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STUDY OF UNIQUE LIMITATIONS ON GAS TUNGSTEN ARC WELDING

[1]Dr. B. VIJAYA KUMAR, [2]P. SWETHA, [3]K. SANKETH KUMAR, [4]L.MOSES

Department of Mechanical Engineering, Guru Nanak Institute of Technology, Ibrahimpatnam, Ranga Reddy District, Telangana, India.

Abstract - The effects of various parameters (welding current, filler materials and groove design) of tungsten inert gas welding (TIG) and hardness test, tensile strength of welded joint. Weld joint quality is depending on the bead dimensions. Bead dimensions of the welded specimens are mainly dependent on welding current. Two MS plates of thickness(10mm&12mm) and make 65 degrees V-shape joint on the plates. This joint made by TIG welding and argon is used as inert gas for shielding of weld pool. Tensile strength is generally depending on the proper welding and thickness of the plates the tensile and bending strength can be determine by using universal testing machine. This joint is generally use in industrial field such as automotive engineering, biomedical engineering and dairy industry, and chemical engineering So that above-mentioned mechanical properties are require to estimate. Hence in this study, the above parameters of TIG welding for hardness, tensile strength of weld can be determined.

Keywords: Tensile test, hardness test, bend test, weld current, weld speed and weld voltage.

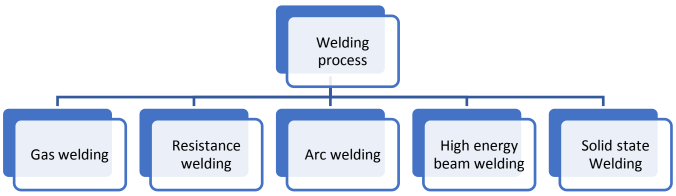
I. INTRODUCTION

Welding: Welding is processes in which two are more parts are joining permanently. The metals are heated to their melting point while being shielded from the air, and then a filler metal is added to the heated area to produce the single piece of metal [1]. This process is used for joining metals using a large variety of application.

Welding process is classified into two types:

- **Fusion Welding:** Fusion welding is a process in which that uses heat to join two or more materials by heating them to a melting point.
- **Solid state welding:** Solid state welding is a process in which two or more workpieces are joined under the pressure providing and contact between them and its temperature is essentially below the melting point of the parent metal.

Classification of welding process:



Arc Welding

In this welding process an electric power supply is produced an arc between electrode and work piece to join the material, so that work piece metals melt at a point of two metals. Welding should be only done by power supply for arc welding process. It may be AC or DC type.

Gas Welding

In this welding process a high temperature flame produced by the combustion of gas and it is used to melt the work pieces to join an external filler material for proper welding.

Resistance Welding

In this welding, heat is generated due to passing of high amount current 1000100000. Although this resistance caused by the contact between two metal surfaces.

High energy Beam welding

In high energy Beam welding a focused energy beam with high intensity such as laser beam or electron beam is used to melt the work piece and join together [2]. These types of welding mainly used for precision welding.

Solid State Welding

In this welding process it does not involve in melting of the work piece of the materials to be joined. Types of solid-state welding are

- Ultrasonic Welding
- Explosion Welding
- Electro Magnetic pulse welding
- Friction Welding
- Friction Stir Welding etc...

Arc Welding: Arc welding is widely used for different types of materials. Types of Arc welding process are

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- Shielded metal arc welding
- Gas metal arc welding
- Gas tungsten arc welding

Shielded Metal Arc Welding (SMAW)

It is the most common type arc welding process; a flux coated consumable electrode is used. As the electrode melts, the flux melts and produces shielding gas that protects the weld area from atmospheric oxygen.

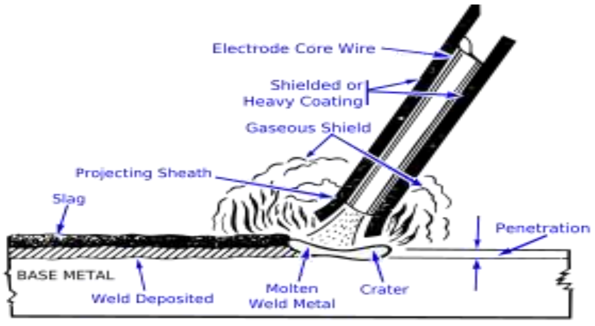

Fig: 1 Shielded Metal Arc Welding

Gas Metal Arc Welding (GMAW)

Metal inert gas or metal active gas welding (MIG/MAG). In this welding process a continuous and consumable wire electrode is used.

Gas Tungsten Arc Welding (GTAW)

It is a welding process in which it uses a consumable tungsten electrode to produce the weld. The weld is protected from atmosphere with a shielding gas generally argon or helium or sometimes mixture of argon and helium [3]. E.g: Aluminium and magnesium.

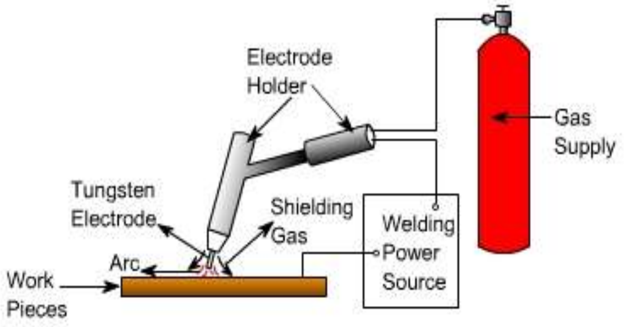

Fig: 2 Schematic Diagram of TIG Welding System.

II. EXPERIMENTAL PROCEDURE

Materials

- In a gas tungsten arc welding MS plates are used for welding.
- Size :150mmx120mmx6mm

Properties for material

Chemical Properties

Chemical Compositions of MS plate

ELEMENTS	PERCENTAGE %
Carbon	0.16 – 0.18
Manganese	0.70 – 0.90
Silicon	0.40
Phosphorus	0.04
Sulphur	0.04
Carbon steel or Mild Steel	0.05 – 0.026

Table: 2.1 Chemical Compositions of MS plate

Mechanical Properties

Mechanical properties of MS Plate

Properties of Mild Steel	Value
Young's modulus	207 GPa
Shear Modulus	80 GPa
Poisson's ratio	0.3
Density	7600 Kg/m^3
Shear Strength	370

Table: 2.2 Mechanical Composition of MS plate

Heat-affected zone

The heat-affected zone (HAZ) is the area of base material, either a metal or a thermo-plastic, which is not melted and has had its microstructure and properties altered by welding or heat intensive cutting operations the heat from the welding process and subsequent re-cooling causes this change from the weld interface to the termination of the sensitizing temperature in the base metal. Arc welding falls between these two extremes, with the individual processes varying somewhat in heat input [5]. To calculate the heat input for arc welding procedures, the following formula is used

$$Q = \frac{V \times I \times 60}{S \times 1000} \times \text{Efficency}$$

Where,
Q=Heat input (kJ/mm)
V=Voltage (V)
I=Current (A)
S= Welding speed (mm/min).

The efficiency is dependent on the welding process used with shielded metal arc welding having a value of 0.75, gas metal arc welding and arc welding is 0.9 and gas tungsten arc welding is 0.8

III. EFFECTS OF PARAMETERS

Weld current: Higher current in TIG Welding can be led to splatter and work piece become damage. Again, lower current setting in TIG Welding leads to sticking of the filler wire sometimes larger heat effect area can be sound for lower welding current, if high temperatures need to apply for longer periods of time to deposit the same amount of filling materials.

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Weld Voltage: Welding voltage can be fixed or adjustable depending on the TIG welding equipment. A high initial voltage allows for easy arc imitation and a greater range on working tip distance [13]. Too high voltage, can leads to large variable in welding quality.

Weld 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, therefore less weld reinforcement result and penetration of welding decreases. Welding speed is primarily controlling the size of bead and penetration. To travel 1mm of weld time required is of 1sec.

Distance between Tungsten Electrode and Work piece: The gap between tungsten and work piece should be maintained at between 1.6 mm to 2.4 mm.

Heat input: Welding heat input calculator formula & step by step calculation to predict how much heat transfer while welding.

H= A x V x 0.06/s. Welding current (A) in Amps, Arc voltage (V) in volts & the welding speed (S) in mm/min are the key elements of this calculation.

a) Formula

The below mathematical formula is used in mechanical engineering to calculate how much heat is used for welding. Besides, the step by step calculation for each calculation performed by using this welding heat input calculator. Let the users to know, how to perform such calculations manually.

Welding Heat Input:
Required Formula

$$H = A \times V \times \frac{0.06}{S}$$

H=Heat input required in ampere volts min/mm
A= welding current A in Amps
V=Arc voltage in volts.
S=welding speed in mm/min.

The field of mechanical engineering, while working with heat transfer, sometimes it is important to analyse welding heat to finish a particular job. The above formula by step calculation may be useful for users to understand how the values are used in the formula to find the heat input, however, when it comes to online for quick calculations.

b) Welding Heat Input Calculation

Fig: 3.1 High current TIG welding

High Current

V-Arc voltage is 60 volts
A-Welding current is 172 amps
S-Welding speed is 120 mm/min
Output:
Heat Input = 5.16 (KJ/mm)
Calculation:
Heat Input (Q) =A x V x 0.06/S
=172 x 60 x 0.06/120
=5.16 KJ/mm.

Fig: 3.2 Low current TIG welding

Low current

V-Arc voltage is 60 volts
A-Welding current is 117 amps
S-Welding speed is 120 mm/min
Output:
Heat Input =3.51 KJ/mm.
Calculation:
Heat Input (Q) =A x V x 0.06/S
=117 x 60 x 0.06/120
=3.51 KJ/mm.

IV. TESTING OF WELD JOINTS

Destructive test: Weld joints are generally subjected to destructive tests. Toughness, bend and tensile test for developing the welding procedure specification and assessing the suitability of weld joint for particular application Visual inspection reflects the quality of external features of a weld joint such as weld bead profile indicating weld width and reinforcement, bed angle and external defects such an craters crack, distortion etc [6].

Universal testing machine: A universal testing machine (UTM) is also known as universal tester material testing machine or materials test frame. It is used to test the tensile strength and compressive strength of materials the "universal" part of the name reflects that it can perform many standard tensile and compression tests on materials components and structures in other words, that it is versatile.

The set-up and usage are detailed in a test method, often published by a standards organization. This specifies the

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sample preparation, fixturing, gauge length (the length which is under study or observation) analysis etc.

Fig: 4.1Universal testing machine

Tensile test: Tensile properties of the weld joints namely yield and ultimate strength and ductility (% age elongation, % age reduction in area) can be obtained either in ambient condition or in special environment (low temperature, high temperature, corrosion)[7]. Depending upon the requirement of the application, using tensile test, this is usually conducted at constant strain rate (ranging from 0.0001 to10000 mm/min). Tensile properties of the weld joint are obtained in two ways a) Taking specimen from transverse direction of weld joint consisting base metal-heat affected zone-weld metal-heat affected zone-base metal and b) All weld metal specimen as shown in Fig.

Fig: 4.2 Schematic of tensile specimen transverse section of weld joints

Fig: 4.3 Schematic of tensile weld metal specimen

Tensile test results must be supported by respective engineering stress and strain diagram indicating modulus of elasticity, elongation at fracture, yield and ultimate strength. Tests results must include information on following point about test conditions.

Hardness test: Hardness is defined as resistance to indentation and is commonly used as a measure of resistance to abrasion or scratching. For the formation of a scratch it causing abrasion, a relative movement is required between two bodies and out of two, one body must penetrate/indent into other body [8].

Various methods of hardness testing can be compared on the basis of following three criteria 1) Type of indenter, 2) magnitude of load and 3) measurement of indentation.

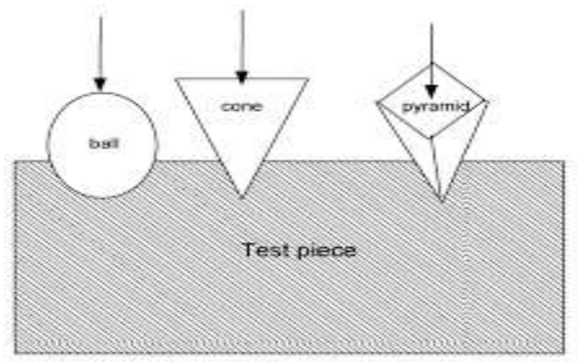

Fig: Schematic diagram showing different indenters.

Steel ball of different diameters (D) is used as an indenter in leab hardness test. Diameter of indentation (d) is measured to calculate the projected area and determine the hardness of the plate.

Leab hardness test: Leab hardness test is a method of measuring the hardness of a material by pressing a chromium steel or tungsten carbide ball (commonly one cm or 0.4 inch in diameter) against the smooth material surface under standard test conditions (generally between 300 to 3000 kilo grams of force for 5 to 30sec). The hardness is expressed in Leab hardness member (BHN) computed by dividing the load in kilo grams by the area of indentation made by the ball measured in square mm.

Bending test: Bend test is one of the most important and commonly used destructive tests to determine the ductility and soundness (for the presence porosity, inclusion penetration and other macro-size internal weld discontinuities) of weld joint produced using less than one set of welding conditions.

V. RESULT AND DISCUSSION

Tensile strength: The results obtained from tensile test are shown in table. It was observed that the joint bore, the force up to 35KN (low current) and 50KN (high current) before finally undergoing fracture.

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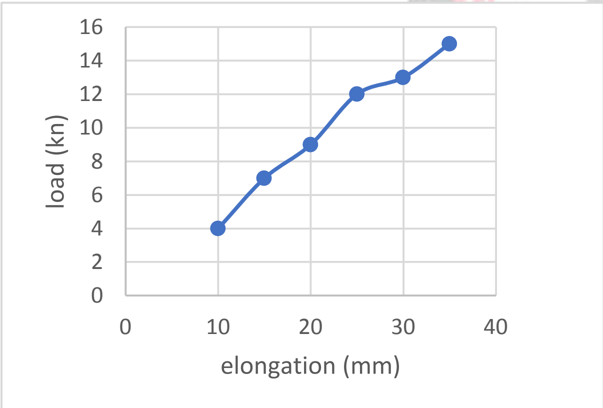
Low Current

Sl. No	Load	Elongation
1	5kn	2mm
2	10kn	4mm
3	15kn	7mm
4	20kn	9mm
5	25kn	12mm
6	30kn	13mm
7	35kn	15mm

Table: 5.1 Tensile tests using low current

Fig. 5.1 Specimen after Tensile Test using low curre



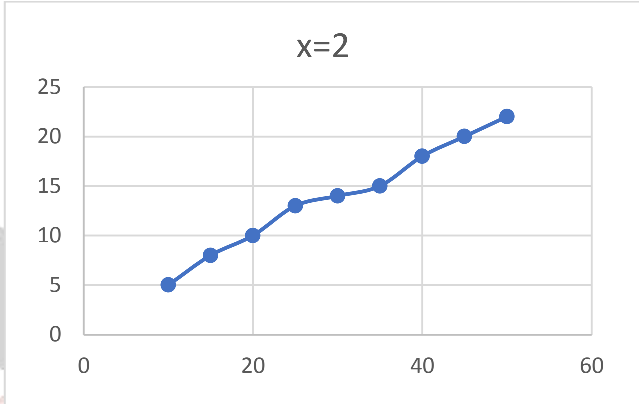
Graph 5.1 Low current tensile tests

High Current

Sl. no	Load	Elongation
1	5	2.5 mm
2	10	5 mm
3	15	8 mm
4	20	10.5 mm
5	25	13 mm
6	30	14.9 mm
7	35	15 mm
8	40	18 mm
9	45	20.5 mm
10	50	22 mm

Table: 5.2 Tensile tests using high current

Fig: 5.2 Specimen of tensile test using high current



Graph: 5.2 High current tensile tests

Hardness test: The result obtained from hardness test performed on leab hardness testing machine are as follow. The following table shows the indentation obtained from the test.

High current

Sl.no	Parent Material-1	HAZ-1	On weld	HAZ-2	Parent material-2
1	112HB	97HB	198HB	96HB	112HB
2	95HB	111HB	207HB	106HB	115HB
3	103HB	103HB	188HB	105HB	114HB

Table: 5.3 Result obtained from hardness test of low current

Low current

Sl.no	Parent Material-1	HAZ-1	On weld	HAZ-2	Parent material-2
1	100 HB	90 HB	94 HB	101HB	92 HB
2	94 HB	97 HB	87 HB	99 HB	107 HB
3	97 HB	90 HB	115HB	112 HB	104 HB

Table: 5.4 Result obtained from hardness test of high current

Bending test: The results obtained in bending test are shown in table. From bending test bending moment and inertia is calculated.

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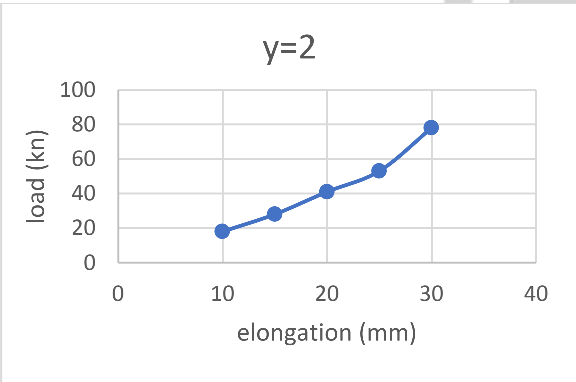
Low Current

Sl. no	Load	Elongation
1	5	2 mm
2	10	18 mm
3	15	28 mm
4	20	41 mm
5	25	53 mm
6	30	78 mm

Table: 5.5 Bend test using low current

Fig: 5.3 Specimen after Bend test using low current



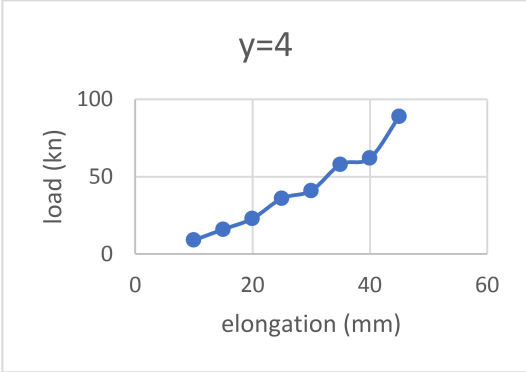
Graph 5.3 Low current bending tests

High Current:

Sl. no	Load	Elongation
1	5kn	4mm
2	10kn	9mm
3	15kn	16mm
4	20kn	23mm
5	25kn	36mm
6	30kn	41mm
7	35kn	58mm
8	40kn	62mm
9	45kn	89mm

Table: 5.6 Bend test using high current

Fig: 5.4 Bending test of ms plate using high current



Graph: 5.4 High current bending test

High current

Load (P) =45 KN

Deflection =25mm

Length (L) =89 mm

Thickness =6 mm

Under three-point bending in figure a) when the load P is applied at the mid span of a rectangular bar of a length L between the two rollers, the highest bending moment at the mid span is Bending moment (M) =PL/4

$$(M) = \frac{45 \times 1000 \times 89}{4}$$

=1001250 N-m

=1001.25 N-mm

$$(I) = \frac{2{\times}6{\times}3{\times}3{\times}3}{3} = 108$$

Low current

Load (P) =30 KN

Deflection 25 mm

Length (L) =78 mm

Thickness =6 mm

$$(M) = \frac{30 \times 1000 \times 78}{4}$$

=585000 N-m

=585 N-mm

$$(I) = \frac{2 \times 6 \times 3 \times 3 \times 3}{3}$$

=108

VI. Conclusion

In TIG welding process joining of two similar thickness plates (MS plates) is possible by using copper coated mild steel filler rod. On this joint we can perform several testing's like destructive testing. Welding strength or tensile strength of the weld joint depends on the welding parameters like welding speed and welding current with the increase in current, tensile strength of the weld joint increases. Similarly with the decrease in current, tensile strength of the weld decreases. Hardness value of the weld zone change with the distance from weld centre due to change of microstructure at lower welding speeds strength is more due to more intensity of current for both side welding tensile strength is found almost equivalent to the strength of base material for both sided welding performed

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with high current, welding speed have no specific effect on tensile strength of the weld joint.

FUTURE SCOPE

In present work welding is performed without any filler material. A filler rod/wire feeding system can be included in the system so that by using filler rod/wire thicker plate can be welded. Welding setup can also be used for welding of some other materials.

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