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Parametric Analysis of Welding Parameters on TIG (Tungsten Inert Gas) Welding Dissimilar Materials

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Abstract:The use of TIG Welding to combine dissimilar materials is a new area for weight reduction in power generation, electric, nuclear, petrochemical and chemical industries. A successful weld between dissimilar material is one that is as strong as the weaker of the two metals being joined, i.e., possessing sufficient tensile strength and ductility so that the joint will not fail in the weld. To improve welding quality of dissimilar material, the welding process is performed by different welding parameters, like...Welding speed, welding current, welding voltage. Tensile strength test has done on the weld zone to evaluate the effect of welding parameters on welding quality.

I. Introduction

1.1 Introduction of Welding

Welding is manufacturing process of generating permanent joint of materials obtained by the fusion of the surface of the parts to be joined together with the application of heat and with or without the application of pressure and a filler material weld. The materials joined may be similar or dissimilar each another. The heat supply for the fusion of the material may be obtained by arc or burning of gas.

1.2 Background of Welding

A metal joining process can be traced out in history to the age-old times. In the Bronze Age, nearly 2000 years ago, circular boxes made of gold were welded in lap joint arrangement by applying of pressure. Later on in the Iron Age, Egyptians started welding pieces of iron together. But welding as we know nowadays came into presence only in 19th century.

Vastly Petro v, a Russian scientist, discovered the electric arc in 1802, and advocated its practical applications, including welding. Sir Humphrey Davy used two carbon electrodes and a battery to create an electric arc. Weld materials were then developed using this idea. Finally, in 1885, E lihu Thomson invented resistance welding. Edmund Davy discovered acetylene gas in 1836, but it could not be employed in welding due to a lack of a suitable welding torch. After the invention of the required welding torch in 1900, oxy-acetylene welding quickly became one of the most common forms of welding, owing to its cheaper cost. However, arc welding surpassed it in most industrial applications during the twentieth century.

1.3 Types of Welding Process

There are two types of welding process: (1) Fusion Welding (2) Forged Welding

1.3.1 Fusion Welding

Process of the Fusion Welding that uses heat to join two or more metal by heating them to melting point. This process may or may not require the use of filler material. External application of pressure is not for fusion welding process. According to method of heat generation Fusion Welding may be as:

(1) The rmite Welding process

(2) Gas welding process

(3) Electric Arc Welding process

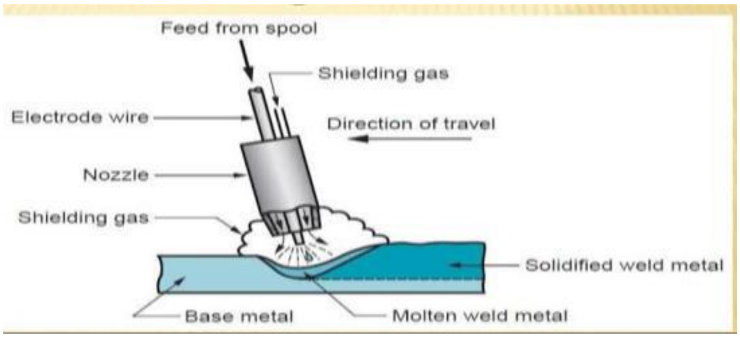


Fig : Fusion Welding

1.3.2 Forge Welding

Forge Welding is hardstaste welding process that joins two pieces of metal by heating t them hammering together. It may also consist of heating and forcing the material together with presses or other means, creating enough pressure to plastic distortion at the weld surface. This process is one of the simplest methods of joining metals and has been used since ancient time. The principle of applying heat and pressure, either simultaneously is widely used in the process known as spot, seam, projection welding.

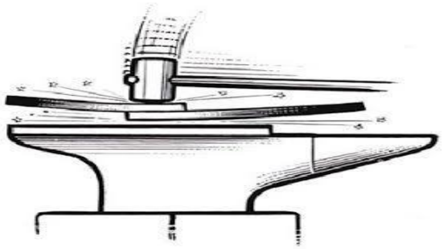


Fig: Forge Welding

1.4 Different types of welding process based on the heat source

The different types of welding process based on the heat source are as follows:

1.4.1 Arc Welding

Arc Welding is a type of welding process that uses an electric arc create heat to melt and join the metals. A power supply creates an electric arc between a consumable and non-consumable electrode and the base material using either AC and DC.

1.4.2 Gas Welding

Gas welding process that melts and joins metals by heating them a flame produced from reaction of fuel gas and oxygen. The most normally used method is Oxyacetylene welding, due to high flame temperature.

1.4.3 Solid State Welding:

Solid State welding is a process in which two work pieces are joint under a pressure providing an intimate contact them and at a temperature essentially below the melting point of base material.

1.4.4 High Energy Beam Welding:

High Energy Beam Welding is a group of welding processes using beams of energy with sufficient density to produce the coalescence of work piece. These processes are applied with or without the application of pressure or with or without the application of filler material.**1.5 Electric Arc Welding**

Arc Welding is a type of welding process that uses an electric arc to create heat to melt and join the metals. A power supply creates an electric arc and non-consumable electrode and the base material using either AC other DC.

1.5.1 How Does it Work?

Arc Welding is one type of Fusion Welding Process used to join a metal. An electric produced from AC or DC power supply creates an extreme heat of around 65000F which melts the metal at the join between doubal work pieces.

The arc can be also manually or mechanically guided the line of the join, while the electrode either simply carries the current or conducts the current and melts in source filler metal to join.

Because of the metal react chemically to oxygen and nitrogen in the air when heated to highTemperature by the arc, a protective shielding gas or slag is used to minimize the contact of the molten metal with air. Once the molten metal is cooled, it is solidified to form a metallurgical bond.

1.5.2 Different Types of Arc Welding

This process can be categorized into two different types of Method: Consumable ElectrodeMethod and Non-Consumable Electrode Method

1.5.2.1 Consumable Electrode Method

In the Expendable Electrode Method and electrodes melt itself during welding and Subsequently deposits on the weld surface. So, electrodes act as a filler metal. Hence, noadditional filler metal is required

The different types of consumable electrode method are following:

(1) Metal Inert Gas Welding & Metal Active Gas Welding
(2) Shielded Metal Arc Welding (SMAW)
(3) Flux Corded Arc Welding (FCAW)
(4) Submerged Arc Welding (SAW)
(5) Electro-Slag Welding (ESW)
(6) Arc Stud Welding (SW)

1.5.2.2 Non-Consumable Electrode Method

In the Non-Consumable Electrode method, electrode does not melt down or deposit on weld surface. It remains intact throughout the welding. Hence, filler material is required to supply separately.

The different types of Non-Consumable Electrode Method are following:

(1) Tungsten Inert Gas Welding (TIG) or Gas Tungsten Arc Welding (GTAW)
(2) Plasma Arc Welding (PAW)

1.6 Dissimilar Welding

The method of uniting materials with various alloys by welding is known as disparate welding. Mild steel and stainless steel, steel and aluminum, for example. This is accomplished by physically fusing the two metals together or inserting the filler metal into the joint until it becomes one solid piece. For the automobile industry, dissimilar lightweight material welding is utilized to join different metals. The melting points of the metals, coefficients of thermal expansion of both metals, electrochemical differences, solubility of each metal, and the end usage of the weld component may all be considered in this welding process.

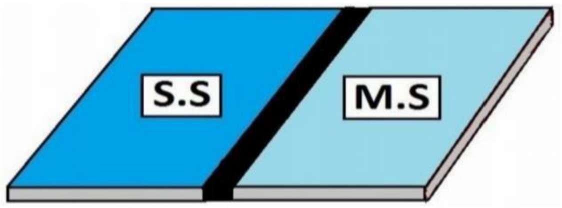


Fig. 4: Dissimilar Material Welding

1.7 Basic mechanism of Tungsten Inert Gas welding:

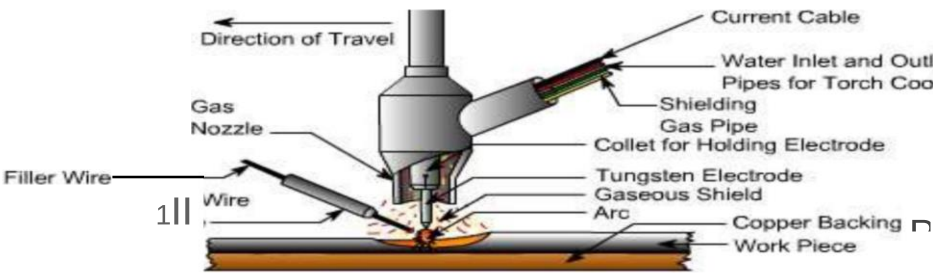


Fig5:SchematicDiagramofTIGWeldingSystem.IRef:l]

Tungsten electrodes are normally available from 0.5 to 6.4 millimeter width and 150 - 200 mm length. The current capacity of each electrode depends on whether it is connected to negative or positive terminal of Direct Current power source.

When the arc length is altered over many millimeters, the power supply necessary to maintain the TIG arc has a drooping or constant current characteristic, which offers an effectively constant current output. As a result, in hand welding, natural fluctuations in arc length have no effect on welding current. When the electrode is short circuited to the work piece, the ability to limit the current to the set value is also critical; otherwise, an extremely high current will flow, destroying the electrode. The open circuit V of the power source is 60 and 80 V.

1.8 Types of welding current used in TIG welding

Direct Current Straight Polarity*:* Direct current is employed in this type of TIG welding. The negative end of the power supply is connected to the tungsten electrode. The most frequent and widely utilized DC welding procedure is this sort of joining. The tungsten will only receive 30% of the welding energy if it is linked to the negative terminal. The resulting weld has a small profile and good penetration.

DCRP: In The positive terminal of the power supply is linked to the tungsten electrode in this sort of TIG welding configuration. Because the tungsten absorbs the majority of the heat, this sort of connection is rarely used because the tungsten can readily overheat and degrade. DCRP has a shallow, wide profile and is typically used on very light materials at low amps.

AC: It is the preferred welding current for white metal ,e.g. aluminum and magnesium. The heat input to the tungsten is averaged out as the AC wave passes from one side of the wave to the other. where the tungsten electrode is positive electrons will flow from base material to tungsten. This will resulting the lifting of any oxide skin on the base material. This side of the waveform is called the cleaning half .As the wave moves to the point where the tungsten electrode become negative thee electrons will flow from the welding tungsten electrode to the base material. This side of the cycle is called the penetrate on half of the AC wave forms.

Alternating Current with Square Wave: With the advent of modem electricity AC welding machines can now be produced with a wave form called Square Wave. The square wave has better control an detach side of the wave can give more cleaning half of the welding cycle and more penetration.

1.9 Process Parameter of TIG Welding

The parameters that affect the quality and outcome of the TIG welding process are given below.

a) Welding Current

Higher current in TIG welding can lead and piece become damage. Again, lower current setting in TIG welding led to sticking of the filler wire. Sometimes larger heat affected area can be found for lower welding current, as high temperatures need to applied for long periods of time to deposit the same amount of filling materials.

b) Welding Voltage

Welding Voltage can be fixed and manually depending on TIG welding equipment. A high voltage allows for easy arc initiation and range of working tip distance. Too high voltage, can lead to large every able in welding quality.

c) Inert Gases:

The welding cost, weld temperature, arc stability, weld speed, splatter, electrode life, and other factors all influence the shielding gas selection. It also has an impact on the completed weld's penetration depth and surface profile, as well as porosity, corrosion resistance, strength, hardness, and brittleness. TIG welding can be done with either Argon or Helium. Pure argon is used to weld exceedingly thin materials. Argon produces an arc that is often smoother and quieter.

When Argon is utilized, arc penetration is lower than when Helium is used. For these reasons, argon is favored in most applications, with the exception of welding metals with high heat conductivity in larger thicknesses, when higher heat and penetration are required. Metals with excellent heat conductivity, such as aluminum and copper, are examples of the type of material for which helium is useful in welding relatively thick portions. Structural steels, low alloyed steels, stainless steels, aluminum, copper, titanium, and magnesium can all be welded using pure argon. Some stainless steels and nickel alloys are welded with an argon hydrogen mixture. Aluminum and copper can both be treated with pure helium. Mixtures of helium and argon can be employed used for low alloy steels, aluminum and copper.

D) Welding speed:

Welding speed is an important parameter for TIG welding. If the welding speed is increased, power or heat input per unit length of weld is decreases, there for weld rein for cement results and penetration of welding decreases. Welding speed or travel speed is primarily control the bead size and penetration of weld. It is interdependent with current.

2. Research Paper Work

After a lot of research in the field of dissimilar welding, several fascinating conclusions regarding the challenges encountered in dissimilar welding have been presented. A lot of academics have investigated parameter optimization of various types of welding for achieving diverse output responses using a variety of materials. For evaluating and producing outcomes, they employ a variety of approaches, strategies, and mathematical models. Many studies have been conducted on various materials in order to get maximal yield and tensile strength.

S. I. Bachani and N. D. Ghetiya (**Multi-objective optimization of process parameter in Activated Tungsten Inert Gas[A-TIG] Welding)**Tungsten Inert Gas welding is a process which is used in those application requiring a high degree of quality and accuracy. However, this welding process has the disadvantage of less productivity. To overcome this disadvantage, Activated Tungsten Inert Gas(A-TIG) welding was developed. In the present work, experiments were performed on 6 mm thick 304L stainless steel plates using A-TIG welding process. TIG welding fixed arc length and different welding speeds. Three different combinations of fluxes like Tio2+, Mno2, SiO2+,TiO2 and Al2O3+ CaO were used to investigate its effect on geometricShape and distortion of well-meant. A-TIG welding process parameters optimization was performed by a multi-objective optimization technique named as Gray Principal component Analysis {G-PCA}. The optimum process parameters were found to be 140 A current, 100 mm/min speed and a mixture of SiO2 and TiO2 flux.

Mamta Kumari, John Deb Barma and Subhash Singh(Parametric Observation of TIG Welding on AISI 304 Stainless Steel of Thickness 5 mm) 5 mm thickness of AISI 304 stainless steel plate was used for welding and the type of welding was selected TIG welding for its various advantages. When multiple process parameters such welding speed, current, and gas pressure were combined in TIG welding, significant changes in the weld zone, Heat Affected Zone, and welding material mechanical properties were observed. To obtain suitable modifications after welding, microstructure measurement and micro hardness testing were done on TIG welding joints. It was also explored the micro structural changes that occurred on the welding zone, and HAZ was found to be evident in every specimen when the input current was high; hardness in the weld zone reduces with increasing current and increases with increasing welding speed. It also observed that gas pressure is also very important parameter to get the better weldment hardness, bead width and DOP increases with the increase of gas pressure and decreases when gas pressure decreases. Key words – Microstructure, Micro hardness, Bead Width, Depth of penetration (DOP)

P Vasantha raja and M V asudevan (Optimization of A-TIG welding process parameters for RAFM steel using response surface methodology) In the present work, the optimization of Activated TIG (A-TIG) welding process parameters can achieve the desired weld bead shape parameters such as depth of penetration and heat-affected zone (HAZ) width have been carried for using response surface methodology. The main problem faced in fabrication of weld joints is the selection of optimum combination of input variables for achieving required quality of welds. This can be solved by development of mathematical model and execution of experiments by RMS. Central composite design of GSM has been used to generate the design matrix for generating data on the influence of A-TIG welding process parameters. The response variables con- side red were depth of penetration, bead width and HAZ width..Keywords: Reduced activation ferrites / martens tic steel, A TIG welding, response surface methodology, central composite design.

Kumar and Sundar rajan Pulsed TIG welding of 2.14 mm AA5456 Al alloy was done with a welding current of 40-90 A and a welding speed of 210-230 mm/min. To improve the mechanical properties of pulsed TIG welding, the Taguchi method was used to optimize the process parameters and regression models were created. All of the welds' microstructures were examined and connected with their mechanical properties. Plan ishing resulted in a 10-15% improvement in mechanical characteristics due to the dispersion of internal stresses in the weld.

M. F. M. Roslan , A. I. M. Shaiful, A.E. Beleed, M. N. B. Omar, S. Illias (V-Groove Shape Effect on Tensile Strength of Metal Inert Gas Aluminum to Steel Welding)study about the impact of groove shape on Metal Inert Gas welding procedure of 6mm thickness A6061 aluminum combination and 304Stainless steel in overlap configuration with welding parameters as; voltage, wire feed rate and shielding gas are17 volts, 2m/min and 15L/min respectively, the experiment was performed in which the aluminum is upper.1-mm diameter of ER4042 filler material and pure argon gas as shielded gas.V-groove shapes in steel samples were made with angle 450. The experiment conducted usingSYNERGIC. PRO2 450-4 machine. Tensile test was carried out for each welded sample Universal Testing Machine of MIG welding processes with and without v-grove in steel side.

In comparison to v-groove samples, the results showed that v-groove specimens have a maximum tensile strength of 26,24 N / mm2. It demonstrates the ability to use a reversed groove angle to mount inert gas / brazing process aluminum to steel and to maximize welding parameters. The least temperature gradient along the steel interface was reported to the smallest variance from top to bottom with IMC (In termetallic Compound Thickness) thicken values in conjunction with the half-V-shaped groove. The highest bonding interface and the correct IMC interface distribution on the steel surface were observed in tensile tests, owing to the remarkable diffusion behavior of filled filler material.

3. Project Work& Method

3.1 Tungsten Inert Gas Welding (TIG) Process

Tungsten Inert Gas welding also known as Gas-tungsten Arc Welding is a type of arc welding that uses heat generated by an electric arc between a non-consumable tungsten electrode and the work piece.The arc zone may be supplied using a filler rod. To prevent air contamination of the molten weld pool, an inert gas barrier (argon or helium) is employed.

3.1.1 A TIG unit consists of:

(I) Power supply; either D.C or A.C. to produce arc.
(ii) A gas supply unit with a flow meter and a pressure gauge.
(iii) A gas regulator and Fitted to the gas cylinder the flow of gas.
(iv) A TIG welding are torch Special type
(v) A non-consumable tungsten electrode with different tip shapes.
(vi) A filler rod is used to supply filler metal to the weld pool.

TIG Welding Working Setup

TIG Electrodes

3.1.2 Parameters affecting to the TIG Welding

TIG welding process is as follows:

- Voltage
- Welding Current
- Welding Speed
- Type of Shielding Gas and flow rate
- Arc Pulsing
- Arc Length

3.2 Considered Parameters

Welding Voltage: 15 to 30 V Range
Welding Current: 100 to 250 Amps Range
Gas Flow Rate: 10 to 25kg/cm2 Range

3.3 Sample Preparation

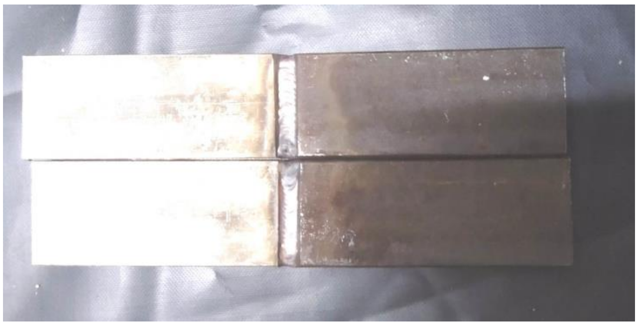
Stainless Steel 304 and Mild steel plates with the dimensions of 100 x40x8 mm are Converted into V Groove shape For Better Penetration.

3.4 Welding Operation

Plates are placed on the workstation after edge preparation. The distance between the nozzle and the work piece, as well as the electrode extension, was 20 and 10 millimeters in each installation.

The welding electrode is held perpendicular to the welding surface. The plates were welded atsingle pass.

3.5 Methodology



4. Tensile Strength Test and Result

4.1 Ultimate Tensile Strength Test

The basic test for determining the yield stress and Ultimate Tensile Strength is carried out by Universal Testing Machine. A universal testing machine (UTM) is a machine that uses tensile, compressive, or transverse stresses to evaluate the mechanical properties (tension, compression, etc.) of a test specimen. UTM can be used to perform various tests like as peel, flexural, tension, bend, friction, and spring tests, among others.

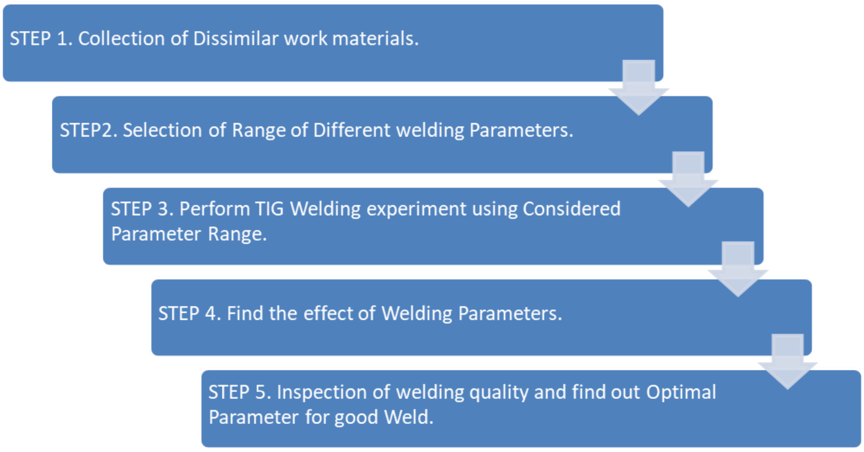


Fig : Universal Testing Machine

Fig: Tested Work Pice

4.2 Result Discussion

After performing experiment in defined path, tensile strength of dissimilar material welding specimen is measured by using universal testing machine.

- Test Specimen 1:

Main effect plot is shown in Figure, which displays effect of load on The input current is 140 A, voltage is 16 V, gas pressure is 1000 psi (constant).

- Test specimen 2:

Main effect plot is shown in Figure, which displays effect of load on The input current is 160 A,voltage is 18 V, gas pressure is 1000 psi (constant).

- Test specimen 3:

Main effect plot is shown in Figure, which displays effect of load on The input current is 170 A, voltage is 20 V, gas pressure is 1000 psi (constant).

- Test specimen 4:

Main effect plot is shown in Figure, which displays effect of load on The input current is 190 A, voltage is 22 V, gas pressure is 1000 psi (constant).

Output Result

Sr. No.	Input Parameters			Output Parameter
	Gas Pressure (psi)	Welding Current (Amp)	Welding Voltage (v)	Tensile Strength (MPa)
1.	1000	140	16	318.95
2.	1000	160	18	331.88
3.	1000	170	20	269.90
4.	1000	190	22	374.33

Table.: Input parameters and output parameter for TIG Welding Operation

The result shows that the increasing the current the tensile strength increasing and more force is required to break the weld. But simultaneously on increasing the current and the tensile strength decreases as can be seen from the main effect graphs and the result values.

• COMPARISSION FOR TIG WELDING TO MIG WELDING DATA

Sr. No.	Input Parameters			Output Parameter
	Gas Pressure (psi)	Welding Current (Amp)	Welding Voltage (v)	Tensile Strength (MPa)
1.	**12**	**160**	**16**	**226.30**
2.	**12**	**170**	**18**	**284.64**
3.	**12**	**180**	**20**	**276.43**
4.	**12**	**190**	**22**	**326.06**

Conclusion

Experiments on ultimate tensile strength with respect to current and voltage variations are carried out in this paper. For each adjustment of input parameter, four experimental readings are recorded, which are utilized to conduct parametric research for optimizing welding process parameters during welding of dissimilar materials.
The ultimate tensile strength is 318.95 MPa when the gas pressure is kept constant at 1000 psi, the current is 140 amperes, and the voltage is 16 volts. The maximal tensile strength incenses significantly 331.88 MPa after increasing the current and voltage to 140-160 ampere and 16-18 volts while maintaining the gas pressure unchanged.
But when we can see that the gas pressure again constant to 1000 psi and kept the current and voltage 160-170ampere and 18-20 volts respectively the ultimate tensile strength decrees (331.88-269.90MPa).
In this experiment tensile strength 374.33 MPa is obtained at experiment no 4 with Current 190 A, Voltage 22 V and Gas pressure 1000 psi While the minimum value of tensile strength 269.90 MPa is obtained at experiment no 3 with Current 170 A, Voltage 20 V and Gas pressure 1000 psi.
In this Experiment the too low and too high voltage and current are rusty the effecting the welding and decrease tensile strength and break down easily.

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