Optimization of Parameters in TIG Welding of SS 304 using GRA Technique

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Abstract - Manufacturing industry has taken advantage of the TIG welding to join the thin section. High quality weld for stainless steels and non-ferrous alloys are also be obtained with this technique. However, in comparison to arc welding processes the TIG welding has lower productivity due to shallow penetration, which confined its application only to thin section. From the industrial point of view, stainless steel 304 is a very commonly used material due to its property of resistant to corrosion and better creep rupture strength. Stainless steel is extensively used for various applications in chemical, petrochemical, fertilizer, food processing, nuclear industries and in many other major industrial operations.

In this experimental work, the main objectives is to analysis of test results for investigating the influence of various parameters on tensile strength, hardness and % elongation of the joint.To study the effect of activated flux with various parameters on tensile strength, hardness and % elongation of the joint.To conduct an experiment investigation for optimization of Tungsten Inert Gas welding parameters for higher tensile strength and hardness of joint using grey relational analysis methodology.

Keywords: GTAW, Activated flux, SS 304, DOE, ANOVA, GRA

1. INTRODUCTION

A fabrication process which aids the joining of various like and dislikes materials usually metals or a thermoplastic by causing coalescence is known as welding. This is generally perform by melting and adding filler material to the work pieces in order to form a pool of molten material that cools to become a tenacious joint with application of pressure (sometimes). Welding process is an efficient and effective method in use to join two or more pieces of metal together by applying either thermal energy or pressure. It is in turn a precise, reliable, cost-effective method for joining materials. This technique is widely accepted and used in manufacturing due to diverse application of the process. Therefore, welding technique is employed to serve ever growing demands of the modern industry and is essential to produce most of usual objects ranging from big structures such as bridges and ships, to vehicles, to microelectronic components [2].

1.1 Tungsten Inert Gas Welding

Tungsten inert gas (TIG) welding also known as Gas tungsten arc welding (GTAW), is an arc welding process that uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmospheric contamination by an inert shielding gas (argon or helium) and a filler metal is normally used though some welds but known as autogenously welds, do not require it[3]. GTAW is mostly used to weld thin sections of stainless steel and non-ferrous metals such as aluminum, magnesium and copper alloys. The process grants the operator greater control over the weld than competing processes such as shielded metal arc welding and gas metal arc welding allowing for stronger and higher quality welds [5]. However, GTAW is however more complex and difficult to master than competitors. Furthermore, it is significantly slower than most other welding techniques as shown below in figure 1.1.

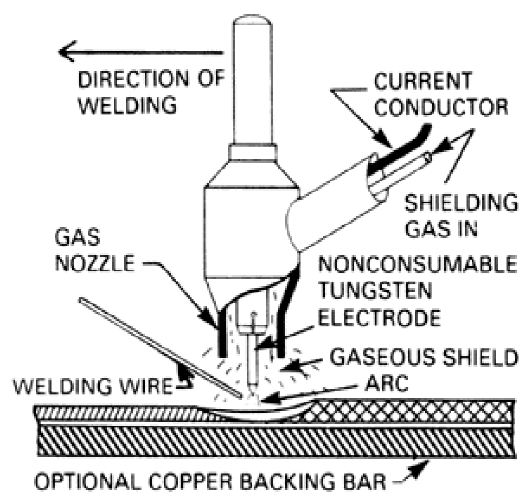

Fig -1: Gas tungsten arc welding process

1.2 Welding Parameters

To obtain high production rates and good quality of products the control of the operating variable in TIG welding is essential. Few important variables which require optimum control are listed below:

i. Welding Current

ii. Welding voltage

iii. Welding speed

1.3 Grey Relational Analysis Method

Grey relational analysis method uses an exact model of information as it defines situations through no information as black, and those by way of perfect information as white. In actual situations involvement of these extremes can be described as living being grey, hazy or fuzzy. Therefore, a grey system means that a system in which part of information is known and part of information is unknown. With this definition, the information quantity and quality form a continuum from a total lack of information to complete information – from black through grey to white. Since uncertainty always exists, one is always somewhere in the middle, somewhere between the extremes, somewhere in the grey area [7].

Grey analysis then comes to a clear set of statements about system solutions. At one extreme, no solution can be defined for any system with no information available. On the other extreme, a system with perfect information has a unique solution. In the middle, grey systems will give a variety of available solutions. Grey analysis does not attempt to find the best solution, but does provide techniques for determining a good solution, an appropriate solution for real world problems.

Let $x_i(k)$ is the value of the number *i* listed project and the number *k* influence factors.

Usually, three kinds of influence factors are included, they are:

1. Benefit – type factor (the bigger the better),
2. Defect – type (the smaller the better)
3. Medium – type, or nominal-the-best (the nearer to a certain standard value the better).

2. LITERATURE SURVEY

Kumar Harish et al., (2016) Austenitic stainless steels are widely used for different applications in chemical, petrochemical, fertilizer, food processing and nuclear industries. Welding process like Tungsten Arc welding (TIG), Activated Tungsten Arc welding (A-TIG) and Multi Pass Tungsten Arc welding (MP-TIG) have been used for the fabrication of industrial components. This paper addresses the laser welding aspects, which may be of considerable interest because it offers several advantages over other welding processes.

Tseng Kuang-Hung., (2017) The experiments reported in this study involved using a new activated flux developed by the National Pingtung University of Science and Technology (NPUST) to systematically investigate the influence of oxide-based flux powder and carrier solvent composition on the surface appearance, geometric shape, angular distortion, and ferrite content of austenitic 316L stainless steel tungsten inert gas (TIG) welds. The flux powders comprising oxide, fluoride, and sulfide mixed with methanol or ethanol achieved good spreadability. For the investigated currents of 125 to 225 A, the maximum penetration of stainless steel activated TIG weld was obtained when the coating density was between 0.92 and 1.86 mg/cm2.

3. PROBLEM FORMULATION & METHODOLOGY

The objectives of present research are listed below:-

i. Analysis of test results for investigating the influence of various parameters on tensile strength, hardness and % elongation of the joint.

ii. To study the effect of activated flux with various parameters on tensile strength, hardness and % elongation of the joint.

iii. To conduct an experiment investigation for optimization of Tungsten Inert Gas welding parameters for higher tensile strength and hardness of joint using grey relational analysis methodology.

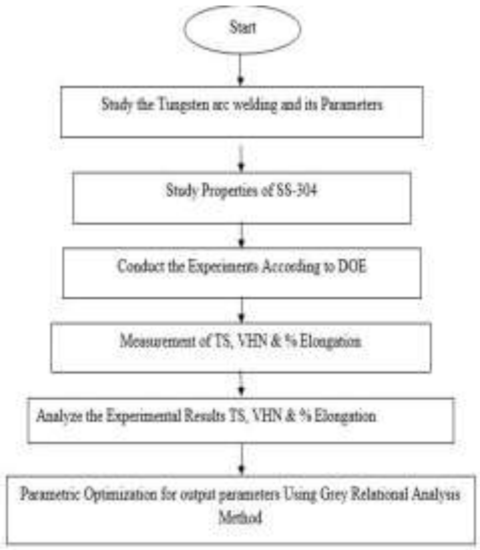

Fig -2: Work Plan

4. EXPERIMENTAL WORK

SS 304 is use as work material for this research work. It is a high strength steel [19]. It has significant better weld ability and can easily be welded. It has also better strength properties and machinability. SS 304 is the most widely used austenitic stainless steel. Popularly known as 18/8 stainless steel, it has excellent corrosion resistance and forming characteristics

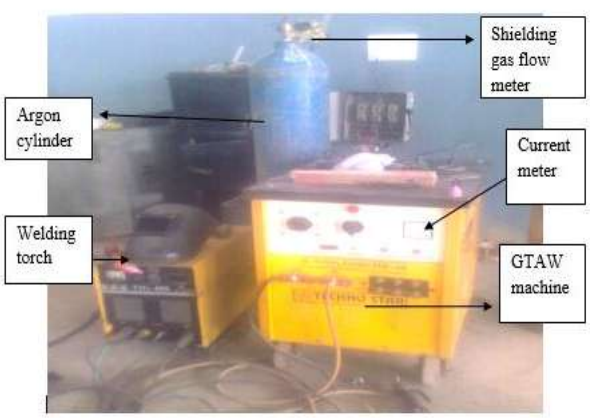

Fig -3: Tungsten Arc Welding Machine

4.1 Design of Experiment:

Designs of experiments are prepared for conducting the experiment.

Table -1: Design of Experiment

S.No	Welding Current (Ampere)	Welding Speed (mm/sec)	Flux Type
1	100	2.3	1
2	100	2.8	2
3	100	3.7	3
4	120	2.3	2
5	120	2.8	3
6	120	3.7	1
7	140	2.3	3
8	140	2.8	1
9	140	3.7	2

4.2 Ultimate Tensile Strength (UTS)

It is the maximum stress that a material can withstand while being pulled or stretched before breaking or failing. When material break without plastic deformation, these type of failure are called a brittle failure. While material break with plastic deformation and possible necking, these type of failure are called ductile failure and the unit of tensile strength is the Pascal (Pa). A linear stress-strain relationship show linear elastic behavior of material. While non-linear stress-strain relationship show plastic behavior of material. [7]

4.3 Universal Testing Machine (UTM)

Universal testing machine are used to test the compressive strength and tensile strength of the material. Universal testing machine are also called universal tester and material testing machine. The Testing is done in CITCO Chandigarh.

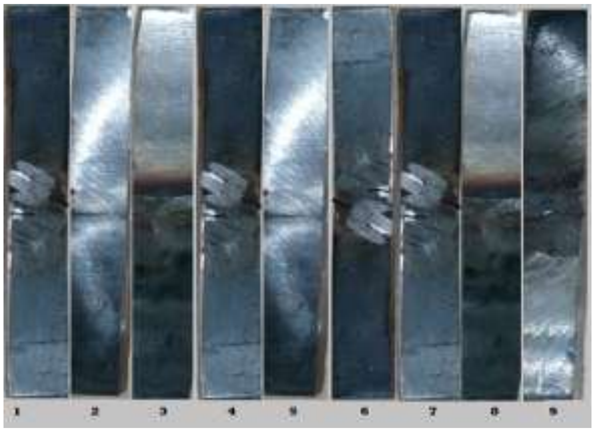

Fig -4: Specimens before Tensile test

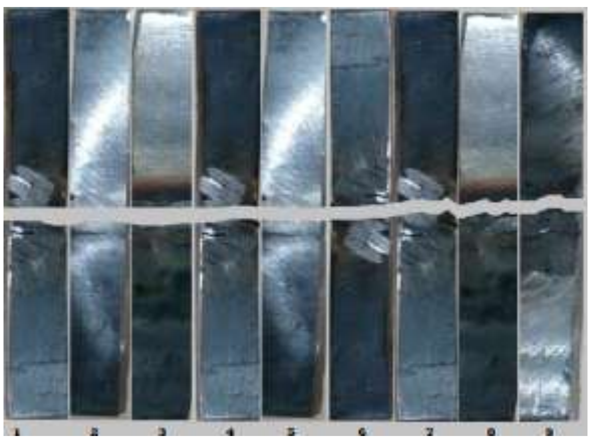

Fig -5: Specimens after tensile testing

5. **MAIN EFFECT PLOTS**

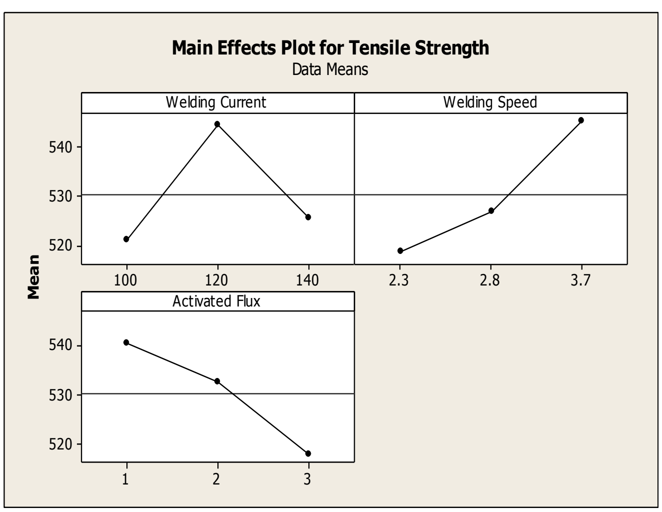

Fig -6: Tensile Strength

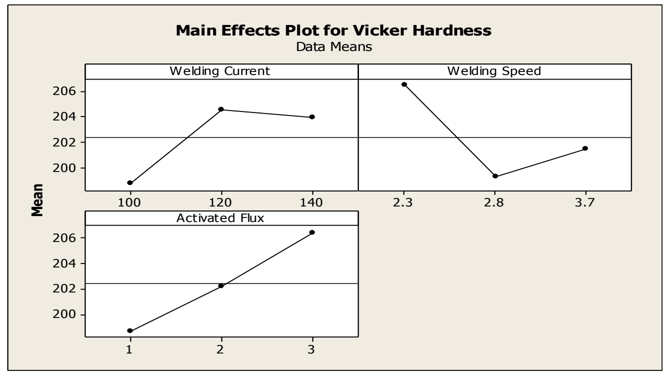

Fig -7: Vicker's Hardness

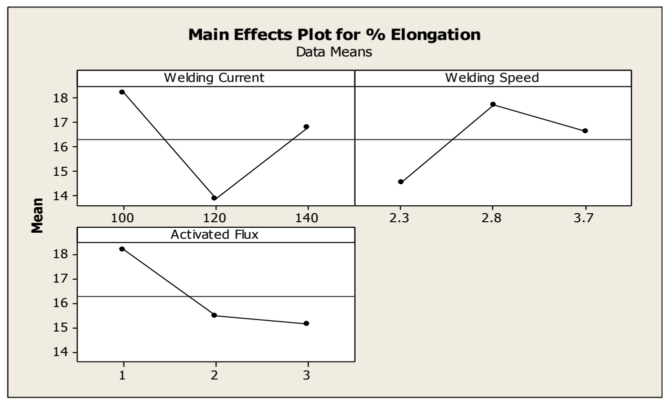

Fig -8: % Elongation

Table -2: Result for GRA Coefficient

S.NO	Grey Relational Coefficient			
	TS	**VHN**	**% Elongation**	**Rank**
1	1.000	0.847	0.802	9
2	0.630	1.000	1.000	8
3	0.617	0.597	0.670	5
4	0.471	0.200	0.000	1
5	0.886	0.472	0.341	4
6	0.000	0.730	0.703	3
7	0.858	0.000	0.462	2
8	0.507	0.882	0.967	7
9	0.706	0.627	0.571	6

5 PREDICTING OPTIMUM PERFORMANCE AT THEIR LEVELS

To calculate the optimum output characterstics for Tensile Strength, Hardness and % Elongation by using the realtion: $N_2 + S_1 + A_1 - 2T$

For calculate the maximum value of tensile strength, firstly select the maximum value of welding current. Secondly select the maximum values of welding speed and then select the type of activated flux.

Predicting Tensile Strength (TS) = $N_2 + S_1 + A_2 - 2T$

Where, T = overall mean of tensile strength

N_2 = average tensile strength at second level of welding current i.e. 120 ampere.

S_1 = average tensile strength at first level of welding speed i.e. 2.3 mm/sec.

A_2 = average tensile strength at second level of flux type of electrode i.e. $mgcl_2$.

TS = 544.28 + 518.81 + 532.47 – 2×530.28
TS = 535 KN/mm^2

Predicting Vickers Hardness (VHN) = $N_2 + S_1 + A_2 - 2T$

Where, T = overall mean of Vickers Hardness

N_2 = average Vickers Hardness at second level of welding current i.e.120 ampere.

S_1 = average Vickers Hardness at first level of welding speed i.e. 2.3 mm/sec.

A_2 = average Vickers Hardness at second level of flux type of electrode i.e.$mgcl_2$

VHN = 204.53 + 206.50 + 202.18 – 2×202.42

VHN = 208.37

Predicting % Elongation = $N_2 + S_1 + A_2 - 2T$

Where, T = overall mean of % Elongation

N_2 = average % elongation at second level of welding current i.e.120 ampere.

S_1 = average % elongation at first level of welding speed i.e. 2.3 mm/sec.

A_2 = average % elongation at second level of flux type of electrode i.e. $mgcl_2$.

% Elongation = 13.87 + 14.53 + 15.47 – 2×16.28

% Elongation = 11.31

6. COMPARISION OF EXPERIMENTAL VERSUS PREDICTING RESULT

Experimental results are mentioned below:

Maximum Tensile Strength= 542.78 KN/mm^2

Maximum Vickers Hardness= 208.97

Minimum % Elongation= 10.70

Predicting results are mentioned below:

Maximum Tensile Strength= 535 KN/mm^2

Maximum Vickers Hardness= 208.37

Minimum % Elongation= 11.31

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