

# Experimental Investigation of Laser Welded Joints on AISI 304L Stainless Steel Using Fiber Laser



## Engineering

**KEYWORDS :** Fiber laser, Laser beam welding, Austenitic stainless steel

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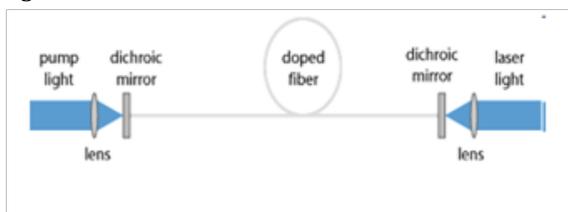
### ABSTRACT

Using laser technology joining of thin materials has been an increased interest in recent years. Laser beam welding (LBW) offers a high speed, high power, clean heat source to join materials. Due to its advantage over conventional welding processes Laser welding of thin material are increasingly used in various industry such as less heat affected zone (HAZ), less contamination of the joint, no indentation mark, short process time and accuracy. In this study Fiber laser welding process has successfully used for butt welding of thin austenitic stainless steel (AISI 304L) plates. Selection of proper parameters is important to obtain the desired quality of weld. Laser power, welding speed and beam diameter are selected as process parameters. A statistical design of experiment (DOE) is used to optimize selected LBW parameters. The experiments are designed with full factorial approach. Butt welding trials are conducted as per DOE using 100W SPI fiber laser source in the continuous wave mode on 0.2 mm and thick sheet.

### I. INTRODUCTION

**1.1 Laser welding :** The main factors for welding processes used in industry today are the source of energy used for welding and the strength of welded joint obtained. Various laser welding technologies are used in the manufacturing industry, especially in the fabrication of small components for electronics, aerospace, biomedical, micro-electro-mechanical systems (MEMS)[1]. The advantages of laser welding over conventional fusion welding processes include precise welds with a high aspect ratio, narrow, heat affected zone, high welding speed, low heat input and an efficient process. It is very difficult to weld thin metal sheets using conventional methods because the excessive heat input leads to blow holes in the bead. Lasers differs not only with respect to wavelength or optical power from each other but also in the way how the power is emitted. Laser can be used in distinct modes of operation. The most important of which are CW operation, Quasi-CW operation, Gain switch operation, Q-switched operation, mode locked operation. The two types of lasers commonly used in are solid state lasers and gas lasers. Fiber laser is a type of solid state lasers. Fiber laser use a telecommunication grade diode to pump and optical fiber. This laser extremely compact and efficient and have superior beam quality and stability over a lamp pumped and diode pumped system. Basic construction of fiber is shown in the figure 1.

**Figure 1: Basic construction of fiber laser**



Advantages of fiber laser are good reliability and lifetime, high stability of laser output leading to consistency of processing, small size of overall unit, generally longer warranty than standard lasers, option of air cooled or water cooled up to a few hundred watts output power, integrated damage protection against back reflection issues, etc.

Operating characteristics of laser beam welding includes beam power (W), welding speed (mm/min), beam diameter (μm), power density (W/cm<sup>2</sup>), beam angle, beam width. Different applications of laser welding are in automobile industry, medical equipment, electronics and electrical industries, [12][13] etc.

### 0.2 Stainless steels:

Stainless steels contain chromium, nickel, and other alloying elements that keep them bright and rust resistant in spite of

moisture or the action of corrosive acids and gases. Stainless steels are used for the pipes and tanks of petroleum refineries and chemical plants, for jet planes, and for space capsules. The stainless steel are classified as,

1. Austenitic Stainless Steels
2. Ferritic Stainless Steels
3. Martensitic Stainless Steels
4. Duplex stainless steels

**Table(1) Classifications of Stainless steels[14]**

Steel Type	AISI Grade	C max.	Si max	Mn max	Cr	Ni
Austenitic Stainless Steels	301	0.15	1	2	16-18	6 to 8
	302	0.15	1	2	17-19	8 to 10
	304	0.08 - 0.1	1	2	17.5-20	8-10.5
	304L	0.08	1	2	18-20	8-10.5
Ferritic Stainless Steels	405	0.08	1	1	11.5-14.5	
	409	0.08	1	1	10.5-11.75	
Martensitic Stainless Steels	410	0.15	0.5	1	11.5-13.0	
	416	0.15	1	1.25	12.0-14.0	
Duplex stainless steels	Type 329	0.1	1	2	28	6
	Type 326	0.05	0.6	1	26	6.5

The austenitic stainless steels generally have higher tensile strengths, reduction in area is about the same for both groups and higher elongation than the ferritic stainless steels but lower yield strengths. Table shows mechanical properties of AISI 304 Stainless steel.

**Table(2) Mechanical properties of AISI 304 stainless steel**

S.no	Property Name	Units	Value
1.	Tensile Strength	Mpa	586
2.	Compression strength	Mpa	210
3.	Proof stress 0.2%	Mpa	241
4.	Elongation (%)	Mpa	55

### II. LITERATURE REVIEW

Anawa et al.[2] by using Taguchi Method has optimized welding pool of dissimilar AISI 316 stainless steel and AISI 1009 low

carbon steel plates. They have optimized Laser power, welding speed and defocusing distance for good quality of weld. From their study they concluded that Laser power has strong effect on fusion area. By changing the laser power value the response will be changed dramatically. The focusing position parameter has insignificant effect on the total weld pool size.

**Y. Okamoto et al.[3]** studied fine micro-welding of thin stainless steel sheet (25µm). Single-mode cw Yb-fiber laser (SPI SP-100C) of 1090 nm in wavelength and pulsed Nd:YAG laser (HAAS HL62P) of 1064 nm in wavelength were used as a laser source in this study. They conclude that, a narrow welding region obtained using a laser beam with a large focus diameter of 160 µm without pulse control, while a small focus diameter of 22 µm was found in general to provide good control of the welding state. A small focus diameter could result in an excellent welding seam from the start, even without pulse control. The penetration depth could be controlled by the energy density with a small focus diameter of 22 µm at the energy densities less than 1 J/mm<sup>2</sup>.

**A.Klimpel et al.[4]** has studied welding process of Butt joint of AISI 321 of 0.5 mm and 1 mm thick. They used high power diode laser (HPDL) machine for welding. To protect weld root from oxidation shielding gas supplied from copper backing plate. They concluded as, At constant welding speed, Increase of beam power resulted increase of bead width and depth of penetration & also increase width of HAZ. Increase in welding speed at constant beam power resulted decreasing of bead width and depth of penetration. Bending test showed high plasticity of joint. Tensile strength of 1 mm thick specimen were not lower than strength of base material because all specimen broken at base metal. But 0.5 mm thick specimens had broken at the weld region.

**Jose Roberto Beretta et al.[5]** Investigated the technique to weld AISI 304 stainless steel to AISI 420 stainless steel of 0.8 mm thickness of stainless steel sheet by pulsed using the Nd:YAG laser technique. They have studied influence of laser beams position on the weld characteristics such as its geometry, depth of penetration, formation of cracks and pores by moving the beam on 0.1 mm and 0.2 mm on either side of joint. They observed under all welding conditions that the joints were uniform. They observed that variation in beam position did not affect the fillet geometry. They observed the microstructures of joints in scanning electron microscope. Energy dispersive spectroscopic measurements were done to determine wt% of chemical elements (Cr, Ni, and Fe) and observed that these chemical elements in the fillet cross section were influenced by laser beam position with respect to joint. Gradual reduction in hardness occurs along the cross section of the weld area when the laser beam shifts in the direction of AISI 304 from AISI 420 stainless steel.

**G.R. Mirshekari, A.Saatchi, A.Kermanpur, S.K.Sadrnezhaad** [6] have shown in their work a comparative study on laser welding of Ni-Ti wire to itself and to AISI304 austenitic stainless steel wire. Microstructures, mechanical properties and fracture morphologies of the laser joints were investigated using optical microscopy, scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), X-ray diffraction analysis (XRD), Vickers micro hardness (HV0.2) and tensile testing techniques. The results showed that the NiTi-NiTi laser joint reached about 63% of the ultimate tensile strength of the as-received NiTi wire with rupture strain of about 16%.

**Lifang Mei, Genyu Chen, Yi Zhang, Xiang zhong Jin** [7] presented useful results on deep-penetration laser welding of high-strength galvanized stainless steel sheets, carried out by the CO<sub>2</sub> laser unit with maximum power output of 1.5kW. Due to laser heating and the recrystallization the hardness distribution, microstructures and the elemental distribution of the joints which are welded can be changed. Static tensile testing was also carried out so as to determine the mechanical properties of the joints. With experimental results it was shown that both micro-hardness and strength of welded joints were higher as compared to that of the base metal.

**A.G. Olabi, F.O. Alsinani, A.A. Alabdulkarim, A. Ruggiero, L. Tricarico, K.Y. Benyounis** [8] Laser power effect, focal point position on mechanical properties welding speed and on operating cost was investigated using response surface methodology (RSM). The experimental plan was based on Box-Behnken design; the result showed that the welding speed is the most effective parameter affecting the main weld bead dimensions as the area and the middle width.

**Mingjun Zhang, Genyu Chen, Yu Zhou, Shenghui Liao** [9] examined the effect of the processing parameters on the weld bead geometry and investigations of the microstructure and mechanical properties of the optimal joint were done. For achieving good full penetration joint there is a critical range of welding speed. The result shows that the focal position is a key parameter for thick plates in high-power fiber laser welding. Bottom shielding gas improves the stability of the entire welding process and yields good weld appearances at both the top and bottom surfaces. The obtained maximum tensile stress of the joint was 809 MPa.

**K. R. Balasubramanian, G. Buvanashakaran and K. Sankaranarayanan** (2006)[10] have worked on Mathematical and ANN Modeling of Nd: YAG Laser Welding of Thin SS Sheets. They have investigated Laser welding of Austenitic stainless steel (AISI 304) of thickness 3.0 mm using 2 kW CW Nd: YAG laser. The effect of laser power (0.6-1.4 kW), welding speed (0.8- 2 m/min) and shielding gas flow rate (5 -15 l/min) on the weld-bead geometry i.e. depth of penetration (DOP), weld bead width (BW) was investigated.

**P. Sathiya, K. Panneerselvam, R. Soundararajan**[11] showed that in determining the quality of a weld joint laser welding input parameters play a very significant role. The weld bead geometry such as depth of penetration, bead width (BW) and tensile strength of the laser welded butt joints made of AISI 904L super austenitic stainless steel were investigated in this study. Full factorial design was used to carry out the experimental design. The good agreement between the theoretically predicted (GA) and experimentally obtained tensile strength, depth of penetration and also the bandwidth which confirms the applicability of these evolutionary computational techniques for the optimization of process parameters in the welding processes.

Extensive literature survey was carried out for acquiring the knowledge of effect of process parameters on mechanical properties of laser welded stainless steel. From the literature survey one can conclude that laser butt joint welding is governed by various process parameters and each one of them have potential of affecting the desired output. Therefore it is required to analyse the parameters very carefully. After studying the literature we know that research had done in the area of laser welding is limited to pulsed energy input, spot welding and lap joint, very few research done on continuous as well as butt type joint. So continuous butt welding need to be analysed. The factors selected for experimentation as well as further optimization are laser beam power, welding speed and beam diameter.

The main objective of the work is to study the relationship between weld strength and welding parameter for AISI 304L stainless steel using fiber laser. Scope of the project is to evaluate and analyse feasibility of fiber laser for continuous welding of AISI 304L stainless steel.

#### Subobjectives are:

1. Selecting process parameters to obtain maximum weld strength.
2. Examining weld by destructive testing.
3. Determining variation in the weld strength by graphical technique

### III. DESIGN OF EXPERIMENTAL PREREQUISITES

#### 3.1 EXPERIMENTAL SET UP

In this study fiber laser is used for laser welding. It consists of following subassembly,

1. Fiber laser machine with chiller
2. Laser head
3. XY Stage and microcontroller

**3.2 WORKING OF FIBER LASER SYSTEM:**

Laser beam transmitted through optical fiber cable to laser head, it gets concentrated with the help of lens of 100 mm focal distance. Laser pointer is used to align the laser beam with joining line of specimen. Laser power is adjusted as per requirement from computer system. Fixture placed on the top of XY stage used to clamp and position the specimen and speed is controlled with microcontroller. Figure 3.4 shows actual setup of fiber laser system. Once the beam is align with joining line welding process starts, by adjusting laser power, welding speed and beam diameter[15]. Then the welded specimen de-clamped.

**Figure 2: Set up of Fiber Laser system**



**3.3 SELECTION OF TYPE AND SIZE OF MATERIAL.**

In present scenario, not much development has taken place in joining thin plates of stainless steel in butt weld configuration. So there is a wide scope to carry out analysis of laser butt welding for stainless steel. Considering the above factors, sheets of AISI 304 with thickness 0.2mm and 0.5mm are selected for experimental work.

**3.4 PREPARATION OF SPECIMEN**

To check weld quality test like tensile test, bending test, weld examination etc. are required to carry out. Each test has its own size and shape specification e.g. for tensile test dog bone shape specimen required.

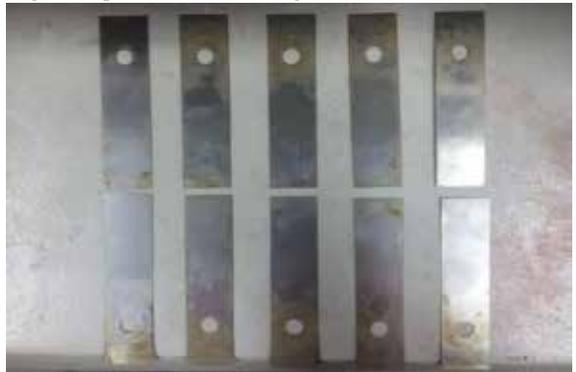
The standard tensile test specimen is prepared. The rectangular pieces of the sizes 103X30X0.2 mm are cut from the sheet of AISI 304 steel, with the help of hydraulic operated shearing machine. Since the edges of the above pieces had deformed in it, so they are further finished with wire electric discharge machine (WEDM) shown in Figure 3.5. To reduce efforts, a stack of all plates are prepared by C clamp and the finish cut perform on whole stack.

**Figure 3:Wire EDM (Electric discharge machine)**



To serve this purpose surface of specimen to be joined for butt joint is polished on different grade of polish papers in increasing order of its fineness. The main purpose behind this polishing process is to get uniform surface finish without disturbing straightness of the specimen. Following Figure 4 shows specimen which are ready for welding.

**Figure4:Specimen for welding**



**Figure 5: Welded specimen as per ASTM**



After cleaning the specimen with acetone, the specimen are welded on fiber laser and then converted in to standard size as per ASTM on wire EDM machine. Figure 5 shows welded specimen as per ASTM standard.

**Figure 6: Sample preparations for microstructure analysis**



The standard dog bone shape made after welding instead of making two half dog bone shape and join together because initially reflectivity of material is more, weld form at the start and end may be weak, so properties of weld differs than original. It is better to weld the plate first and then cut it in required shape and finally the sample is prepared for further microstructure analysis.

**2.5 WELD STRENGTH TESTS :**

This test is carried out to find tensile strength of welded joints. Sample used for Weld strength (tensile strength) test had the shape as shown in figure 5, the tensile strength is referred as weld strength. Electronic Tensometer Tester shown in Figure 7 is used to conduct tensile test. The maximum capacity of this machine is 20KN. There is a provision to adjust test speed in mm/min.

Figure 7: Setup of Electronic Tensometer Tester



**IV. EXPERIMENTAL WORK**

Analysis of the Laser butt welding identifies the need of conducting series of experiments for:

1. Evaluating the feasibility of butt welding of stainless steel plates by Fiber laser
2. Examining the shape and size of weld zone
3. Determining variation in the weld strength,

In tune with these objectives, this chapter covers the details of the procedures, observations and results of the experiments.

**4.1 STEPS IN EXPERIMENTATION**

The experiments are planned for laser butt welding for stainless steel plates using SPI Fiber Laser as below:

- 1) Performing pilot experiments to identify the process parameter range.
- 2) Preparation of Welding plates on fiber laser
- 3) Perform tensile test.
- 4) Examination of depth of penetration of welding in base metal by checking its microstructure.

**4.1.1 Pilot experiments:**

To decide level of process parameters pilot experiments are carried out by varying processing parameter like Laser power, welding speed and beam diameter. Results of pilot experiments are shown in table 3.

Table (3) Result of pilot experiments

Welding speed 4 mm/s			Power 50 W			Power 90 W		
Beam diameter 100µm			Beam diameter 100µm			Beam diameter 100µm		
Sr. No.	Power	Remark	Sr. No.	speed	Remark	Sr. No.	speed	Remark
1	50	Weld	1	4	Weld	1	4	Weld
2	55	Weld	2	6	Weld	2	6	Weld
3	60	Weld	3	8	Weld	3	8	Weld
4	65	Weld	4	10	Weld	4	10	Weld
5	70	Weld	5	12	Weld	5	12	Weld
6	75	Weld						
7	80	Weld						
8	85	Weld						

The level of process parameters are decided for further experiments depend on above experimentation. Pilot experiments are carried out as per combination shown in Table 4.1. After pilot experiments, the specimens are inspected and it has been observed that weld quality look better for laser power 75 to 85 W and for a speed 4 to 6mm/s. So from this result of pilot experiments, the level of process parameter listed in Table 4.

Table (4) Process parameters and design level

Sr. No.	Variables	Factor Symbol	Unit	Focal		
				1	3	5
1	Beam Power	P	W	70	75	80
2	Welding Speed	S	mm/s	4 to 10	4 to 12	4 to 12

**4.1.2 Welding Procedure**

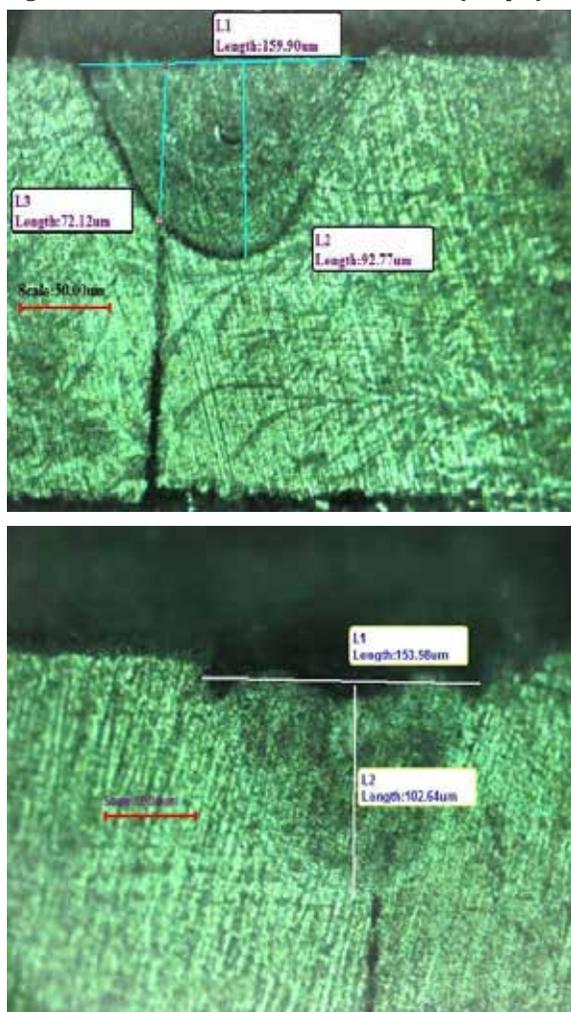
The specimens are cleaned with acetone and then clamped on fixture. The joining line of specimen is aligned with laser beam with the help of laser pointer and screws of fixture. Nitrogen gas is used as a shielding gas with a constant flow rate of 20 LPM, in this experiment the laser beam is focused on welding line.

**4.1.3 Examination of depth of penetration of welding in base metal by checking its microstructure**

The welded specimen are converted in to standard dog bone shape, the middle portion is used to check width of weld. The accurate size of width measured with the help of metallurgical microscope. The variation of weld width is shown in Figure.

Following figure shows microstructure view of laser welded component of Power=50W, welding speed=4mm/s, focal position=1; whereas next figure shows microstructure view of laser welded component of Power=70W, welding speed=10mm/s, focal position=1 for 0.2mm thickness SS 304L dog bone shape plate.

Figure 8: microstructures of 50041 and 70101 (sample)



**4.1.4 Tensile testing:**

Tension is test carried out with the help of Electronic Tensometer Tester shown in figure 3.9. The test speed is set as 0.5 mm/min, with a higher limit 2000N and minimum 20N for load. Gauge length used for experiments is 51mm as per ASTM standard. The result of tensile test concludes specimen fail in weld joint but the maximum value of stress is 1077.2

**V. EXPERIMENTAL RESULTS**

Experimental results for weld strength and width of weld and its graphs are obtained and are as in table below. Set 2 is carried out wherever necessary for the specimen. Data is presented on the graph as a result of varying power, varying speed and for depth of penetration.

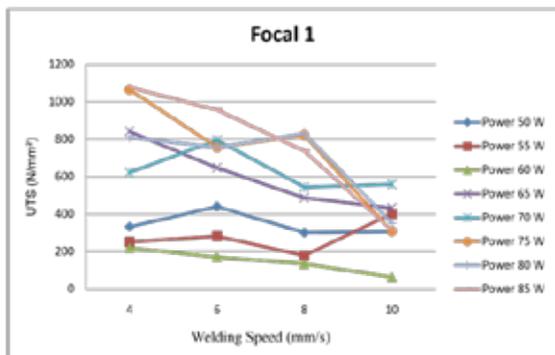
Power 50 W			SET 1				SET 2			
Welding Speed (mm/sec)	Peak Load (N)	UTS N/mm <sup>2</sup>	L1 (µm)	L2 (µm)	L3 (µm)	% Depth	L1 (µm)	L2 (µm)	L3 (µm)	% Depth
4	58.8	332	208.23	134.71	137.71	68.855	#	#	#	#
6	1118	440	142.63	102.15	102.15	51.075	167.27	94.74	80.68	40.34
8	764.9	301.2	165.46	110.66	110.66	55.33	142.45	80.88	52.91	26.455
10	774.8	305	157.45	91.37	40.89	20.445	148.19	82.93	30.58	15.29
Power 55 W			SET 1				SET 2			
Welding Speed (mm/sec)	Peak Load(N)	UTS (N/mm <sup>2</sup> )	L1 (µm)	L2 (µm)	L3 (µm)	% Depth	L1 (µm)	L2 (µm)	L3 (µm)	% Depth
4	768.35	302.5	172.21	102.67	32.21	16.105	155.19	86.49	55.08	27.54
6	715.9	281.9	161.35	127.33	59.52	29.76	154.26	99.77	#	#
8	451.12	177.6	118.91	88.33	88.33	44.165	162.44	95.74	44.48	22.24
10	1019.9	401.5	130.76	83.89	58.09	29.045	184.08	139.9	119.37	59.685
Power 60 W			SET 1				SET 2			
Welding Speed (mm/sec)	Peak Load(N)	UTS (N/mm <sup>2</sup> )	L1 (µm)	L2 (µm)	L3 (µm)	% Depth	L1 (µm)	L2 (µm)	L3 (µm)	% Depth
4	745.3	293	169.14	132.38	39.86	19.93	#	#	#	#
6	431.88	170	372.75	380.54	200	100	#	#	#	#
8	343.2	135.1	380.19	302.67	200	100	#	#	#	#
10	**	**	366	316.26	200	100	#	#	#	#
Power 65 W			SET 1				SET 2			
Welding Speed (mm/sec)	Peak Load(N)	UTS (N/mm <sup>2</sup> )	L1 (µm)	L2 (µm)	L3 (µm)	% Depth	L1 (µm)	L2 (µm)	L3 (µm)	% Depth
4	2137.9	841.7	176.74	165.34	158.18	79.09	68.67	##	#	#
6	1644.65	647.5	184.05	200.82	17.3	8.65	250.19	227.95	200	100
8	1235.7	486.5	151.56	102.15	102.15	51.075	340.91	285.83	200	100
10	1098.4	432.4	183.66	142.77	55.45	27.725	460.89	343.17	200	100
Power 70 W			SET 1				SET 2			
Welding Speed (mm/sec)	Peak Load(N)	UTS (N/mm <sup>2</sup> )	L1 (µm)	L2 (µm)	L3 (µm)	% Depth	L1 (µm)	L2 (µm)	L3 (µm)	% Depth
4	1578.9	621.6	149.12	111.43	102.08	51.04	181.79	122.57	110.54	55.27
6	245.2	96.5	231.29	181.64	200	100	#	#	#	#
8	1382.8	544.4	159.5	132.75	123.64	61.82	171.64	139.73	#	#
10	1422.2	559.8	153.49	96.22	85.86	42.93	208.46	171.64	82.21	41.105
Power 75 W			SET 1				SET 2			
Welding Speed (mm/sec)	Peak Load(N)	UTS (N/mm <sup>2</sup> )	L1 (µm)	L2 (µm)	L3 (µm)	% Depth	L1 (µm)	L2 (µm)	L3 (µm)	% Depth
4	2706.2	1065.6	375.01	281.26	200	100	434.16	338.67	200	100
6	1922.2	756.8	202.19	187.37	200	100	#	#	#	#
8	2088.9	822.4	169.12	73.57	105.61	52.805	#	#	#	#
10	931.67	308.9	##	##	##	##	213.74	203.45	##	##
Power 80 W			SET 1				SET 2			
Welding Speed (mm/sec)	Peak Load(N)	UTS (N/mm <sup>2</sup> )	L1 (µm)	L2 (µm)	L3 (µm)	% Depth	L1 (µm)	L2 (µm)	L3 (µm)	% Depth
4	2057.4	810	218.48	164.29	200	100	#	#	#	#
6	696.3	756.8	473.35	424.27	200	100	198.67	159.62	200	100
8	2108.1	830.1	367.68	267.16	200	100	201.35	169.56	200	100
10	353.1	139	186.42	134.89	200	100	#	#	#	#
Power 85 W			SET 1				SET 2			
Welding Speed (mm/sec)	Peak Load(N)	UTS (N/mm <sup>2</sup> )	L1 (µm)	L2 (µm)	L3 (µm)	% Depth	L1 (µm)	L2 (µm)	L3 (µm)	% Depth
4	2736.2	1077.2	571.21	529.62	200	100	#	#	#	#
6	2432.1	957.5	548.43	555.43	200	100	164.38	78.43	#	#
8	1873.1	737.5	387.26	287.14	178.43	89.215	215.81	139.43	126.23	63.115
10	**	**	167.12	154.43	200	100	213.74	169.28	200	100

**Abbreviations** : UTS: Ultimate tensile strength, L1: Top width, L2: Bottom width, L3: Depth of penetration

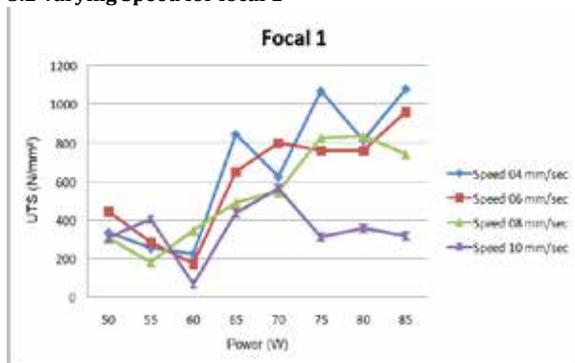
**Indications** :#: Reading not taken, ##: Reading not obtained, \* : Data from Remaining(1),\*\* : Data from remaining(2) i.e. data carried afterwards,- : microstructure not check With reference to the data obtained from experimentation,the obtained results are then plotted on graph as shown below,

**5.1 Varying Power for focal 1**

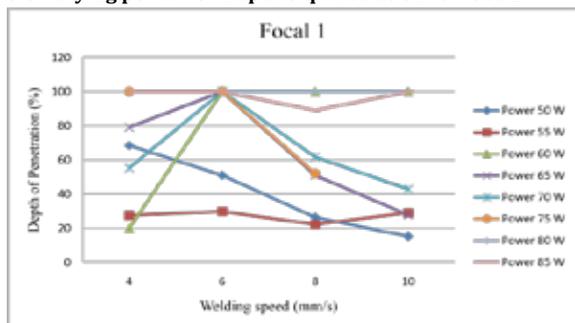
**4.3.1.1 Varying Power for focal 1**



**5.2 Varying Speed for focal 1**

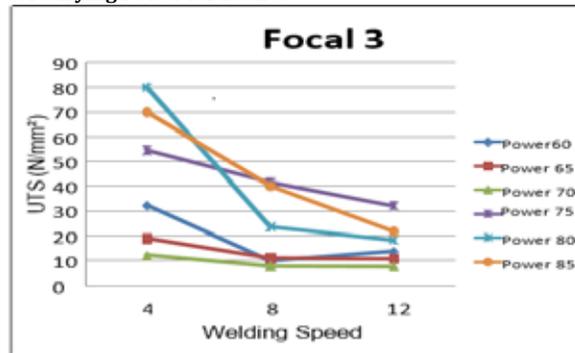


**5.3 Varying power for Depth of penetration for focal1**

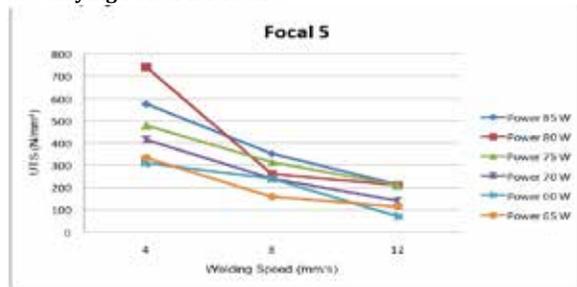


Similarly data is obtained for focal 3 and focal 5 and the results obtained are as shown in graphical representation below,

**5.4 Varying Power for focal 3**



**5.5 Varying Power for focal 5**



**VI. CONCLUSION**

Experiments are successfully carried out on austenitic stainless steel AISI304L plates of 0.2 mm thickness, to study the effect of process parameters i.e. Laser power, welding speed and focal position for butt welding by using 100 W fiber lasers.

By observing the above results and graphs we can say that weld strength is directly proportional to laser power (P) and inversely proportional to welding speed (S). The observations of model can be summarized below: (1) As laser power increases weld strength increases, also weld width will increase, (2) As welding speed increases weld strength decreases, also weld width will decrease, (3) Also increase in focal position causes decrease in weld strength. The value of Laser power, welding speed and focal position for achieving maximum weld strength are found to be 80 W, 4mm/s respectively. This is confirmed through the confirmation experiments where the maximum weld strength of 1077.2 MPa is obtained.

The conclusions derived out of the present investigation are summarized below:

1. Laser welding is a very successful process to join AISI304L stainless steel
2. Laser power has strong effect on fusion area. By varying the power input significant change can be observed in responses, so the amount of power applied should be carefully selected.
3. Welding speed has the stronger effect on the fusion area, which is inversely proportional to response.
4. It is necessary that the edges of the plate were cleaned and grinded along the weld line to ensure full contact.
5. Focusing position of the laser beam also affects the response in case of joining of AISI 304L and the main effect plot gives the maximum weld strength for P = 80 W, S = 4 mm/s and focal position 1.

**VII. FUTURE SCOPE**

1. As laser welding is successfully used to join AISI304L stainless steel plates of 0.2mm thickness in butt configuration. The weld strength of welded plates must be equal to or greater than that of base metal. In this study base metal strength is 586 MPa and achieved weld strengths are greater than strength of base metal. So it is required to carry out experiments for different levels of process parameters in order to achieve weld strength more than two times greater than strength of base metal. Generally, for power greater than 70 W, welding speed 4mm/s and focal position 1.
2. Experiments can be carried out for thickness like 0.2, 0.5mm in order to develop reference values of process parameters for butt welding.
3. Fiber laser welding can be utilized for welding of dissimilar metals in butt configuration. These material combinations are used in various applications e.g. Copper and stainless steel: Used in manufacture of solar panel.

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