in accordance with ASTM B895.

From the above literature it is observed that optimization for input process can be obtained by Taguchi Method for 304 SS

The gas tungsten arc welding (GTAW) and gas metal arc welding (GMAW) welding processes are very often used for welding of these alloys. However, GTAW process is generally preferred because it produces a very high-quality weld.

Metallurgical advantages of pulsed and magnetic arc oscillation welds that are frequently reported in the literature includes grain refinement in the fusion zone, reduced width of HAZ, less distortion, control of segregation, reduced hot cracking sensitivity and reduced residual stresses. All these factors will help in improving mechanical properties. Current pulsing has been used by several investigators to obtain grain

refinement in weld fusion zones and improvement in weld mechanical properties.

Hence, in this investigation an attempt has been made to find optimal combination of pulse current TIG welding process parameters to improve tensile properties of 304 Stainless Steel weldment.

III. THE GTAW (TIG) PROCESS

The necessary heat for Gas Tungsten Arc Welding (TIG) is produced by an electric arc maintained between a non-consumable tungsten electrode and the part to be welded. The heat-affected zone, the molten metal, and the tungsten electrode are all shielded from the atmosphere by a blanket of inert gas fed through the GTAW torch. Inert gas is that which is inactive, or deficient in active chemical properties. The shielding gas serves to blanket the weld and exclude the active properties in the surrounding air. It does not burn, and adds nothing to or takes anything from the metal. Inert gases such as argon and helium do not chemically react or combine with other gases. They possess no odour and are transparent, permitting the welder maximum visibility of the arc. In some instances, a small amount of reactive gassuch as hydrogen can be added to enhance travel speeds.

The GTAW process can produce temperatures of up to 35,000° F/ 19,426° C. The torch contributes only heat to the work piece. If filler metal is required to make the weld, it may be added manually in the same manner as it is added in the oxyacetylene welding process. There are also a number of filler metal feeding systems available to accomplish the task automatically. Figure 1 shows the essentials of the manual GTAW process.

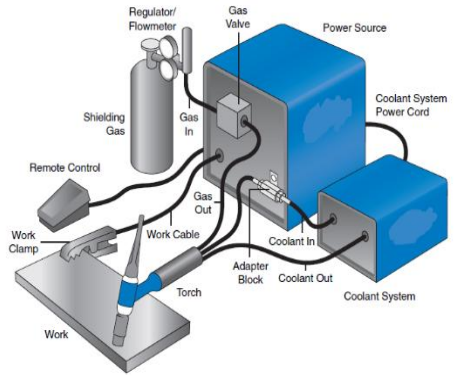


Fig 1Manual GTAW Machine

IV. SELECTION OF MATERIAL

304 stainless steel, also known as 18/8 stainless steel, European norm 1.4301, is the most common stainless steel. The steel contains both chromium (usually 18%) and nickel (usually 8%) metals as the main non-iron constituents. It is an austenite steel. It is not very electrically or thermally conductive and is non-magnetic. It has a higher corrosion resistance than regular steel and is widely used because of the ease in which it is formed into various shapes. It contains 17.5–20% chromium, 8–11% nickel, and less than 0.08% carbon, 2% manganese, 1% silicon, 0.045% phosphorus, and 0.03% sulphur.

V. TUNGSTEN INERT GAS

A.Welding Parameters

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.

B. Working Welding Process Parameters

From the literatures, the predominant factors which are having greater influence on fusion zone grain refinement of PCTIG welding process have been identified.

They are:

(i) Current, Amps
(ii) Voltage, Volts
(iii) Gas Flow Rate,(lit/min)

C.Welding Current

Welding current is the most influential variable in arc welding process which controls the electrode burn off rate, the depth of fusion and geometry of the weld elements.

D. 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 arc voltage.

E. Welding Gas Flow Rate

Gas flow rate is the volume of gas that passes a particular point in a particular point of time.

F. Tensile Test

A tensile test, also known as is probably the most fundamental type of mechanical test you can perform on material. Tensile tests are simple, relatively inexpensive, and fully standardized. By pulling on something, you will very quickly determine how the material will react to forces being applied in tension. As the material is being pulled, you will find its strength along with how much it will elongate.

G. Salt Water Spray Test

The salt spray test is a standardized and popular corrosion test method, used to check corrosion resistance of

material and surface coating. This accelerated laboratory test was invented at the beginning of the 20th century. It provides a controlled corrosive environment and has been used to produce relative corrosion-resistance information for specimens of metals and use stainless steels.

VI. DESIGN OF EXPERIMENTS

A. Taguchi Method

1. Quality should be designed into a product, not inspected into it.

Quality is designed into a process through system design, parameter design, and tolerance design. Parameter design, which will be the focus of this article, is performed by determining what process parameters most affect the product and then designing them to give a specified target quality of product. Quality "inspected into" a product means that the product is produced at random quality levels and those too far from the mean are simply thrown out.

2. Quality is best achieved by minimizing the deviation from a target.

The product should be designed so that it is immune to uncontrollable environmental factors.

In other words, the signal (product quality) to noise (uncontrollable factors) ratio should be high.

3. The cost of quality should be measured as a function of deviation from the standard and the losses should be measured system wide.

This is the conceptof the loss function, or the overall loss incurred upon the customer and society from a product of poor quality. Because the producer is also a member of society and because customer dissatisfaction will discourage future patronage, this cost to customer and society will come back to the producer.

B.Orthogonal Array

The selection of which OA to use predominantly depends on these items in order of priority:

1. The number of factors and interactions of interest

2. The number of levels for the factors of interest

3.The desired experimental resolution or cost limitations

The first two items determine the smallest orthogonal array that it is possible to use, but this will automatically be the lowest resolution, lowest cost experiment. The experimenter may choose to run a larger experiment (larger orthogonal array) which will have higher resolution potential but will also be more expensive to complete.

Orthogonal Arrays: Two basic kinds of orthogonal arrays are listed in the appendixes

Appendix B contains two level arrays

L4 L8 L12 L16 L32

Appendix C contains three level arrays

L9 L18 L27

The number in the array designation indicates the number of trials in the array; an L8 has eight trials and L27 has 27 trials, for example. A factor may be assigned to any and all columns in the OA.

C. Selection of Orthogonal Array

The number of levels used in the factors should be used to select either two-level or three-level types of OAs. If the factors are two levels then an array App B should be chosen; if factors are of three-levels array then an array App C should be chosen.

	Number of factors											
Number of levels		2	3	4	5	6	7	8	9	10	11	12
	2	L4	L4	L8	L8	L8	L8	L12	L12	L12	L12	L16
	3	L9	L9	L9	L18	L18	L18	L18	L27	L27	L27	L27

TABLE 1. Number of factor

For our experiment we are considering three levels and three parameters as variable and so we can select L9 orthogonal array for conducting the experiment

TABLE 2.L9 Orthogonal array

S. No	**Current A**	**Voltage V**	**Gas flow rate lit/min**
1	150	10	14
2	150	15	18
3	150	20	22
4	170	10	18
5	170	15	22
6	170	20	14
7	190	10	22
8	190	15	14
9	190	20	18

VII. RESULT OF TENSILE TEST

A. Tensile Test

A tensile test, also known as is probably the most fundamental type of mechanical test you can perform on material. Tensile tests are simple, relatively inexpensive, and fully standardized. By pulling on something, you will very quickly determine how the material will react to forces being

applied in tension. As the material is being pulled, you will find its strength along with how much it will elongate.

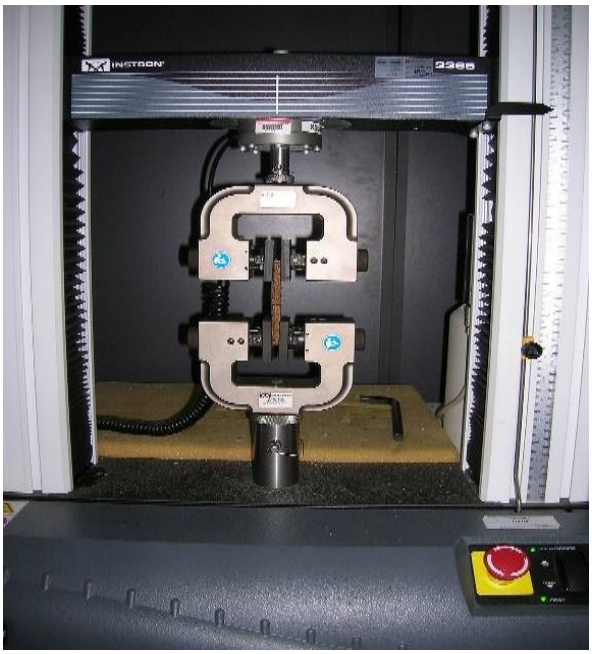


FIG2. TENSILE TEST MACHINE

B. Specimen Preparation

In the tensile test process, the specimen should be in the properdimension. Because doing tensile test without proper dimensions, the elongationdoes not exist at the welded place.so, the welded specimen should be kept in the proper dimensions

FIG 3 SPECIMEN

C. Design of experiments of L9 orthogonal array and output response

TABLE 3 Design of experiments of L9 orthogonal array and output response

S.No	CURRENT	VOLTAGE	GAS FLOW RATE	TENSILE TEST
1	150	10	14	612.52
2	150	15	18	634.55
3	150	20	22	653.85
4	170	10	18	672.64
5	170	15	22	693.33
6	170	20	14	696.25
7	190	10	22	701.74
8	190	15	14	706.45
9	190	20	18	710.22

D. Taguchi Analysis: Tensile Test versus Current, Voltage, Gas flow rate

The Taguchi analysis is done in MINI TAB 18 software based on the three parameters current, voltage and gas flow rate with respect to tensile strength. Also, the graph Signal to Noise ratio and Main effects are obtained.

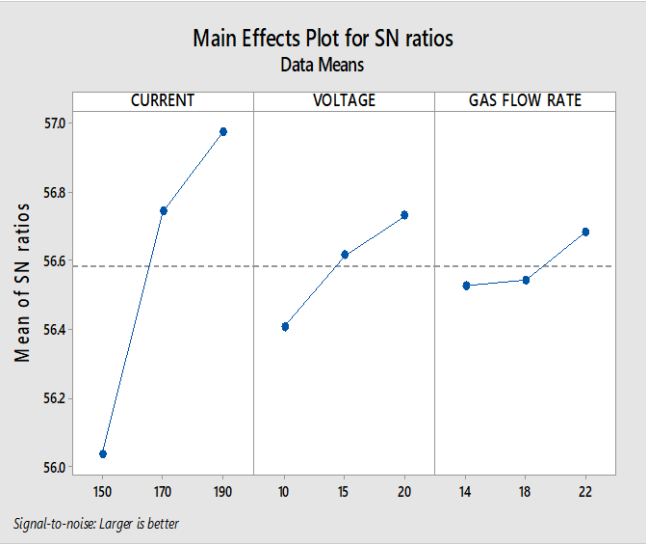
Here the graph indicates that the tensile strength increases when the parameters get increased. Also, it indicates that the current plays a major role in influencing the tensile strength of the material. Here Larger is better tends to assumed.

a) Signal to Noise ratio

Table 5. Response Table for Signal to Noise Ratios

Larger is better

Level	Current	Voltage	Gas flow rate
1	56.03	56.41	56.53
2	56.74	56.62	56.54
3	56.98	56.73	56.68
Delta	**0.94**	**0.32**	**0.16**
Rank	**1**	**2**	**3**

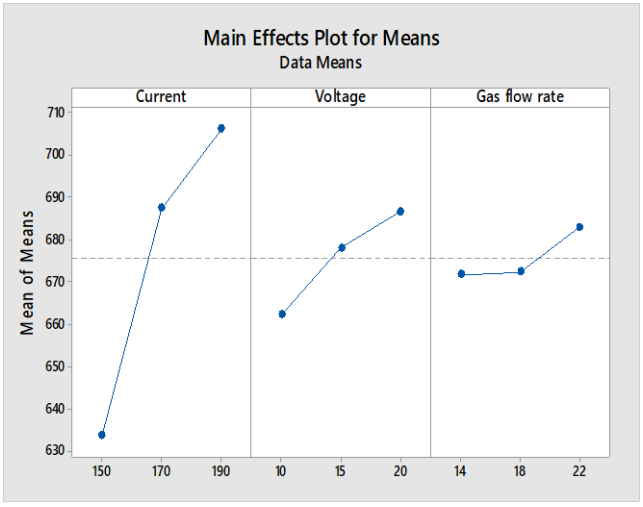


Graph1. Signal Noise ratio

b) Main effects plots for means

Table 6. Response Table for Means

Level	Current	Voltage	Gas flow rate
1	633.6	662.3	671.7
2	687.4	678.1	672.5
3	706.1	686.8	683.0
Delta	**72.5**	**24.5**	**11.2**
Rank	**1**	**2**	**3**



Graph 2. Main effects

VIII. CONCLUSION

Using Minitab L-9 orthogonal array is obtained to conduct experiments. For the parameters current, voltage, gas flow rate for different levels of welding is done and the tensile test is conducted and noted in the table 3. From the table it is inferred that the current 190amps, voltage 20 v and gas flow rate18 gives the maximum tensile strength. From the graph 1 the combination obtained for the maximum tensile strength are current 190 amps,20 v, gas flow rate 18.

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