

Distortion Measurement For Laser Beam Butt Welded Joints

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Abstract: Stainless steel weldments are widely in automobile and structural industries. In this study the similar joints of SS316L are made with CO₂ Laser beam welding processes. The experimentation is carried out with two set of process parameters varying the laser power and estimating the response of the welded component. Radiography is measured in the transverse direction to weldment. The lower the better-quality characteristics is chosen for distortion. Distortion is measured using the vernier height gauge. Radiography The results include the radiography analysis and distortion in the weldments. The welds are free from flaws. And the lower heat input results the lower distortion.

IndexTerms - Laser Beam Welding, Heat Input, Radiography, Distortion.

1. INTRODUCTION

Stainless steel have been increasingly used in the industry, due to its favorable combination of physical and mechanical properties such as low density, high strength, good corrosion, and creep resistance. Also, the Stainless steel 316L, is widely employed in the aerospace industries due to the corresponding superior mechanical properties and oxidation resistance at elevated temperature. These highly versatile materials are being integrated into complex multi-component systems, to increase the design flexibility and enhance the product functionality. T.C. Yang and C. Chen (2004) had conducted experimentation on stainless steel 422 and Inconel 625 filler metal with dimension of 120mm length and 3.6 width these materials welded by laser beam welding and we have to take the parameters laser power 3.3kW, scan rate 350mm/min, focal length 200mm shielding gas as argon. The details microstructure examination is carried out.

G.D. Janaki Ram et al. (2013) has conveyed Inconel 718 plate is welded using Nd:YAG LASER WELD using the laser power 400W, welding speed 2mm, pulse frequency 15hz, focus position 1mm, focusing lens 120mm, heat input 150J/mm, peak power 2.98kW, shielding gas as argon to understand the mechanical and structural characterization. M Youssefieh et al. (2003) had studied the microstructural changes in the electron beam welded plate of 5mm thick. Damain (2013) had conducted experimentation with Inconel 625 of 0.8mm plate is welded with fiber laser welding process with various welding speeds and undergone microstructural examination to understand the weldability and changes with each combination. Further, in his studies has stated on weld bead geometry, mechanical and micro structure characterization were carried for dissimilar joints of Ti to SS combinations using laser beam welding process of 0.8mm plate. Good weld ability and fine solid solubility were verified through SEM and EBSD analysis.

A.T. Egbewande et al. (2009) Inconel 738 plate is used to understand weldability, microstructure and hardness of the laser beam welded plate of 6.5mm thick. Inconel 625 material is welded with Direct Diode with Laser welding

power 2.0kW, focal length 82mm. The results are obtained in Inconel 625 is microstructure, microhardness, fractographs. S.H. Baghjari (2014) Nd:YAG laser welding is used with pulse voltage for joining of 2mm plate, Focused beam 0.7mm, pulse duration 6ms welding speed 1.4, 0.7, 2mm/sec, pulse frequency 6Hz. The results are concluded base metal microstructure, SEM micrograph, XRD patterns, ED's analysis of weld metal growth rate.

S. Williams and R.M. Miranda (2011) had reported on NiTi foils of 0.34mm thick and AISI 316L of 0.47mm thick plate were used studied. The process parameters of the above materials is flash lamp voltage 190-400V, wavelength 1.06μm, maximum pulse energy 80J, maximum pulse peak power 6.0kW, pulse duration 0.5-50 ms, connecting power 1.7kw, beam spot diameter 1mm in using dissimilar laser welding of NiTi to stainless steel the SEM analysis is carried out at various zones in the weldment.

The objective of this work is to study the Non-Destructive testing methods are used for understanding the quality of the weld structure. The CO₂ Laser Beam welding process is used for joining the plates. Vernier height gauge is used to measure the distortion in the weldment.

2. EXPERIMENTATION

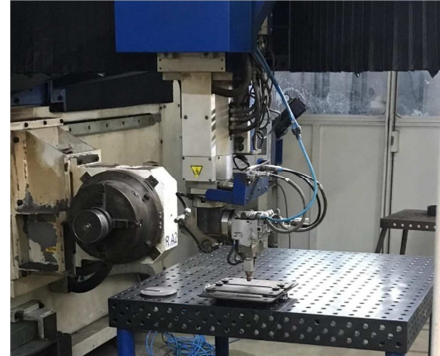
Stainless steel plate of 5mm thick plate is used for the study. CO₂ Laser Beam Welding process is used for the joining. The samples prepared such way that welding edges are well finished with CNC milling to avoid burrs. The samples are prepared with zero gap between the butting edges. The dimensions of the plate are 80mm*110mm*5mm and the joining is carried out in the with 80mm side. The details dimensions of the plate are shown in fig.1. The controlled process parameters are laser power (W), welding speed (m/min) and shielding gas (LPM). The process parameters with combinations are shown in table -1. The shielding at the samples is provided with helium. Figure 2 (a) shows samples after the machining which are free from burrs and fig.2 (b) shows the final weld joint with the dimensions of 220mm*80mm*5mm.

Table –1. process parameters for SS316L to SS316L

Trail no	Laser power	Welding speed	Shielding flow rate
	W	m/min	LPM
1	3000	1.0	10
2	3300	1.0	10



(a) Clamping the work pieces



(b) CO₂Laser beam welding machine

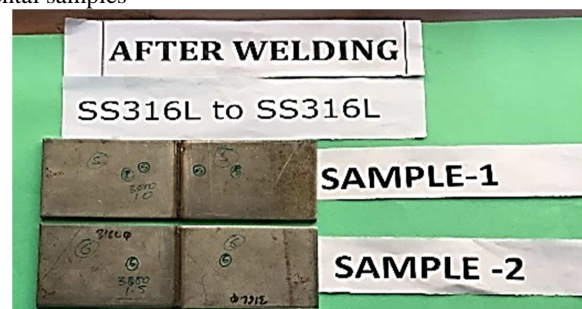


(c) Preparation tacks for the sample

Fig:1. Experimental samples



(a)



(b)

Fig:2. Experimental samples

The heat input calculation for each bead on plate is given in equation-1. The heat input supplied by the LBW to the base material is calculated by the formula mentioned below.
where W is the laser power in kW and V is the travel speed

in m min⁻¹. The calculation of heat input for the trails are table-

$$HI = \frac{60W}{V}$$

(1)

The distortion in the weldment is caused by rapid heat and cooling process during the welding process. The distortion in the weldment causes in accuracy and affect the in assemblies of the structure. The quality characteristic for

Distortion is 'Smaller the Better'. The shapes of distortion can cause in weldment are the longitudinal and transverse direction which was shown in Fig.3. The principle of distortion measured with vernier height is represented in fig 4 (a) and 4 (b) shows the measurement of distortion in the weldment.

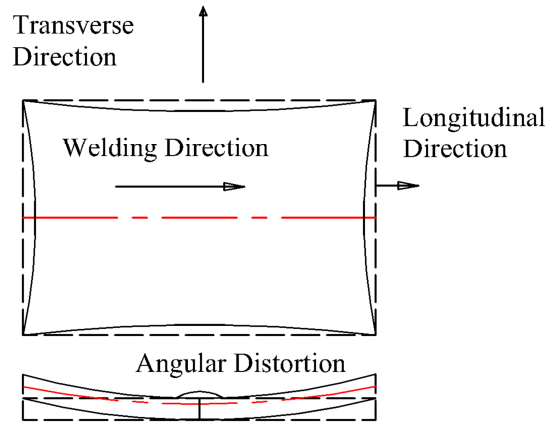


Fig. 3. Distortion caused by welding

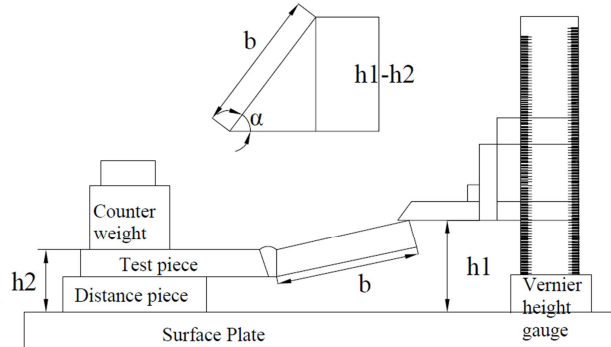


Fig 4(a). Measurement of distortion using Vernier height gauge



Fig 4(b). Measurement of distortion for weldments

The calculation of the angular distortion for the weldments is carried with Equation 2. The angular distortion of the weldment is expressed in degrees.

$$a = \sin^{-1} \left[\frac{h_1 - h_2}{b} \right]$$

(2)

3. RESULTS AND DISCUSSION

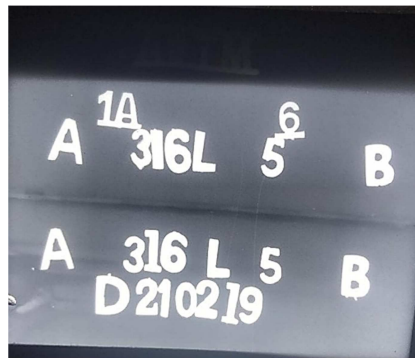
3.1 Radiography

NDT purposes, the material to be examined is set between the radiation source, which regularly emanates X-beam or gamma radiation, and a bit of film that is delicate to the given kind of radiation. As the radiation is discharged, the thickness of the material will decide the measure of radiation that is fit for infiltrating through to the film to shape a shadowgraph.

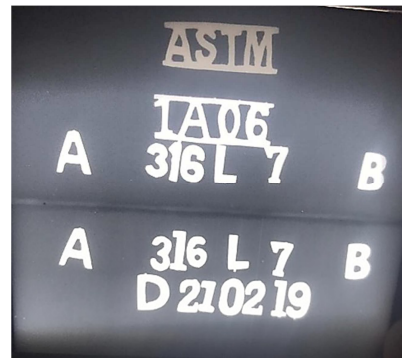
The darkness of the film will subsequently change, contingent on the measure of radiation that is fit for entering through the modern material1. This variety of the shadowgraph obscurity decides the thickness or structure of the material being broke down and will likewise give valuable data on the nearness of any defects or discontinuities that might be available inside the material. Table- shows the radiography results of the welded samples. The welded structures are free from defect and in the figure. The X-ray radiography test was carried out for laser welded samples of similar and dissimilar combinations. ASME SEC IX – 2017 standard was used for testing process with focal spot size of 1.5x1.5mm and Exposure Time of 1.30min. the radiography results for the samples are shown in fig 5 (a and b) and the sample results are given in table-2. The experiments shows the all the trails are accepted without any defect

Table-2 radiography analysis for 316 L to 316 L

Sl. No.	Location	Interpretation	Result
1	Transverse Direction	NSD	Acceptable
2		NSD	Acceptable



(a) Sample-1



(b) sample-2

Fig.5. Radiography analysis for similar joints

3.2 Distortion

The distortion is measured on the top surface of the weldment cools to ambient temperature. The measurement is carried out using the vernier height gauge. The lower the better-quality characteristic is chosen for distortion measurement. Table-3 shows the distortion measured values of the weldments. The trail-1 shows the better lower

distortion. Distortion in trail-1 was 3.57mm for heat input of 180J/min. whereas for trail-2 is was 4.45mm for heat input of 198J/min. The heat input increases the distortion in the weldment also increases. fig 6– shows the distortion in the both the trails. From the results the distortion was infused by the laser power. The distortion was observed with difference of 0.88mm within the trails.

Table –3 Process parameters with levels and Response for SS316L to SS316L

Trail no	Welding parameter with levels				Response
	Laser power	Welding speed	Shielding flow rate	Heat input	Distortion
	kW	m/min	LPM	J / min	mm
1	3000	1.0	10	180	3.57
2	3300	1.0	15	198	4.45

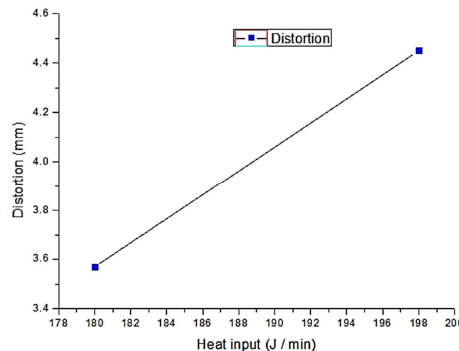


Fig. 6. Heat input vs Distortion in the weldments

4. CONCLUSIONS

The study of laser beam butt welded joints is made for SS316L. All the trails show full penetration in the weldment. After the weldments reaches to ambient temperatures the quality of the weldments are measured. The weldments are free from defect through visual inspection and verified through radiography analysis. Distortion was observed in the both the trails, but the lower heat input results the lower distortion.

Nd:YAG laser welding of AISI 420 stainless steel to kovar alloy,” *Materials & Design*, vol. 57, pp. 128–134, May 2014.

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