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Effect of Welding Speed on the Mechanical Properties of TIG Welded Aluminium Alloy's

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ABSTRACT

Tungsten Inert Gas welding is one of the widely used techniques for joining ferrous and non ferrous metals. TIG welding process offers several advantages like joining of unlike metals, low heat effected zone, absence of slag etc compared to MIG welding. The accuracy and quality of welded joints largely depends upon type of power supply (DCSP or DCRP or ACHF), welding speed, type of inert gas used for shielding. This paper deals with the investigation of effect of welding speed on the tensile strength of the welded joint. Experiments are conducted on specimens of single v butt joint having different bevel angle and bevel heights. The material selected for preparing the test specimen is Aluminium AA6351 Alloy. The strength of the welded joint is tested by a universal tensile testing machine and the results are evaluated. (

Keyword: - TIG welding, GTAW welding, V butt welds, Welding Speed, Tensile Strength

1. INTRODUCTION

Welding is one of the most important and versatile means of fabrication available to industry. Welding is used to join hundreds of different commercial alloys in many different shapes. Actually, many products could not even be made without the use of welding, for example, guided missiles, nuclear power plants, jet aircraft, pressure vessels, chemical processing equipment, transportation vehicle and literally thousands of others. Many of the problems that are inherent to welding can be avoided by proper consideration of the particular characteristics and requirements of the process. Proper design of the joint is critical. Selection of the specific process requires an understanding of the large number of available options, the variety of possible joint configurations, and the numerous variables that must be specified for each operation. If the potential benefits of welding are to be obtained and harmful side effects are to be avoided, proper consideration should be given to the selection of the process and the design of the joint. Generally, the quality of a weld joint is strongly influenced by process parameters during the welding process. In order to achieve high quality welds a good selection of the process variables should be utilized, which in turn results in optimizing the bead geometry. In this study an attempt is made to investigate the effect of welding speed and joint design parameters on tensile strength of the welded joint. With this objective, several test specimens were welded with varying welding speed (by using adjustable speed motor) and variety of possible joint configurations (bevel angel and bevel height). Results of these studies indicated that numerous process variables of GTAW and variety of possible joint configuration have profound effect on tensile strength of the weld joint.

2.TIG WELDING

TIG welding (Tungsten inert gas welding) is also called as gas Tungsten Arc Welding (GTAW) uses a non consumable electrode and a separate filler metal with an inert shielding gas. GTAW process welding set utilizes suitable power sources, a cylinder of Argon gas, welding torch having connections of cable for current supply, tubing for shielding gas supply and tubing water for cooling the torch. The shape of the torch is characteristic, having a cap at the back end to protect the rather long tungsten electrode against accidental breakage.

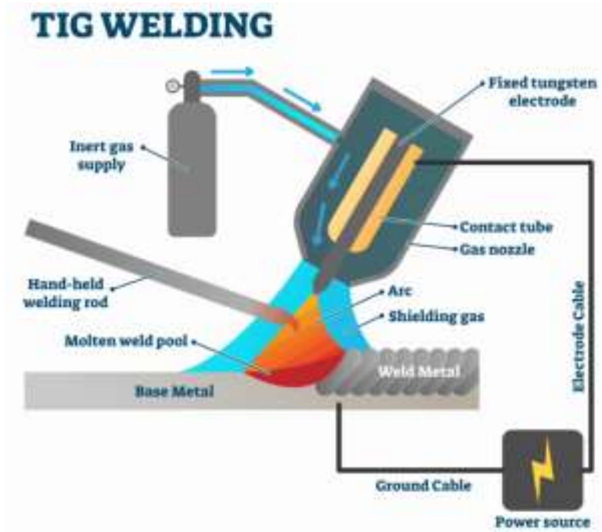


Figure 1: Tungsten Inert Gas Welding Process

2.1 Power Sources for TIG Welding

Power sources for use with TIG welding must be capable of delivering a constant current at a preset value. They are often called "drooping characteristic" units. Rectifier units are commonly used for Dc welding although motor generators may be more suitable for site use. Combined ac/dc power sources can be used where there is a mix of work.

2.2 Electrodes for TIG Welding

Pure tungsten electrodes can be used for TIG welding. Thoriated and zirconiated types give easier starting and better arc stability and are generally preferred. Thoriated tungsten electrodes contain 2% thoria (thorium oxide) and are used for dc welding. Zirconiated tungsten electrodes contain 2% zirconia (zirconium oxide) and are recommended for ac welding of aluminium. The diameter of the electrode is chosen to match the current. The minimum current depends on arc stability. The maximum current a given diameter of electrode can carry is determined by the onset of overheating and melting.

2.3 Shielding Gases for TIG Welding · Pure argon Suitable for all metals. · Alumaxx Plus. An argonhelium mixture which allows faster welding and deeper penetration on aluminium and its alloys and copper and its alloys. · Inomaxx TIG. An argon helium hydrogen mixture which gives lower ozone emissions, less surface oxidation, improves the weld profile, welding speed and penetration on stainless steel, cupro-nickel and nickel alloys.

2.4 Process Variables in TIG Welding

The following are some of the variables that affect weld penetration, bead geometry and overall weld quality:
(1) Welding current
(2) Polarity (DCSP/DCRP)
(3) Arc voltage (arc length)
(4) Travel speed (5) Weld joint position
(6) Electrode diameter
(7) Shielding gas composition and flow rate

Knowledge and control of these variables is essential to consistently produce welds of satisfactory quality. These variables are not completely independent, and changing one generally requires changing one or more of the others to produce the desired results.

3. Experimental Procedure

3.1 Materials Used

Chemical composition of the base metals, filler metal and shielding gas used in the experiments is given below. **3.1.1 Base metal dimensions**: 4x50x200 mm

3.1.2 Chemical Composition The chemical composition of Aluminium AA6351 is given in Table

Element	Weight %
Al 97.8	Al 97.8
Si	1.0
Mn	0.6
Mg	0.6

Table 1: Composition of Aluminium AA6351

3.1.1 Filler metal

The chemical composition of filler metal (Aluminium 6063) is given in Table

Element	Weight %
Al	97.9
Si	0.6
Cu	0.28
Mg	1.0
Cr	0.2

Table 2: Composition of Aluminium 6063

2.1.4 Shielding Gas

A shielding gas mixture, M21 is selected for the experiments. It contains 18% CO_2 and 82% Argon.

2.1.5 Experimental Set-up

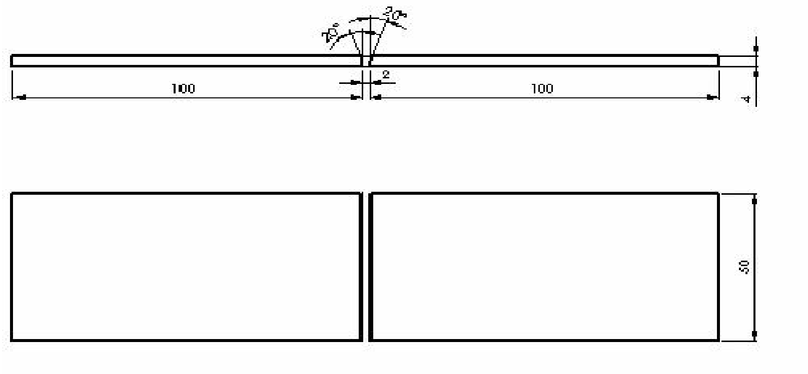
The set-up used during the experiments includes shielding gas regulator, welding machine and a Quicky motor which carries and guides the welding gun and travels with the desired constant speeds along the plates to be welded. The motorized unit of the Quicky motor has an adjustable speed setting ranging from 1 to 10. The calibration of the speed settings was done over 20 cm and converted into corresponding welding speeds. Table 3.4 shows the motor calibration values.

Motor welding speed setting	2	4	6	8
Corresponding welding speed (cm/sec)	0.3	0.6	0.9	1.2

Table 3: Motor calibration values

2.1.6 Sample preparation

Aluminum AA6351 alloy plates with the dimensions of 4x50x200 are prepared with the bevel heights of 1, 1.5, 2, 2.5 millimeters, bevel angle of 30^0, 40^0 50^0, 60^0. These specimens are then welded with a root gap distance 1 millimeter. Figure shows the single V-groove butt joint preparations.



After preparation, plates are placed on the workbench. In each placement, distance between the nozzle and workpiece and the electrode extension were 20 and 10 millimeter, respectively. The welding electrode is held perpendicular to the welding surface. Welding is started and the flow rate of shielding gas is adjusted to 10 lit/sec. The plates were welded at single pass. By changing the weld speeds to 0.3, 0.6, 0.9, 1.2 cm/sec all the samples are welded by keeping the other parameters constant.

Workpiece no	Welding Speed (cm/sec)	Bevel angle (degrees)	Bevel height (millimeter)
1	0.3	30	1
2	0.3	40	1.5
3	0.3	50	2
4	0.3	60	2.5

Table 4: Weld joint dimensions at welding speed 0.3cm/sec

Workpiece No	Welding Speed (cm/sec)	Bevel angle (degrees)	Bevel height (millimeter)
1	0.6	30	1
2	0.6	40	1.5
3	0.6	50	2
4	0.6	60	2.5

Table 5: Weld joint dimensions at welding speed 0.6cm/sec

Workpiece No	Welding Speed (cm/sec)	Bevel angle (degrees)	Bevel height (millimeter)
1	0.9	30	1
2	0.9	40	1.5
3	0.9	50	2
4	0.9	60	2.5

Table 6: Weld joint dimensions at welding speed 0.9cm/sec

Workpiece No	Welding Speed (cm/sec)	Bevel angle (degrees)	Bevel height (millimeter)
1	1.2	30	1
2	1.2	40	1.5
3	1.2	50	2
4	1.2	60	2.5

Table 7: Weld joint dimensions at welding speed 1.2cm/sec

3.Tensile Testing

The ultimate tensile strength of the machined specimens is measured in a calibrated Universal tensile testing machine which has a capacity of 60 tons. Tensile test was carried out according to the ASTM standards. Figure shows the test specimen

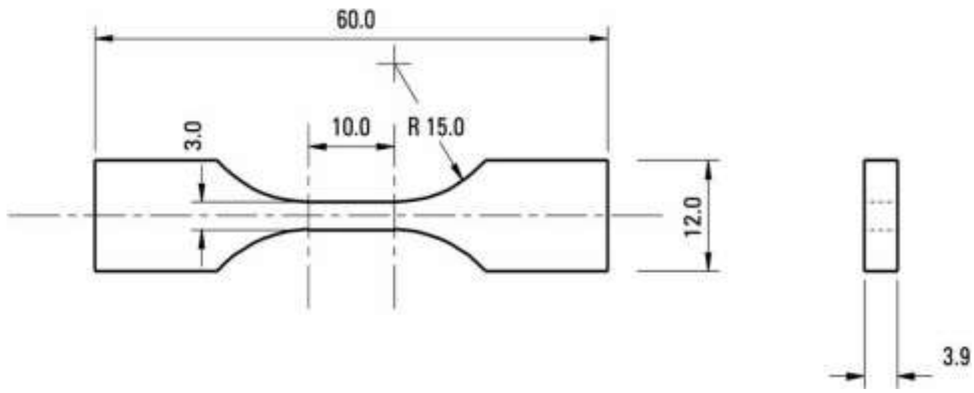


Figure 3: Tensile testing welded specimen

3.1Results and Discussions

3.1.1Tensile Testing Results

The results of tensile testing performed on welded specimens are tabulated below

	Ultimate Tensile strength (Mpa)	% Elongation
Weld metal	78 - 232	09
Unwelded specimen	250	20

Table 8: Tensile strength and % Elongation

The prepared specimens were welded successfully at welding speeds of 0.3, 0.6 0.9 1.2 cm/sec. Some interesting developments in tensile strength have been found to occur in the weldments. The tensile testing of the weld is influenced by the weld joint design bevel angle and bevel height. The effects of welding torch speeds towards the tensile testing of the joint were investigated. The results of the tests are shown in graphs below for the specimen prepared using TIG welded joints obtained at the four different welding speeds is mentioned below.

Workpiece no	Welding Speed (cm/sec)	Bevel angle (degrees)	Bevel height (millimeter)	Tensile strength (Mpa)
1	0.3	30	1	199
2	0.3	40	1.5	230
3	0.3	50	2	215
4	0.3	60	2.5	180
Base	Metal			**250**

Table 9: Tensile strength at weld speed 0.3 cm/sec

Workpiece no	Welding Speed (cm/sec)	Bevel angle (degrees)	Bevel height (millimeter)	Tensile strength (Mpa)
1	0.6	30	1	225
2	0.6	40	1.5	232
3	0.6	50	2	230
4	0.6	60	2.5	190
Base	Metal			**250**

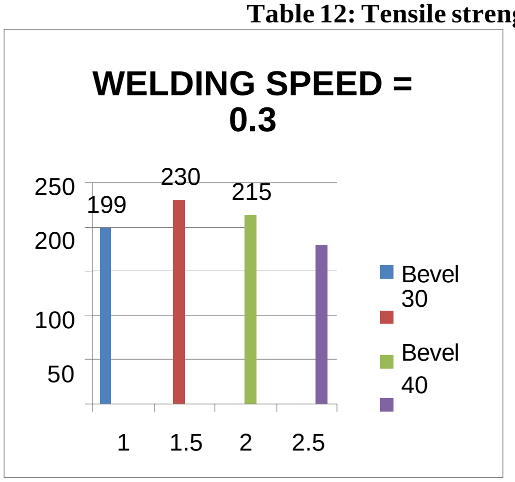
Table 10: Tensile strength at weld speed 0.6 cm/sec

Workpiece no	Welding Speed (cm/sec)	Bevel angle (degrees)	Bevel height (millimeter)	Tensile strength (Mpa)
1	0.9	30	1	195
2	0.9	40	1.5	220
3	0.9	50	2	225
4	0.9	60	2.5	160
Base	Metal			**250**

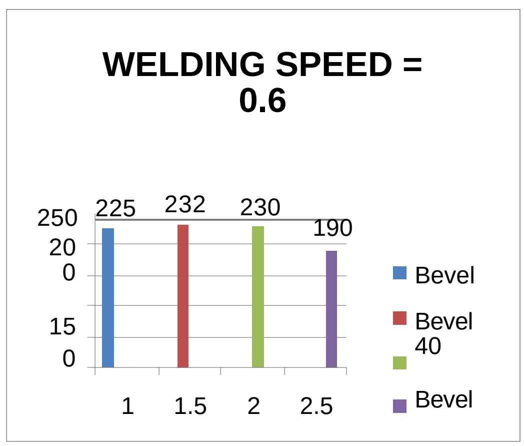
Table 11: Tensile strength at weld speed 0.9 cm/sec

Workpiece no	Welding Speed (cm/sec)	Bevel angle (degrees)	Bevel height (millimeter)	Tensile strength (Mpa)
1	1.2	30	1	180
2	1.2	40	1.5	185
3	1.2	50	2	182
4	1.2	60	2.5	178
Base	Metal			**250**

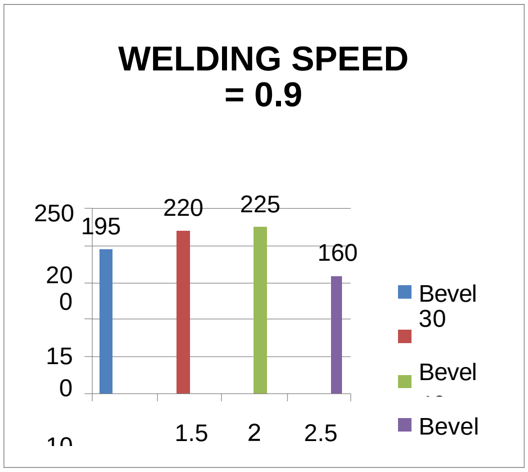
Table 12: Tensile strength at weld speed 1.2 cm/sec

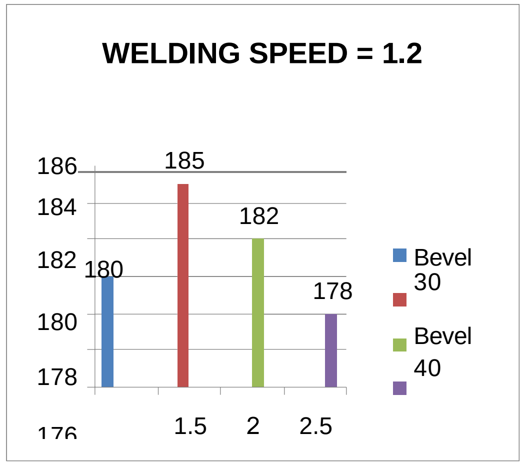


Graph 1: Tensile strength at welding speed 0.3cm/sec



Graph 2: Tensile strength at welding speed 0.6cm/sec





Graph 3: Tensile strength at welding speed 0.6cm/sec

Graph 4: Tensile strength at welding speed 1.2cm/sec

From the above graphs it can be observed that there are no significant changes in the tensile strengthof the weldment at welding speed of 0.3 cm/sec. However there is a sudden decrease in the strength at welding speed of 1.2 cm/sec due to insufficient weld bead penetration into the root gap of the weldment. There is an almost linear correlation with bevel heights (1, 1.5, 2 and 2.5 millimeters, respectively) and welding speed (and amount of penetration as observed during the experiments)

Conclusions

1. The depth of penetration of weld bead decreases with increase in bevel height of V butt joint.
2. Maximum Tensile strength of 230 Mpa was observed at weld speed of 0.6 cm/sec (for 40^0 bevel and 1.5 bevel height). This indicates the strength of the weldment is weaker than the base metal.
3. Tensile strength is higher with lower weld speed. This indicates that lower range of weld speed is suitable for achieving maximum tensile strength.
4. Bevel angle of the weld joint has profound effect on the tensile strength of weldment**.** Bevel angles between 30^0 to 45^0 are suitable for maximum strength.

5. The heat affected zone, strength increased with decreasing heat input rate.

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