# Experimental Studies on Distortions Produced By Tig Welding of Mild Steel and Aluminium Plates

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**Abstract- Welding is a reliable and efficient joining process in which the coalescence of metals is achieved by fusion and is used extensively in fabrication of many structures like marine industries, buildings, pressure vessels, aerospace industries etc. It has so many advantages over the other fabrication processes. However, distortion is a problem facing during welding by non uniform heating and unequal cooling of metals. Correcting unacceptable weld distortion is extremely costly and in some situations impossible. Thus, the development of proper techniques for reducing and controlling distortion would lead to more reliable welded structures. The present work was proposed to carry out experimental work to study distortion like angular distortion in the welded joints due to the heat input for different butt joints using TIG welding process. The different butt joints used in this process are single V groove butt joints and double V groove butt joints. The distortions of mild steel and aluminum with single V groove and double V groove are compared. From the experiment results obtained we can see that aluminum undergoes more distortion when compared to mild steel. The angular distortion is more in single V groove when compared to double V groove butt welded joints.**
**Keywords –TIG Welding, Angular distortion, Mild steel plates, Aluminum plates, Design criteria**

## I. INTRODUCTION

Welding is fabrication or sculptural process that joins materials, usually metals or thermoplastics, by using high heat to melt the parts together and allowing them to cool causing fusion. Welding is distinct from lower temperature metal-joining techniques such as brazing and soldering, which do not melt the base metal.

In addition to melting the base metal, a filler material is typically added to the joint to form a pool of molten material (the weld pool) that cools to form a joint that, based on weld configuration (butt, full penetration, fillet etc.), can be stronger than the base material (parent metal). Pressure may also be used in conjunction with heat, or by itself, to produce a weld. Welding also requires a form of shield to protect the filler metals or melted metals from being contaminated or oxidized.

Many different energy sources can be used for welding, including a gas flame (chemical), an electric arc (electrical), a laser, an electron beam, friction, and ultrasound. While often an industrial process, welding may be performed in many different environments, including in open air, under water, and in outer space. Welding is a hazardous undertaking and precautions are required to avoid burns, electric shock, vision damage, inhalation of poisonous gases and fumes, and exposure to intense ultraviolet radiation.

Until the end of the 19th century, the only welding process was forge welding, which blacksmiths had used to join iron and steel by heating and hammering. Oxy-fuel welding were among the first processes to develop late in the century, and electric resistance welding followed soon after. One of the most popular welding methods, as well as semi-automatic and automatic processes such as gas metal arc welding, submerged arc welding, flux-cored arc welding and electro slag. Developments continued with the invention of laser beam welding, electron beam welding, magnetic pulse welding, and friction stir welding in the latter half of the century. Today, the science continues to advance to Robot welding is common place in industrial settings, and researchers continue to develop new welding methods and gain greater understanding of weld quality.

It is attempted to explore the possibility for welding of higher thickness plates by TIG welding. Al plates (10mm thickness) were welded by pulsed tungsten inert gas welding process with welding current in the range 48-112 A and gas flow rate 7 – 15 l/min. shear strength of the weld metal (73MPa) was found less than parent metal (85MPa). From the analysis of photomicrograph of welded specimen it has been found that, weld deposits are form co-axial micro-structure towards the fusion line and tensile fracture occur near to fusion line of weld deposit did the experiments by Sanjeev Kumar et.al [1].The investigated mechanical properties of the weldments of AA635 during the GTAW/TIG welding with non-pulsed and pulsed current at different frequencies. Welding was performed with current 70-74 A, arc travel speed 700 -760 mm/min, and pulse frequency 3 and 7 Hz. From the experimental results it was concluded that the tensile strength and YS of the weldments is closer to the base metal. Failure location of weldments is occurred at HAZ by the research made by Indira Rani et.al[2] The effect of the tensile strength of the welded joint by TIG welding process of AA6351 aluminum alloy and mild steel of 10mm thickness investigated by.

Ahmed Khalid Hussain et.al [3]. They found that the strength of the welded joint was tested by a universal tensile testing machine. Welding was done on specimens of single V and double V butt joints with welding speed of 1800 – 7200 mm/min. from the experimental results it was revealed that strength of the weld zone is less than base metal and tensile strength increases with reduction of welding speed.

The effect of activated TIG process on weld morphology, angular distortion, delta ferrite content and hardness of 316 L stainless steel by using different flux like $TiO_2$ , $MoO_2$ , $MoO_3$ , $SiO_2$ and $AlO_3$ . To join 6mm thick plate author uses welding current 200 Amp , welding speed 150 mm/min and gas flow rate 10 l/min. from the experimental results it was found that the use of $SiO_2$ flux improve the joint penetration , but $Al_2\,0_3$ flux deteriorate the weld depth and bead width compared with conventional TIG process investigated by .Tseng et.al[4] .

*1.1. Basic mechanism of TIG welding*

TIG welding is an arc welding process that uses a non-consumable tungsten electrode to produce the weld. The weld area is protected from atmosphere by an inert shielding gas (argon or helium), and a filler metal is normally used. The power is supplied from the power source (rectifier), through a hand-piece or welding torch and is delivered to a tungsten electrode which is fitted into the hand piece. An electric arc is then created between the tungsten electrode and the work piece using a constant- current welding power supply that produces energy and conducted across the arc through a column of highly ionized gas and metal vapours. The tungsten electrode and the welding zone are protected from the surrounding air by inert gas. The electric arc can produce temperatures of up to 20,000°C and this heat can be focused to melt and join two different part of material. The weld pool can be used to join the base metal with or without filler material. Schematic diagram of TIG welding and mechanism of TIG welding are shown in fig.1 and fig.2respectively.

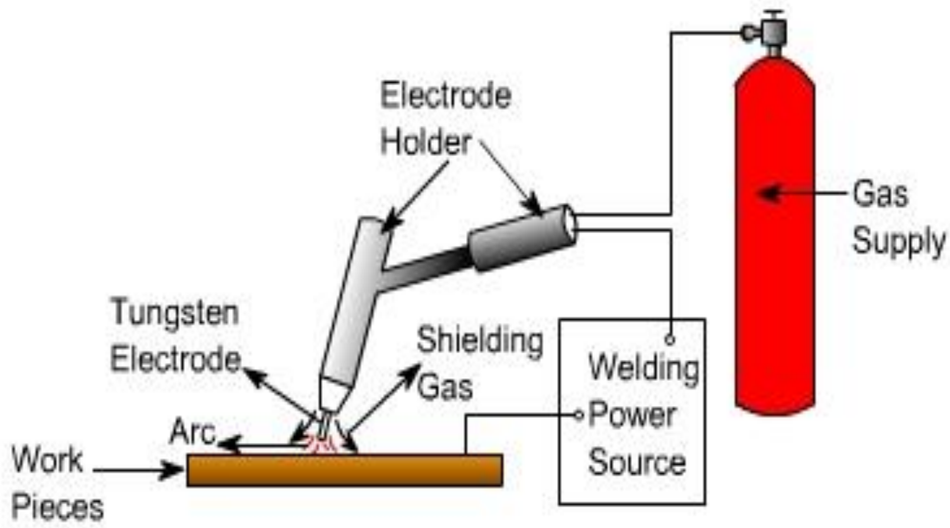


Fig.1: Schematic diagram of TIG welding system

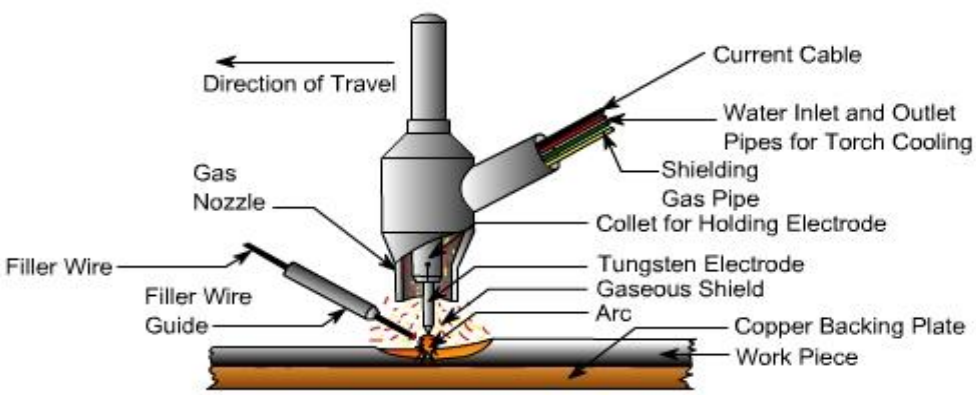


Fig.2: principle of TIG welding

Tungsten electrodes are commonly available from 0.5mm to 6.4mm diameter and 150 – 200 mm length. The current carrying capacity of each size of electrode depends on whether it is connected to negative or positive terminal of DC power source. The power source required to maintain the TIG arc has a dropping or constant current characteristic which provides an essentially constant current output when the arc length is varied over several millimeters. Hence, the natural variations in the arc length which occur in manual welding have little effect on welding current. The capacity to limit the current to the set value is equally crucial when the electrode is short circuited to the work piece, otherwise excessively high current will flow, damaging the electrode. Open circuit voltage of power source ranges 60 to 80 V.

*1.2. Advantages of TIG welding*

TIG welding process has specific advantages over other arc welding process as follows

Narrow concentrated arc.

Able to weld ferrous and non- ferrous metals.

Does not use flux or leave any slag (shielding gas is used to protect the weld-pool and tungsten electrode).

No spatter and fumes during the TIG welding.

*1.3. Applications of TIG welding*

The TIG welding process is best suited for metal plate of thickness around 5 – 10 mm. thicker material plate can also be welded by TIG using multi passes which results in high heat inputs, and leading to distortion and reduction in mechanical properties of the base metal. In TIG welding high quality welds can be achieved due to high degree of control in heat input and filler additions separately. TIG welding can be performed in all positions and the process is useful for tube and pipe joint. The TIG welding is a highly controllable and clean process needs very little finishing or sometimes no finishing. This welding process can be used for both manual and automatic operations. The TIG welding process is extensively used in the so-called high -tech industry applications such as

Nuclear industry.

Aircraft.

Food processing industry.

Maintenance and repair work.

Precision manufacturing industry.

Automobile industry.

*1.4. Process parameters of TIG welding*

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

Welding current

Higher current in TIG welding can lead to spatter and work piece become damages. Again lower current setting in TIG welding lead 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 longer periods of time to deposit the same amount of filling materials. Fixed current will vary the voltage in order to maintain a constant arc current.

Welding voltage

Welding voltage can be fixed or adjustable depending on the TIG welding equipment. A high initial voltage allows for easy arc initiation and a greater range of working tip distance. Too high voltage can lead to large variable in welding quality.

Inert gases:

The choice of shielding gas is depending on the working metals and effects on the welding cost, weld temperature, arc stability, weld speed, argon or helium may be used successfully for TIG welding applications. For welding of extremely thin material pure argon is used. Argon generally provides an arc which operates more smoothly and quietly. Penetration of arc is less when argon is used than the arc obtained by the use of helium. For these reasons argon is preferred for most of the applications, except where higher heat and penetration is required for the welding metals of high heat conductivity in larger thicknesses. Aluminum and copper are the metals of high heat conductivity and are examples of the type of material for which helium advantageous in welding relatively thick sections. Pure argon can be used for welding of structural steels, low alloyed steels, stainless steels, aluminum, copper, titanium and magnesium. Argon hydrogen mixture is used for welding of some grades of stainless steels and nickel alloys. Pure helium may be used for aluminum and copper. Helium argon mixtures may be used for low alloy steels, aluminum and copper.

Welding speed

Welding speed is the important parameter of TIG welding. If the welding speed is increased, power or heat input per unit length of weld decreases, therefore less weld reinforcement results and penetration of welding decreases. Welding speed or travel speed primarily control the bead size and penetration of weld. It is interdependent with current. Excessive high welding speed decreases wetting action, increases tendency of undercut, porosity and uneven bead shapes while slower welding speed reduces the tendency to porosity.

## II. OBJECTIVES OF THE PROJECT

To find the amount of heat input values and speed required to weld the single V groove for both aluminum and mild steel plates.
To find the amount of heat input values and speed required to weld the double V groove for both aluminum and mild steel plates.
To get the average heat input values to weld the aluminum and mild steel plates.
To calculate and compare the amount of angular distortion for the aluminum and mild steel plates with single V groove.
To calculate and compare the amount of angular distortion for the aluminum and mild steel plates with double V groove.
To plot the graphs between:
Angular distortion of Single V groove in mild steel vs aluminum
Angular distortion of double V groove in mild steel vs aluminum
Angular distortion of single V vs double V groove in mild steel
Angular distortion of single V vs double V groove in aluminum

### *2.1. Experimental planning and procedure*

For the present work, experimentation was done in two phase. In first phase, butt welding of aluminum plate (10mm thickness) with single V groove and second phase with Double V groove. Same work is repeated for the mild steel plates.
Commercial aluminum plate of thickness 10mm was selected as work piece material for the present experiment. Al plate was cut with dimension of 250 mm x 250 mm with the help of band saw and grinding done at the edge to smooth the surface to be joined. After that the surfaces are polished with emery paper to remove any kind of external material. After sample preparation, Al plates are fixed in the working table and welding is done so that a butt joint can be formed.
TIG welding with alternate current (AC) was used in experiments as it concentrates the heat in the welding area .Zirconiated tungsten electrode was prepared by reducing the tip diameter to 2/3 of the original diameter by grinding and then striking an arc on a scrap material piece. This creates a ball on the end of the electrode. Generally an electrode that is too small for the welding current will form an excessively large ball, where as too large electrode will not form a satisfactory ball at all.
For the first phase of experiment welding parameters selected are shown in the Table.1. Before performing the actual experiment a number of trail experiments have been performed to get the appropriate parameter range where welding could be possible and no observable defects like undercutting and porosity occurred.

Table. 1: process parameters recorded for single V groove and double V groove butt joints for different specimen of MS plates.

| SL.NO. | WELDING CURRENT, AMPS | WELDING VOLTAGE, VOLTS | TIME TAKEN FOR SVG, MIN | TIME TAKEN FOR DVG, MIN |
|---|---|---|---|---|
| 1 | 200 | 30 | 5.05 | 5.15 |

Table.2: process parameters recorded for single V-groove and double V-groove butt joints for different specimens of aluminum plates.

| SL.NO | WELDING CURRENT, AMPS | WELDING VOLTAGE, VOLTS | TIME TAKEN FOR SVG, MIN | TIME TAKEN FOR DVG, MIN |
|---|---|---|---|---|
| 1 | 180 | 20 | 5.2 | 7.13 |

## III. DESIGN DETAILS (DIMENSIONS OF PLATES)

Set of mild steel plates of different grooves of sizes 250x250x10 in mm, in each type of butt joints were chosen. The set of aluminum plates of different groove sizes 250x250x10 in mm of each type of butt joints were as shown in the figure 3. The two different butt joints like V groove and double V groove were chosen for experimental work as shown in the fig.4. Total eight plates were prepared for the above parameters for welding. The surfaces of the plates were cleaned to remove the rust and dirt before welding with the help of file and emery sheets. Initially tack weld is done for joining the two plates to accommodate the fine welding process. The two different butt joints of V groove and double V groove were made on mild steel specimens and aluminum specimens. The constant parameters like voltage current and time for welding were recorded during welding as given in tables 1 and 2, and welded specimen are shown.

Table.3: process parameters recorded for single V groove and double V groove butt joints for MS specimens with calculated heat input.

| Sl.no | welding current, amps | welding voltage, volts | Time taken for SVG, min | Time taken for DVG, min | Welding speed for SVG, m/min | Welding speed for DVG, m/min | Heat input for SVG, W/mm | Heat input for DVG, W/mm | Average heat input ,W/mm |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 200 | 30 | 5.05 | 5.15 | 0.0495 | 0.0485 | 7272.72 | 7422.68 | 7347.70 |

Table.4: process parameters recorded for single V groove and double V groove butt joints for aluminum specimens and calculated heat input.

| Sl.no | Welding current, amps | Welding voltage, volts | Time taken for SVG, min | Time taken for DVG, min | Welding speed for SVG, m/min | Welding speed for DVG, m/min | Heat input for SVG, W/mm | Heat input for DVG, W/mm | Average heat input, W/mm |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 180 | 20 | 5.2 | 7.13 | 0.0481 | 0.0351 | 4490.64 | 6153.84 | 5322.24 |

## IV. EXPERIMENTAL WORK

The experiment was carried out for welding Mild steel and Aluminum plates using TIG welding process and study on effect of heat input for different grooves with respect to welding distortions.The effect of heat input on angular distortion for V groove and double V groove butt joints are presented. The angular distortions for V groove and double V groove butt joints for the mild steel and mild steel and aluminum specimens are compared.

*4.1 Experimental set up*

The experimental setup of MIG welding machine is shown below.

The base plates made up of mild steel and aluminum were used for welding using above equipment prepared specimens of two different grooves such as single V groove and double V groove on the specimens of size 250x250x10 in mm.

Preparation of specimen:

Root face is 4mm in single V groove and 2 mm in double V groove butt joints. Grooves angle is 45° in single V groove and double V groove and length and width of the specimen taken was 250 mm and thickness is 10 mm for all the specimens.

Single “V” groove
Groove angle = 45°
Double “V” groove
Groove angle = 45°
Experimental results and Conclusions: The calculated values of the angular distortion for single V groove aluminum plates

Table.5

| POSITION | INITIAL DEFLECTION VALUE IN MM | FINAL DEFLECTION VALVUE IN MM | ANGULAR DISTORTION IN DEGREES |
|---|---|---|---|
| 0 | 10 | 10 | 0 |
| 5 | 10 | 10.02 | 0.0046 |
| 10 | 10 | 10.12 | 0.0275 |
| 15 | 10 | 10.26 | 0.0596 |
| 20 | 10 | 10.33 | 0.0756 |
| 25 | 10 | 10.46 | 0.1054 |
| 30 | 10 | 10.34 | 0.0779 |
| 35 | 10 | 10.22 | 0.0504 |
| 40 | 10 | 10.17 | 0.0390 |
| 45 | 10 | 10.06 | 0.0138 |
| 50 | 10 | 10 | 0 |

## V. COMPARISON OF ANGULAR DISTORTION FOR SINGLE V GROOVE BUTT JOINTS IN MILD STEEL AND ALUMINUM

It can be seen that the angular distortion in the single V groove is found to be maximum in aluminum compared to mild steel, because the strength of aluminum is lower. Density of mild steel is higher. Mild steel is harder than Aluminum, so distortion of mild steel is lower than that of aluminum. The graph is drawn as shown in the fig. 3

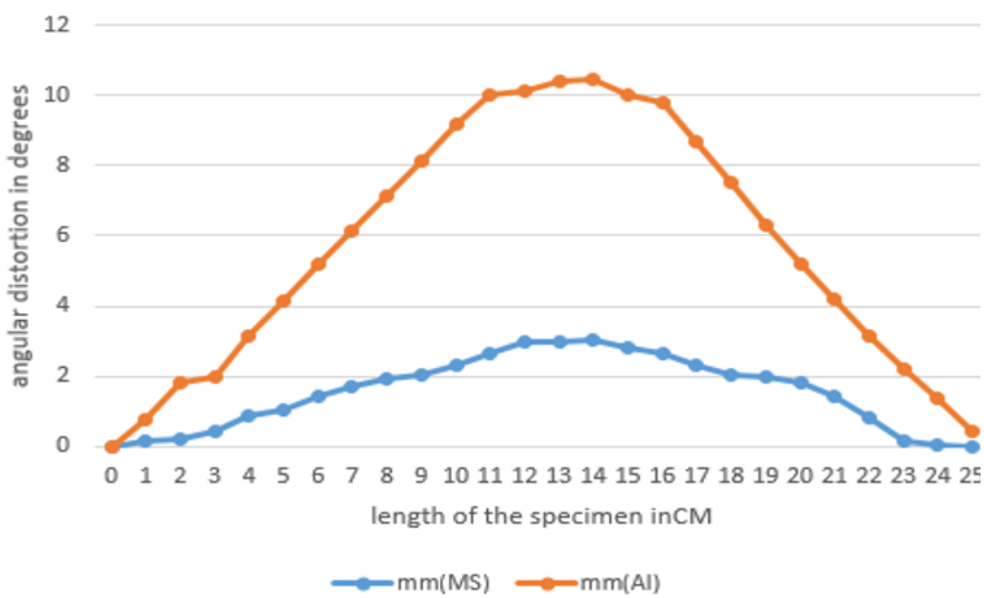


Fig. 3: angular distortion of single V groove in mild steel vs aluminum

### *5.1. Comparison of angular distortion for double V groove butt joints in Mlid steel and Aluminum*

The angular distortion in double V grove is obtained is compared between the MS and Al plates therefore from the fig.4. It is seen that the distortion is greater in aluminum as mild steel is harder and heavier than mild steel.

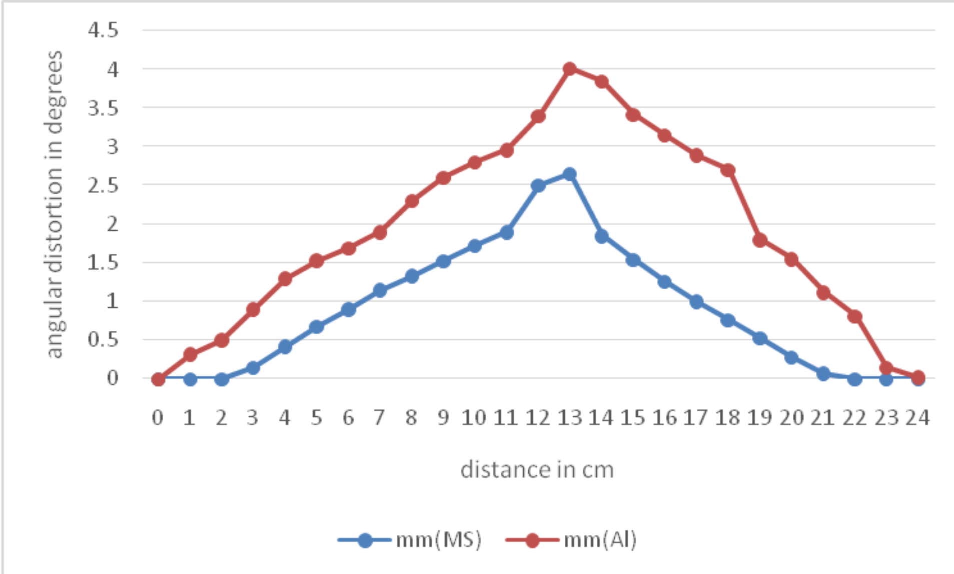


Fig.4: angular distortion of double V groove in mild steel vs aluminium

*5.2. Comparison of angular distortion in single V groove and double V groove butt joints.*

The angular distortion is greater in single V groove butt joint than in double V groove butt joint. The maximum distortion is plotted by using the distortion values, and shown in the fig.5.

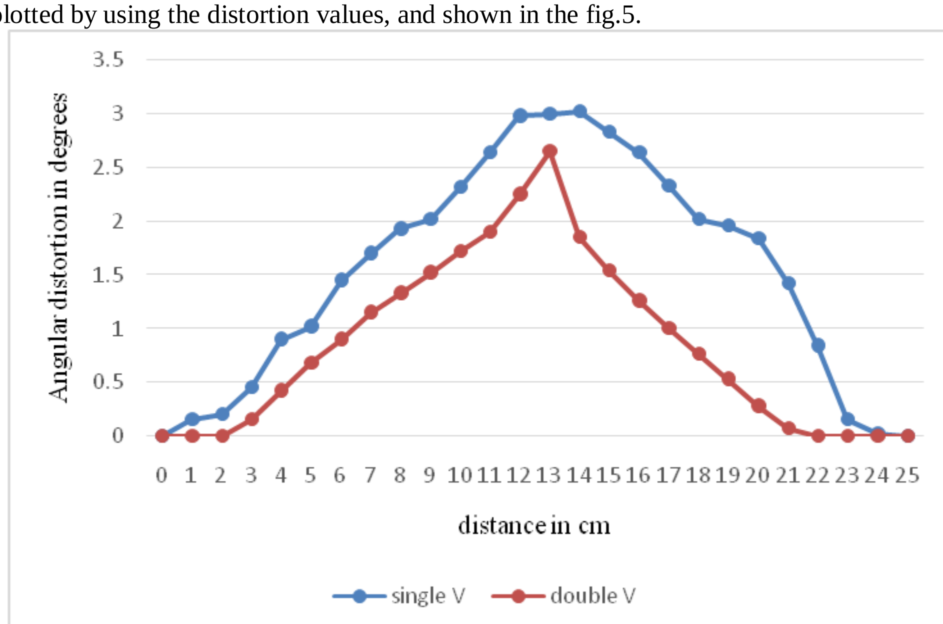


Fig.5: angular distortion of single V vs double V groove in mild steel

*5.3 Comparison of angular distortion in single V groove and double V groove butt joints of Aluminum*

The angular distortion is greater in single V groove butt joint than in double V groove butt joint. The maximum distortion is plotted in the graph as shown in the fig.6 below

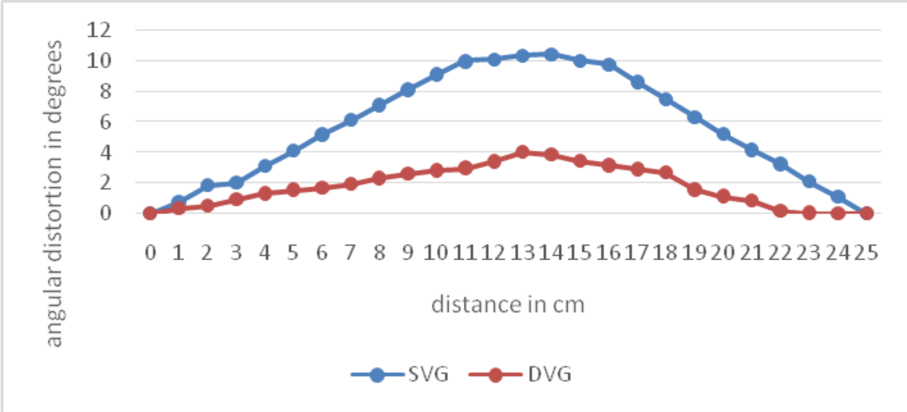


Fig 6: angular distortion of single V vs double V groove in aluminum

The experimental studies on welding distortions on the welded plates for Mild steel and Aluminum for different butt joints had been carried out using TIG welding process. Following are the conclusions drawn within the scope of the investigation.
For same heat input angular distortions is maximum in the single V-groove when compared to double V-groove welded joints.
For the same heat input longitudinal shrinkage is maximum in double V-groove welded joints when compared to double v-groove welded joints when compared to single V-groove.
The angular distortion is greater in aluminum when compared to the angular distortion in mild steel.
The future scope of the project carried out in TIG welding process is given below:
Experimental work can be carried out for T-joints on the distortions.
Finite element analysis can be modeled for butt joints on distortions.
Experimental work can be carried out for different process parameters to vary heat input in butt joints on distortions.
Experimental work can be carried out for the different size of the specimen in butt joints on distortions.
The welding setup consists mainly following parts
TIG welding torch - Torch is fixed with unit. A tungsten electrode is fixed in the torch and Ar gas is allowed to flow through this.
TIG welding machine – This is the main part of TIG welding setup by which controlled amount of current and voltage is supplied during welding . A rectifier with current range 10 – 180 A and voltage up to 230 V. depending on the current setting has been used.
Gas cylinder – For TIG welding Ar gas is supplied to the welding torch with a particular flow rate so that an inert atmosphere formed and stable arc created for welding. Gas flow is controlled by regulator and valve.
Work holding table – A surface plate (made of gray cast iron) is used for holding the work piece so that during welding gap between the tungsten electrode and work piece is maintained.
The torch was maintained at an angle approximate to 90° to the work piece.

## VI. ACKNOWLEDGEMENTS:

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## VII. REFERENCES:

[1] Sanjeev Kumar, "Experimental investigation on pulsed TIG welding of Aluminum plate", International Journal of advanced Engineering technology,Vol.1, No.2, July-September 2010.
[2] Indira Rani.M., Marpu,.,R.N.., "Effect of pulsated current TIG welding parameters on mechanical properties of J-Joint strength of Aa6351,Vol.1,No.1.November 2012.
[3] Hussain et.al "influence of welding speed on tensile strength of welded joints in TIG welding process", International Journal of applied engineering Research, Vol.1, No.3, 2010.
[4] Tseng et.al. "Performance of activated TIG Process in austenitic Stainless Steel Welds" Journal of material processing technology, No.211, 2011.