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STUDY AND ANALYSIS OF THE EFFECT OF WELDING PROCESS ON DISTORTION WITH 304L STAINLESS STEEL WELD JOINTS

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ABSTRACT
The effect of welding process on the distortion with 304L stainless steel 12thk weld joints made by TIG (tungsten inert gas) and SMAW (Shielded metal arc welding) welding process involving different type joint configuration have been studied. The joint configurations employed were double V-groove edge preparation for double side SMAW welding and square – butt preparation for double side TIG welding. All weld joints passed by radiographic. Distortion measurements were carried out using height gauge. Two weld joints exhibited different distortion as the weld joint fabricated by double side TIG welding low distortion than fabricated by double side SMAW process.

KEYWORDS: TIG, SMAW, radiographic, angular distortion.

INTRODUCTION
Now a day usage of stainless steel material highly increased continuously in various industrial application [1] medical application [2] stainless steel sheets are increasingly used for vessels, kitchen, building, transportation etc because of their high corrosion resistivity, beautiful appearance [3, 4] and a reasonable weld ability [5].Austenitic stainless steel constitutes the largest stainless family in terms of of alloy type and usage [6].the standard austenitic stainless weld metals contain two phases(austenite+ferrite) similar to an ''as cast'' microstructure[7]. The austenitic stainless steels are used for a very broad range of applications when an excellent combination of strength and corrosion resistance in aqueous solutions at ambient temperature is required [8]. In general, austenitic stainless steels are easily weldable [9]. Type 304L is used where extensive welding is to occur; it has lower levels of carbon (0.03% max. versus 0.08% for Type 304) to reduce the tendency toward carbide precipitation at the grain boundaries during welding [10]. However, when an austenitic stainless steel is welded, its heat affected zone (HAZ) is often sensitized by formation of intergranular Cr-rich carbides, which deteriorates the corrosion properties of the welded joint [11]. Delta ferrite has a beneficial effect in reducing or preventing microfissuring in austenitic stainless steel weldments [12].TIG welding process is an arc welding that uses 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. Shield metal arc welding (SMAW) is a manual arc welding process that uses a consumable electrode covered with flux to lay the weld. Distortion in a welded structure is the result of the non uniform expansion and contraction of the weld and surrounding base material, caused by the heating and cooling cycle during welding process. Welding distortion has negative effects on the accuracy of assembly, external appearance, and various strengths of the welded structures. In many cases, additional costs and schedule delays are incurred from straightening welding distortion. On the other hand, increasingly, the design of engineering components and structures relies on the achievement of small tolerance. For these reasons, measurement and control of welding deformation have become of critical importance.TIG welding has been reported to produce stainless steel weld joints with reduced distortion. The objective of the present study involves studying the effect of different welding processes and joint configurations on the distortion in 12 mm thick 304 L stainless steel weld joint. Distortion in weld joint was measured by height gauge.

EXPERIMENTAL
Austenitic stainless steel type 304L with chemical composition listed in Table 1 was used in this study. The edge preparation was made on plates of 12 mm thickness as per the joint configuration drawings given in Fig. 1. Fig.

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1(a) shows square-butt joint for double side TIG welding process, while Fig. 1(b) shows double V-groove joint for plates to be welded by SMAW process. The two plates to be welded were tack welded and grids were marked for the distortion measurements.

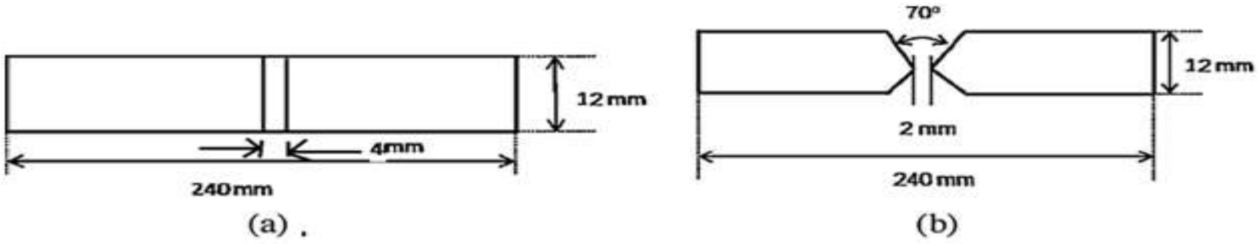

Fig.1 Schematic sketch showing joint configurations (a) square butt joint (b) double V-joint.

Table-1
Chemical composition (Wt%, balance Fe) of 304LN stainless steel

Cr	Ni	Mn	Si	N	P	C	S
18-20	8-12	2 max	1 max	0.1-0.16	0.045 max	0.03 max	0.03 max

FABRICATION OF DOUBLE SIDE TIG WELD JOINT

The square-butt joint was fabricated by TIG welding process with electrode diameter of 4mm using ER-304L stainless steel filler wire of 3.15mm diameter and the welding parameter used are given in table-2.

Table-2

Process	Current (A)	Voltage (V)	Torch Speed (mm/min)	No. of passes	Arc Gap (mm)	Shield gas	Gas flow rate(L/mm)
TIG	216	17	60	7	4	Argon	15

FABRICATION OF DOUBLE SIDE SMAW WELD JOINT

The double V-groove joint was fabricated by SMAW process with electrode diameter 3.15 mm thick using E-304 L the welding parameter used are given table-3

Table-3

Process	Current (Amp)	Voltage (v)	Torch Speed (mm/min)	No. of passes	Arc Gap (mm)
SMAW	120	18	60	8	2

RESULT AND DISCUSSION

Radiographic Testing (RT)

An NDT method that utilizes x-rays or gamma radiation to detect discontinuities in materials, and to present their images on recording medium.

Radiation Properties-

[1] Undetectable by human senses
    a. Cannot be seen, felt, heard, or smelled
[2] Possesses no charge or mass
    a. Referred to as photons (packets of energy)
[3] Generally travels in straight lines (can bend at material interfaces)
[4] Characterized by frequency, wavelength, and velocity
[5] Part of electromagnetic spectrum but not influenced by electrical or magnetic fields

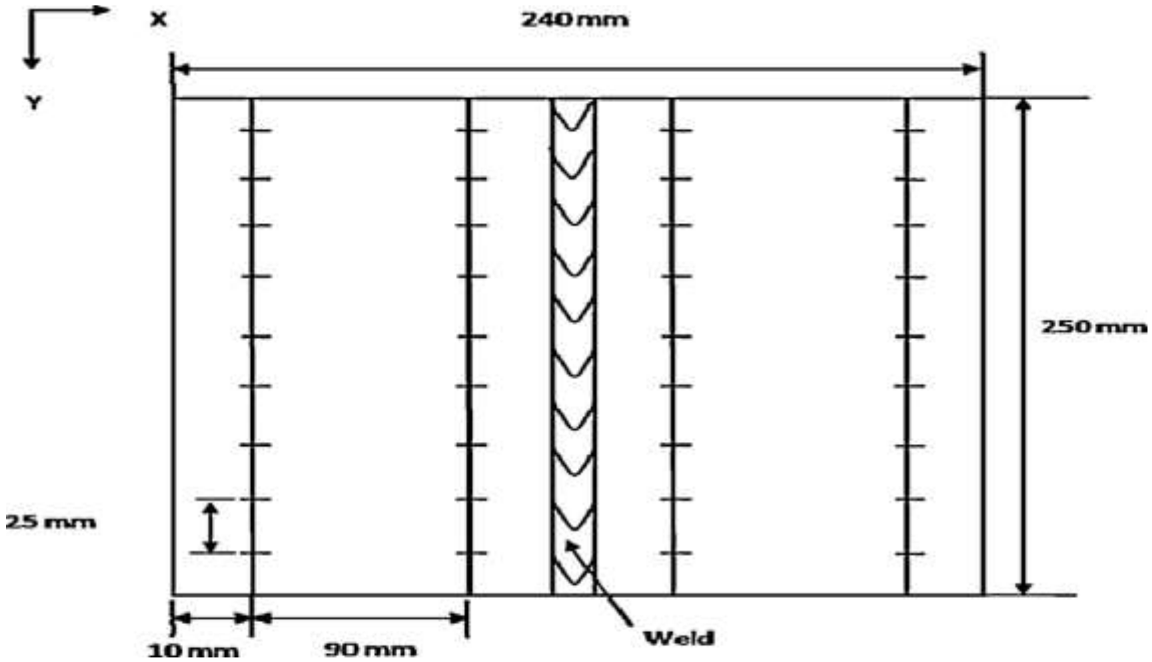

Fig. 2. Schematic diagram showing grid markings on the surface for distortion measurements.

DISTORTION MEASUREMENTS

The distortion measurements were carried out by placing the tip of the vertical height gauge on the plate before welding. After welding the vertical displacement of the plate at those particular grids were measured by the height gauge. The angular distortion values are estimated by the formula.

$$\text{Angular distortion, } \alpha = \tan^{-1}\left(\frac{Z}{AB}\right)$$

Where Z is vertical displacement and AB is distance moved along x-axis. Show in fig-3

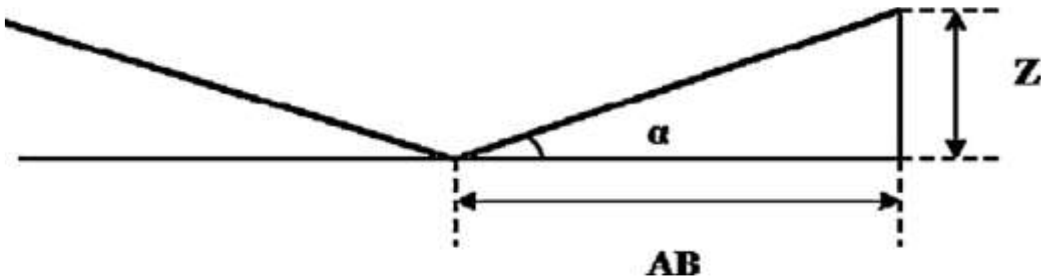

Fig.3. Schematic diagram for estimating angular distortion

The process parameter which are used as main factors are mentioned in table-4

Table-4

S.N	Parameters	Notation	Units	Limits		
				-1	**0**	**+1**
1	Diameter of electrode	d	mm	2	2.5	3.15
2	Weld current	C	amps	108	162	216
3	Time gap between passes	t	min	0	5	10

OBSERVED VALUES OF DISTORTION FOR DOUBLE SIDE TIG WELD JOINT

Table-5

Sr. No.	Observed values of (mm)	values of Angular distortion (α)degree
1	+1.5	6.41
2	+1	6.16
3	+1.9	6.56
4	+1.5	6.41
5	+1.5	6.41
6	+1.8	6.56
7	+1.5	6.41
8	+1.2	6.27
9	+1.9	6.56
10	+1.9	6.56
11	+1.8	6.56
12	+1.9	6.56

The peak angular distortion value exhibited by the TIG weld joint is 6.16˚ positive sign on the distortion value implies that edges of the plates distorted upwards in reference to the weld region.

OBSERVED VALUES OF DISTORTION FOR DOUBLE SIDE SMAW WELD JOINT

Table-6

Sr. No.	Observed values of (mm)	values of Angular distortion (α)degree
1	+4.2	7.6
2	+4.4	7.7
3	+4	7.5
4	+4.2	7.6
5	+4.4	7.7
6	+4	7.5
7	+4	7.5
8	+4.2	7.6
9	+4	7.5
10	+3	7.1
11	+3.5	7.3
12	+4	7.5

The peak angular distortion value exhibited by the SMAW weld joint is 7.1˚ positive sign on the distortion value implies that edges of the plates distorted upwards in reference to the weld region.

PREVENTION OR CONTROL MEASUREMENT OF DISTORTION

Distortion can be prevented or minimized during welding process using some strategies. During welding process, the total number of heating and cooling cycles should be minimized. Shrinkage or contraction cannot be prevented, but it can be controlled[2] Distortion in a weld results from the expansion and contraction of the weld metal and adjacent base metal during the heating and cooling cycle of the welding process. Doing all welding on one side of a part will cause much more distortion than if the welds are alternated from one side to the other. During this heating and cooling cycle, many factors affect shrinkage of the metal and lead to distortion, such as physical and mechanical properties that change as heat is applied. The temperature distribution in the weldment is therefore non uniform. When metals are heated, then shrinkage of metal takes place. Upon cooling, the weld pool solidifies and shrinks, exerting stresses restraint, welding procedure, amount of restraint properties of parent metal etc. Due to welding, the problem of joint edges, non uniform stresses set up in component [3]. So expansion and contraction of the heated material takes place.

CONCLUSION

1. 12mm thick 304L stainless steel weld joints made by different welding process with different angular distortion value.
2. Double side TIG weld joints exhibited lower angular distortion value while double side SMAW weld joint exhibited maximum angular distortion value.
3. The positive effect of angular distortion takes place when length of plates and diameter of electrode increases.
4. The negative effect of angular distortion takes place when current and time gap between passes increases.
5. The highest effect on angular distortion is observed on diameter of the electrode using within the design range of parameters.

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