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Effect of Groove Area on Angular Distortion in CO2 Arc Welding process

[1] B N Sathyanarayana Reddy, [2] H V Panchakshari, [3] Viresh G Patil,[4]K Thirupathi
[1] Professor, [2] Professor & Head,[3][4]Associate Professor
[1][3][4] Department of Mechanical Engineering, Medak College of Engineering & Technology Siddipet, Hyderabad, Telangana, India.
[2] Department of Mechanical Engineering, RRIT Bengaluru

Abstract: -- Angular distortion often occurs in butt welded joints when transvers shrinkage is not uniform along the depth of the plates welded due to non-uniform heating and cooling along the thickness of plates. This is the main source of mismatch and dimensional inaccuracy in large welded structures. There is need for procedural development and understanding the mechanism of residual stresses and angular distortion in connection with CO2 arc welding process. In the present investigation it is proposed to study the effect of different electrode diameter and edge preparations such as included angle and root opening on distortion in CO2 arc welding process on mild steel. The distortions considered for different edge preparations are angular distortions for single groove, bevel groove butt joints and analyze distortions in butt joints for 8mm plate thickness of size 250x250 in mm and then measurement of different distortions made by 3-D coordinate measuring machine. Angular distortion in single V-groove butt welded joints and bevel groove butt welded joints decreases with increase in the Groove area.

Keywords: Groove area, Groove angle, Bevel angle, Root opening, Angular distortion and CO2 arc welding.

I. INTRODUCTION

Today the welding is an important metal joining process and versatile means of metal fabrication. It is permanent joining process and essential for the development of every manufactured product economically. It is used in fabrication, erection and commissioning of plants, huge structures and machinery for power, petroleum, chemical and steel, automobiles, aerospace, marine engineering, railway rolling stock, transmission pipelines, pressure vessels, storage tanks. CO2 arc welding can be carried out in a semi-automatic manner, in which the CO2 is used as shielding gas, the arc length and the feeding of the wire into the arc are manually controlled. The welding operator's job is reduced to controlling and positioning the gun at correct angle and moving it along the seam at a controlled travel speed. It is possible to weld the joints in the thickness range of 1-13mm in all welding positions. All the major commercial metals can be welded by the CO2 arc welding process including carbon steels, stainless steels, aluminum, copper, titanium, zirconium and nickel alloys.

The temperature distribution in the weldment is not uniform, and structural and metallurgical changes take place as welding progresses along a joint as it is locally heated by most welding process. Typically, the weld metal and heat effected zone immediately adjacent to the weld arc at temperatures subsequently above that of the unaffected base metal. As the weld pool solidifies and shrinks, it begins to exert stresses on the surrounding weld metal and heat effected zones. Distortion is caused when the heated weld region contracts non-uniformly causing shrinkage in one part of a weld to exert eccentric forces on the weld cross section. The weldment strains elastically in response to these stresses, and distortion occurs as a result of this non-uniform strain. Among the Various factors influencing distortion, the material properties, specimen dimension, heat input, welding processes, groove area, edge preparations and welding sequence are considered to be the most important ones.

As per the literatures; the many developments have been taken place in characterization of distortion and techniques for analyzing the methods for controlling the distortion parameters. It is found from the literature survey that no researcher has completely characterized the distortion related to the use of CO2 arc welding process with respect to the electrode diameter and edge preparations. There is a need for procedural development and for understanding the mechanism of distortion in connection with the use of CO2 arc welding process.

The various investigations were made to study the effects of various parameters on angular distortion using statistical methods. Kihara and Masubuchi [1] have made an experimental investigation of how various welding process parameters, including the shape of the groove and the degree of restraint, affect the angular distortion in butt joint welds. Hirai and Nakamura [2] conducted an investigation to determine the values of angular changes and coefficient of rigidity for angular changes as a function of plate thickness and weight of the electrode consumed per unit length of weld. Kumose et al. [3] studied how effectively elastic pre-straining could reduce the angular distortion of fillet welds in low-carbon steel. Mahendramani and Lakshmana Swamy [4, 5] investigated the angular distortion for different groove angles and throat thickness in submerged arc welding. Watanabe and Satoh [6] used a combination of empirical and analytical methods to study the effects of welding conditions on the distortion in welded structures. Mandal and Parmar [7] used a statistical method of two level full factorial techniques to develop mathematical models, and reported that welding speed had a positive effect on angular distortion for single pass or multi-pass welding. In multi-pass welding, the magnitude and effect of angular distortion is more dominant than in single-pass welding. Vel Murugan et al. [8] developed mathematical models to study the effects of process variables on the angular distortion of multi-pass Gas Metal Arc welded structural steel plates. In this study, the statistical method of three-factors, five-level factorial central composite rotatable design has been used to develop mathematical models to correlate angular distortion with multi-pass Gas Metal Arc welding process parameters. Yuan and Ueda [9] used it to predict longitudinal residual stress in T-joints and I-beam cross section joints, but no further research on the prediction of angular distortion of T-joints has been done.

In this investigation, experiments were conducted to study the distortions produced by the CO2 arc welding process in single V-groove and bevel groove butt joints for different electrode diameter and edge preparations. The electrode diameters used are 0.8 mm and 1.2 mm. The different edge preparations considered were groove angle and root opening in single V-groove and bevel groove butt joints for 8 mm plate thickness of size 250x250 in mm. The various specimen plates were fabricated with proper process parameters by using CO2 arc welding process and then distortion measurements were carried out on welded specimen plates. An attempt has been made to study the effects of electrode diameter and edge preparations on distortions.

II. EXPERIMENTAL PROCEDURE

The specimens are welded by using CO2 arc welding process and measured for angular distortion, transverse shrinkage and longitudinal shrinkage in order to study the effect of electrode diameter and edge preparations for different butt joints keeping process parameters constant. The mild steel material has been used for the base plate for the preparation of specimen. The size of the specimen used for the experimental work is 250 mm x 125 mm x 8 mm .The electrode wire selected for welding mild steel as per AWS A5.18-79 standards. The electrode wires of diameter 0.8 mm and 1.2 mm have been used in the investigation for plate thickness of 8 mm. The CO2 gas is used as the shielding gas. The root opening of 0 mm, 1 mm and 2 mm and electrode diameter of 0.8 mm and 1.2 mm are used in single V-groove and bevel groove and the double V-groove butt joints. The throat thickness of 4 mm for single V-groove and bevel-groove, 3 mm for double V-groove has been used. The electrode diameters of 0.8 mm and 1.2 mm were selected. The process parameters like welding voltage, wire feed rate, welding current, welding speed and electrode extension are selected and kept constant during the entire welding process. The mild steel plates of 8 mm are machined for the required size of 250 mm x125 mm x 8 mm in length, width and thickness. The parameters such as groove angle, root opening for different electrode diameters were prepared. The two corresponding base plates are tack welded at the ends to prevent the relative movement of the plates during welding process using CO2 arc welding process to prepare sixty six welded specimens.

The base plates are cleaned to remove rust, dirt, scales before welding with the help of files and emery sheets. The base plate is made negative and the electrode is made positive in the CO2 arc welding process. For each welding of plate, the process variables are preset, the tack welded base plates are welded in single pass controlling welding parameters, and thus all the plates of sixty six numbers are welded. Welding parameters for butt welding are Voltage = 22 Volts, Current = 100 Amps, Electrode diameters of 0.8 mm and 1.2 mm, Electrode extension is 6 mm and Wire feed rate is 6 m/min. The welding speed and heat input are almost constant with little variation for all the specimens. In welding both sides the same heat input is used. The specimens are measured for distortion after welding.

The final values of height deflection along the edge for single V-groove butt welded joints, bevel groove butt welded joints and double V-groove butt welded joints for different electrode diameters are measured.

III. RESULTS AND DISCUSSIONS

The results of the research work carried out in the area of distortion of welded joints in CO2 arc welding process for different electrode diameter and edge preparations of 8 mm

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plate thickness is presented in this chapter. The research for analyzing the distortion in the welded plates by the use of CO2 arc welding has been carried out on sixty six specimens in controlled environmental conditions in single V-groove, bevel groove and double V-groove butt joints for different electrode diameters and edge preparations. The various edge preparations such as groove angle and root opening were varied for 0.8 mm and 1.2 mm electrode diameters for 8 mm plate thickness of size 250 mm x250 mm. Angular distortion was measured on welded specimens. The investigation has been made to study the effect of groove area on angular distortion for different electrode diameters in single V-groove, bevel-groove and double V-groove butt welded joints. The influence of edge preparations on angular distortion are discussed under the following subheadings.

A. Effect of groove area on angular distortion in single V-groove butt joints

The angular distortion with groove area for single V-groove butt welded joints for 0.8 mm and 1.2 mm electrode diameters is shown in Fig. 1 It can be observed from the figure that, the angular distortion decreases with increase in the groove area. When the groove area is increased from 0 to 25.24 mm2, the angular distortion for 0.8 mm electrode diameter decreased from 2.831o to 0.6325o with 77.66% reduction of angular distortion. For 1.2 mm electrode diameter, the angular distortion decreased from 2.801o to 0.4265o with 84.77% reduction of angular distortion. The angular distortion reduced in welded joints of 1.2 mm electrode diameter when compared to the welded joints of 0.8 mm electrode diameter.

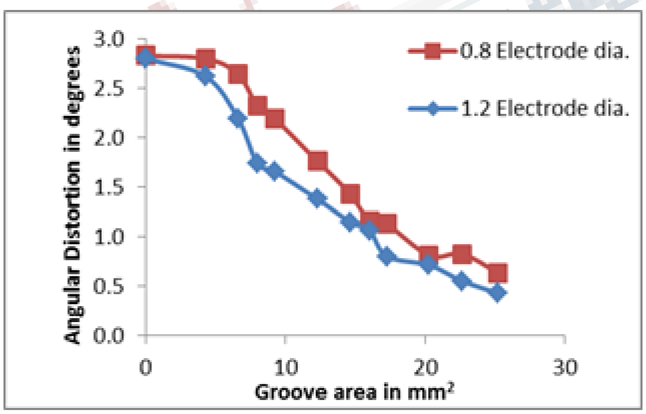

Fig.1: Variation of angular distortion with groove area for single V-groove butt joints.

When the groove area is increased, the filler metal deposited would be wider and deeper, therefore the weld eccentricity from the neutral axis from the base plate decreases with increase in the groove area. The transverse shrinkage along thickness towards bottom of the specimen increases as increase in the included angle which results in the reduction of angular distortion in single V-groove butt welded joints. The heat produced in welded joints of 0.8 mm electrode diameter is more than welded joints of 1.2 mm electrode diameter. Hence the reduction of angular distortion in the welded joints of 1.2 mm electrode diameter is more than 0.8 mm electrode diameter.

B. Effect of groove area on angular distortion in bevel-groove butt joints

It can be observed from the Fig. 2 that, the angular distortion decreases with increase in the groove area. When the groove area is increased from 0 to 20.62 mm2, the angular distortion for 0.8 mm electrode diameter decreased from 2.831o to 0.7284o with 74.27% reduction of angular distortion. For 1.2 mm electrode diameter, the angular distortion decreased from 2.801o to 0.5872o with 79.04% reduction of angular distortion. The angular distortion reduced in welded joints of 1.2 mm electrode diameter when compared to the welded joints of 0.8 mm electrode diameter.

When the groove area is increased, the filler metal deposited would be wider and deeper, therefore the weld eccentricity from the neutral axis from the base plate decreases with increase in the groove area. The transverse shrinkage along thickness towards bottom of the specimen increases as increase in the bevel angle which results in the reduction of angular distortion in bevel-groove butt welded joints. The heat produced in welded joints of 0.8 mm electrode diameter is more than welded joints of 1.2 mm electrode diameter. Hence the reduction of angular distortion in the welded joints of 1.2 mm electrode diameter is more than 0.8 mm electrode diameter.

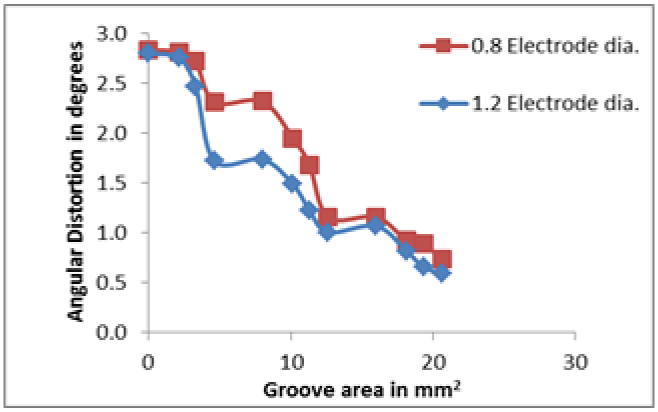

Fig.2: Variation of angular distortion with groove area for bevel-groove butt joints.

C.Effect of groove area on angular distortion in double V-groove butt joints

The angular distortion with groove area for double V-groove butt welded joints for 0.8 mm and 1.2 mm electrode diameters is shown in Fig. 3 It can be observed from the figure that, the angular distortion decreases with increase in the groove area. When the groove area is increased from 0 to 26.4 mm2, the angular distortion for 0.8 mm electrode diameter decreased from 1.2465o to -1.3325o with 6.9% reduction of angular distortion. For 1.2 mm electrode diameter, the angular distortion decreased from 1.0532o to 1.4265o with 35.44% reduction of angular distortion. The angular distortion reduced in welded joints of 1.2 mm electrode diameter when compared to the welded joints of 0.8 mm electrode diameter.

When the groove area is increased, the filler metal deposited would be wider and deeper, therefore the weld eccentricity from the neutral axis from the base plate decreases with increase in the groove area. In double V-groove butt welded joints, the angular distortion induced during welding on one side and the angular distortion reverses during welding on the other side, thereby the angular distortion reduces in double V-groove butt welded joints when compared to the single V-groove and bevel-groove butt welded joints. The heat produced in 0.8 mm electrode diameter is more than welded joints of 1.2 mm electrode diameter. Hence the angular distortion reduced in the welded joints of 1.2 mm electrode diameter.

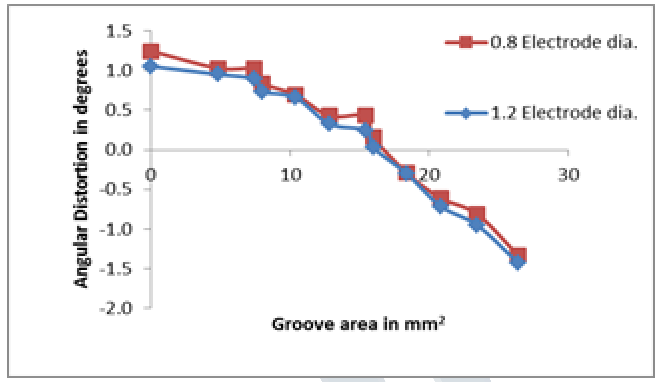

Fig.3: Variation of angular distortion with groove area for double V-groove butt joints.

CONCLUSION

The conclusions of the research work carried out in the present investigation in the area of distortion of welded joints in CO_2 arc welding process for different electrode diameter and edge preparations of 8 mm plate thickness within the scope of this investigation have been presented as follows. Angular distortion decreases with increase in groove area in single V-groove, bevel-groove and double V-groove butt welded joints because of decrease in the weld eccentricity of weld metal.

In double V-groove butt welded joints, the angular distortion induced during welding on one side and the angular distortion reverses during welding on the other side, thereby the angular distortion reduces in double V-groove butt welded joints when compared to the single V-groove and bevel-groove butt welded joints.

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