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Study of Parameters used On Gas Tungsten Arc Welding (GTAW)

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ABSTRACT:

A non-consumable tungsten electrode is used in Gas Tungsten Arc Welding (GTAW) to create the weld joint. Many welding input parameters, such as welding current waveform, welding current, welding speed, and gas flow rate, have an impact on the attributes of the welded connections. These factors are crucial in figuring out how well a weld joint will turn out. In this study, an autogenous GTAW method is used to create a buttweld junction between copper and stainless steel (SS304). Trial runs had been carried out to determine the ideal range of process parameters. Considered are four variables, including welding current, welding speed, welding torch angle, and gas flow rate. The impact of these variables on mechanical characteristics such Analysis is done on the tensile strength, impact strength, bend strength, and hardness of the weld junction.

Keywords: Taguchi Orthogonal Array, GTAW, Micro-hardness, Tensile.

1. Introduction

When the right mix of temperature, pressure, and metallurgical conditions are present, two materials (often metals) are permanently joined through localised coalescence. Depending on how hot it is and how much pressure there is coming from a high. A broad variety of welding methods have been used, ranging from low pressure to high temperature. The process of uniting metals by heating them to their melting point and forcing the molten metal to flow together is referred to as welding. This can be done on anything from basic steel brackets to nuclear reactors. The metal used in autogenous welding is composed with exclusively refers to the basic metal. However, when the solidification temperature range of the base metal to be welded is extremely high (750ºC–1000ºC), autogenous welding can be crack-sensitive.

In the GTAW process, an arc is created between the base metal(s) and a tungsten electrode. When everything is done correctly, the electrode doesn't melt, but the work does when the arc makes contact and forms a weld pool. Thin wire filler is manually inserted into the pool. where it dissolves. Due of tungsten's sensitivity to airborne oxygen, effective shielding with an oxygen-free atmosphere is necessary. Usually, the arc's temperature is close to 6000ºC. The most common shielding gases are nitrogen, argon, or a combination of the first two. Common weld flaws include cracking, undercutting, inclusions, and lack of fusion. 2011 study by Wang et al. examined the joint of dissimilar. Using tungsten inert gas arc welding (GTAW), metal 2205 duplex stainless steel and 16MnR low alloy high strength are joined.

2. Experimentation

Almost all metals, including mild steel, low alloys, stainless steel, copper and copper alloys, aluminium and aluminium alloys, nickel and nickel alloys, magnesium and magnesium alloys, titanium and others, can be joined together using gas tungsten arc welding. This procedure is the most thorough. utilised for welding stainless steel and aluminium alloys when weld integrity is crucial. In order to prevent oxidation of the inside weld bead, an inert shielding gas must often be provided inside the pipe for high quality welds.

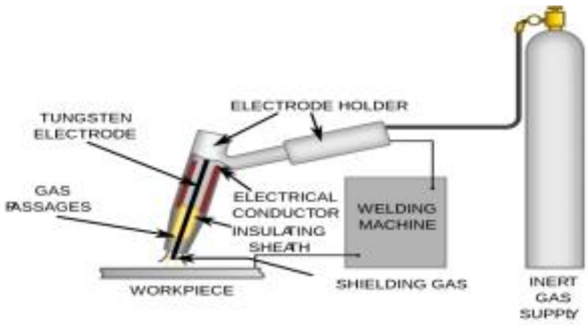

Fig. No.1 Digram of GTAW

The Gas Tungsten Arc Welding (GTAW) Torch, Welding Power Source, Electrodes for GTAW Process, and Inert Gas Cylinder for Gas Tungsten Arc Welding (GTAW) are the four main parts of the process.

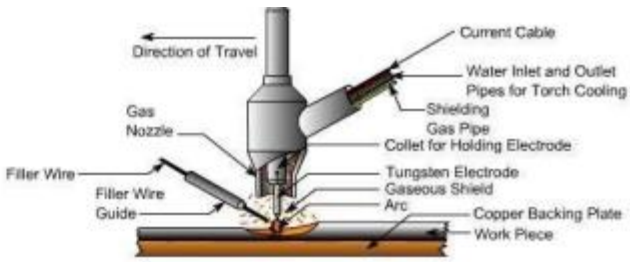

Fig.No.2 GTAW Principle

Gas A non-consumable, non-melting tungsten electrode with a melting temperature of 3410 Celsius is used in tungsten arc welding. Compression and sintering processes used in powder metallurgy are used to create the rods. Tungsten electrodes are categorized according to composition in the following manner.

(a) Pure tungsten electrode

(b) Thoriated tungsten electrode

(c) Ceriated Tungsten Electrode

(d) Lanthanated Tungsten Electrode

(e) Zirconiated Tungsten Electrode

Table No.1 Types of Elecrodes

S.No.	Electrode type	Color coordination	Use and details of electrodes
1	Pure	GREEN	Provides good arc stability for AC welding. Reasonably good resistance to contamination. Lowest current carrying capacity. Least expensive. Maintains a balled end
2	Ceriated Ce02 1.8% to 2.2%	ORANGE	Similar performance to thoriated tungsten. Easy arc starting, good arc stability, long life. Possible replacement for thoriated.
3	Thoriated Th02 1.7% to 2.2%	RED	Easier arc starting. Higher current capacity. Greater arc stability. High resistance to weld pool contamination. Difficult to maintain balled end on AC
4	Lanthanated La203 1.3% to 1.7%	GOLD	Similar performance to thoriated tungsten. Easy arc starting, good arc stability, long life, high current capacity. Possible replacement for thoriated.
5	Zirconiated Zr02 0.15% to 0.40%	BROWN	Excellent for AC welding due to favorable retention of balled end, high resistance to contamination, and good arc starting. Preferred when tungsten contamination of weld is intolerable.

2.`1 Materials used

A good heat conductor is copper. Copper has atomic number 29, atomic mass 63.564, density 8.9 g/cm3, thermal conductivity 4832 W/m*K at 100 o, melting point 1083 oC, and boiling point at 2595 °C. With a face-centered cubic crystalline structure, copper is a reddish metal.

SS304 is an austenitic stainless steel from the T 300 Series. It contains no less than 18% chromium, 8–10% nickel, and no more than 0.08% carbon. It is classified as an austenitic alloy of chromium and nickel. SS304 has a density of 8.03g/cm3, a thermal conductivity of 16.2W/m*K at 100o, and a melting point of 1400ºC.

Copper and stainless steel can be welded with ease if the welding characteristics are understood and the right processes are followed. Although there are other ways to fuse copper and stainless steel 304, the most popular and practical method is a Arc Tungsten Welding. Due to a miscibility gap in the solid state, autogenous welding of these two materials is difficult. The only option left is to perform filler-less autogenous welding with the goal of obtaining a strong weld joint and researching the impact of various welding parameters on dissimilar weld joints of copper and stainless steel 304.

3. Design of Experiment

Models for computer simulations and physical processes can both benefit from experiment design. Simply said, DOE aids in identifying the sensitive components and sensitive regions in designs that lead to yield issues. Designers can then address these issues to create sturdy and higher-quality products. before beginning production, produce designs. The sensitivity to each individual element as well as the combined effect of two or more factors can be estimated using factorial designs. The quadratic connection can be used to express Taguchi's loss function: Where L is the loss related to a certain parameter, and y is the value of the important performance parameter. y, m stands for the nominal parameter value, and k is a constant.

3.1 Experimental Procedure

The validity of proposed process is tested by making a Butt joint as shown in Fig.4

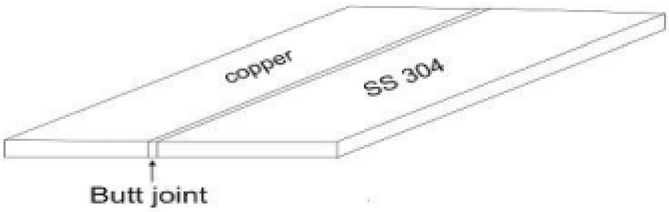

Fig. No.3.1 Butt Joint

Copper and stainless steel plates of thickness 3mm were selected as workpiece material for the present study, chemical composition of base metals are given in Table 2.

Table 2. Chemical composition of base metals (%)

S.No.	Base Metal	C	Si	Cr	Mn	Fe	Ni	Tb	Cu
1	Copper	3.88	0.82	-	-	-	-	-	95.29
2	SS304	0.08	1.34	18.89	1.07	53.54	8.23	18.61	-

Copper and stainless steel plates were cut with dimensions of 150mm×50mmwiththe help of saw machine for welding purpose.

L8 (2n-1, n=4) Orthogonal Array was employed in this experiment's optimisation process. There were four input parameters with low and high levels for each. Every variable was assigned to every orthogonal array column. Welding current, welding speed, torch angle, and gas flow rate were the four input parameters. They each has two levels. In order to investigate the contribution of each parameter using the L8 orthogonal array, eight experiment runs were necessary.

Table 4: Standard Experiment Run of L8 Orthogonal Array

Exp. No.	Welding Current	Welding Speed	Torch Angle	Gas flow rate l/min.
1	1	1	1	1
2	2	1	1	2
3	1	2	1	2
4	2	2	1	1
5	1	1	2	2
6	2	1	2	1
7	1	2	2	1
8	2	2	2	2

Charpy impact test notch specimens were used to assess the impact behaviour of the weld junction. According to ASTMa370-2014 standard, a specimen with dimensions of 100mm 10mm 3mm was cut transverse to the welded joint in order to evaluate the bending strength of the joint.Bend testing is done using the 2T technique. Testing is done on metals to determine their metallurgical characteristics.

4. Results & Discussions

The primary goal of this experimental effort was to assess the characteristics of the autogenous GTAW-welded junction between Copper and SS304 that had different materials. We took into account four factors: welding current, welding speed, torch angle, and gas flow rate. These metrics are used to analyse mechanical qualities such butt joint hardness, impact strength, bend strength, and tensile strength. Table 5 displays the tensile test results.

Table No.-4 Experimental Results for various Runs

Exp. No.	Heat Input kJ/min.	Elongation (%)	Maximum Force (N)	Tensile strength (MPa)
1	10	20	4500	200
2	12	22	4320	190
3	2	23	4600	210
4	4	21	4020	176
5	10	23	4500	192
6	12	23	4080	181
7	2	25	4480	192
8	4	10	4300	194

The Taguchi method is used to analyse the experimental data, and the signal to noise ratio for each response variable under examination is calculated. A signal-to-noise ratio of "larger is better" is selected for tensile strength. It has been demonstrated that current contributes 51.8% of its maximum to the tensile stress. ANOVA analysis of the weld joint strength. It can be assumed that when current level increases, the joint's tensile strength reduces as well.

Table No.-5 Result for ANNOVA

Analysis of Variance					
Source	**DF**	**Adj SS**	**Adj MS**	**F-Value**	**% Contribution**
Welding Current	1	200.615	210.815	8.61	53.8%
Welding Speed	1	54.54	58.584	2.16	12.1%
Torch angle	1	3.167	3.687	0.18	0.74%
Gas flow rate	1	73.725	71.707	3.10	16.7%
Error	3	66.703	20.968		
Total	7	421.404			

5. Conclusion

From the experimental procedure of joining Copper and SS304 using autogenous GTAW process, the following conclusions are drawn:

 Welding current has maximum contribution to tensile strength of weld joint followed by welding speed.

 From the above result it can be conclude that with increase in the level of speed the impact strength of joint decrease as the welding speed is directly proportional to the heat input.

 With the change in cooling rate and solidification sequence of weld pool, the grain size changes, and with the change in the grain size micro hardness number changes.

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