Research Paper on an Experimental Investigation of Medium Carbon Steel & Steel Alloys-309 through Laser Welding

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Abstract— There are various effects of the Laser Power with Different Materials but in case of automobile industry and aerospace industry as per known used Medium Carbon Steel and Stainless Steel used. It's also considered here the tensile effects and heat affected zone with respect to Fiber Laser Welding Process. There are implements various laser Power used and also its effects. This investigation mainly based on input parameters like Laser power, Laser Speed and Focal Position, There is output parameters are Tensile strength, Heat affected zone and also want to check microstructure of the material after laser welding. There is method for analysis is full factorial method.

Key words: Laser Welding, Steel Alloys-309

I. INTRODUCTION

After this, physicists and specialists around the globe have joined "the race" to make up a good range of lasers. This "race" still exists in these days; consequently this range of science is still moderately new making. Laser bar fastening depends on the communication between a lightweight bar with a selected organization and therefore the work piece material. The pillar is focused domestically, making this fastening strategy a powerful thickness method. Diverse optical maser sources exist, for example, YAG, fiber, CO2. The fiber laser creates a lightweight emission optical quality for actual cutting and fastening activities. Because of the close Heat data, profound welds can be created at high warming and cooling rates. These procedure qualities make it conceivable to deliver accuracy joints with a restricted Heat influenced zone and forced work piece distortion resulting to fastening. The high Heat trade rates likewise have a constructive outcome when change of integrity totally different metals.

The different parameters which will be set and controlled throughout the fastening method for optimizing the heat input and so the penetration and weld quality for a selected application are:

1) Laser beam power and fastening speed,
2) In the case of pulsed optical maser fastening additionally the beam pulse frequency,
3) Duration and type, type and flow of shielding gas.

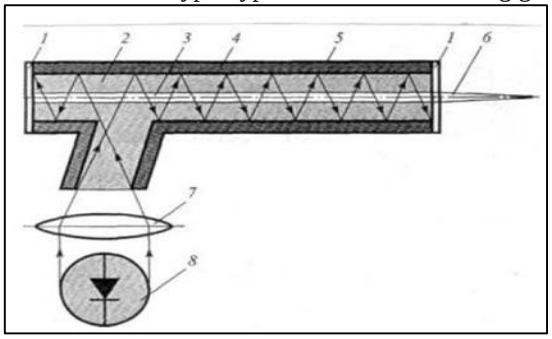

Fig. 1: Scheme of a fiber laser

1 Mirrors, 2 optical quartz fiber, 3 light-guiding activated fiber, 4 reflector coating, 5 protective shell, 6 a laser beam, 7 focusing lens, 8 LED

II. EXPERIMENTAL METHODOLOGY

In industry, planned trials can be utilized to deliberately examine the procedure or item variables that impact item quality. After you distinguish the procedure conditions and item segments that impact item quality, you can guide change endeavours to upgrade an item's manufacturability, dependability, quality, and field execution.

A. Full Factorial Design

Full factorial outline is utilized for concurrent investigation of a few component consequences for the procedure. By fluctuating levels of components at the same time we can discover ideal arrangement. Reactions are measured at all mixes of the exploratory element levels. The blend of the component levels speak to the conditions at which reactions will be measured. Every test condition is a run. The reaction estimation is a perception. The whole arrangement of run is an Design of Experiment. It is utilized to discover the variables which are the most impact on the reaction and their collaborations between two or more elements on reactions.

$$N = L^m$$

Where, L = Number of levels for each factor, M = Number of factors.

Three-level style is written as a 3k factorial design. It means thaZk factors are thought-about, each at three levels. These are referred to as low, intermediate and high levels. These levels are numerically expressed as zero, 1, and 2. One could have thought-about the digits -1, 0, and +1, but this could be confusing with relevance the 2-level styles since zero is reserved for centre points. Therefore, we can use the 0, 1, 2 scheme. Thus commonplace order condition of -1, 0 and 1 severally, 000 and 222 indicates all process parameters are at their low levels and higher levels severally.

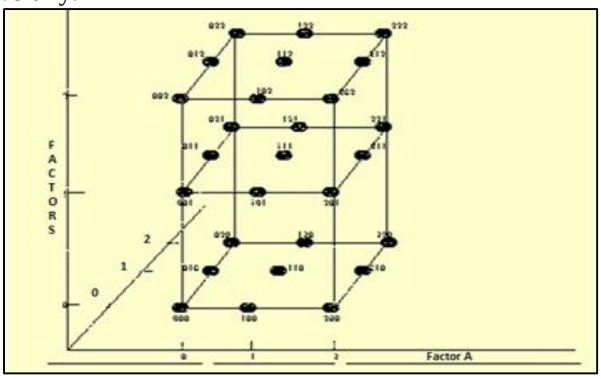

Fig. 2 Schematic diagram of 33 full factorial design of experiment

Fig.2 shows the geometric illustration of the style of experimentations. The set of 27 tests have been performed arbitrarily

B. Factors and Their Level for Fiber Laser Welding Machine

Process parameter	Unit	Level-1	Level-2	Level-3
Laser Power	W	400	500	600
Welding Speed	Mm/min	300	450	600
Focal Position	Mm	14	16	18

Table 1: Factors and their level for Fiber Laser Welding Machine

III. SELECTION OF LASER WELDING MACHINE

Fig 3: YLR-1000 Laser Machine

The Experiment were carried out Fiber Laser Welding Machine at (Sahjanand Laser Technology Limited Sector 26 GIDC, Gandhinagar.) with various Laser power, Speed and Focal position.

A. Work Material

– MEDIUM CARBON STEEL
– STEEL- 309

C	Si	Su	Ph	Mn	Ni	Cr	Ml	Vn	Co
0.18	0.35	0.09	0.017	1.45	0.019	0.016	0.04	0.08	0.031

Table 2: Chemical Composition of MEDIUM CARBON STEEL

C Max	Si Max	Mn Max	Cr	Ni	P Max	S Max
0.03	0.75	2.00	18.00/20.00	8.00/12.00	0.045	0.030

Table 3: Chemical Composition of STEEL- 309

Sr. No.	Laser power [W]	Welding Speed [mm/min]	Focal Position [mm]	Tensile Strength [MPa]	Heat Affected Zone [mm]
1	400	300	14	438	2.11
2	400	300	16	432	2.12
3	400	300	18	423	2.11
4	400	450	14	442	2.23
5	400	450	16	434	2.21
6	400	450	18	428	2.14
7	400	600	14	444	2.21
8	400	600	16	436	2.19
9	400	600	18	430	2.09
10	500	300	14	445	2.28
11	500	300	16	436	2.21
12	500	300	18	433	2.22
13	500	450	14	453	2.48
14	500	450	16	444	2.29
15	500	450	18	439	2.28
16	500	600	14	457	2.69
17	500	600	16	447	2.48
18	500	600	18	441	2.38
19	600	300	14	448	2.78
20	600	300	16	440	2.69
21	600	300	18	436	2.62
22	600	450	14	456	2.81
23	600	450	16	448	2.69
24	600	450	18	439	2.53
25	600	600	14	471	2.92
26	600	600	16	455	2.85
27	600	600	18	442	2.73

Table 4: Data ‘obtained from Laser welding process For Tensile Strength and HAZ.

IV. MAIN EFFECTS PLOT OF TENSILE STRENGTH

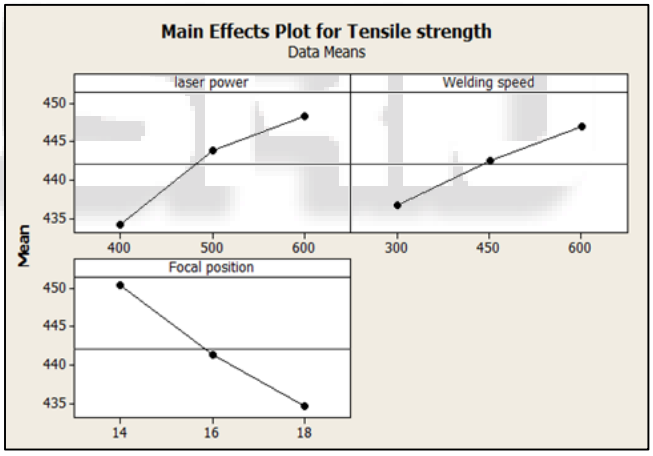

Fig. 4: Tensile strength Effect

V. MAIN EFFECTS PLOT OF HAZ

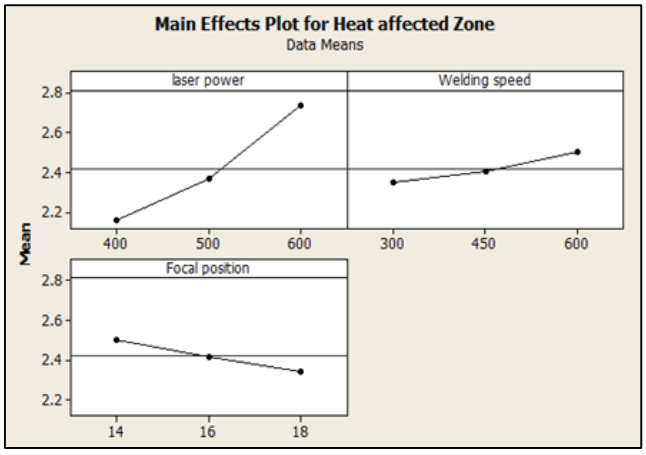

Fig. 5: Heat affected zone Effect

VI. REGRESSION CO-EFFICIENT FOR TENSILE STRENGTH

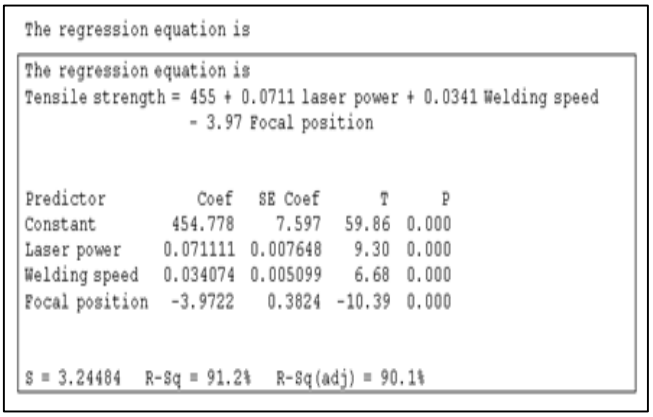

Fig. 6: Regression Equation

Predictor	Coeff.	SE Coef	T	P
Constant	454.778	7.597	59.86	0.0
Laser Power	0.071111	0.007648	9.30	0.0
Welding Speed	0.034074	0.005099	6.68	0.0
Focal Position	-3.9722	0.3824	-10.39	0.0

Table 6: Regression Coefficient for Tensile Strength

VII. REGRESSION COEFFICIENT FOR HEAT AFFECTED ZONE

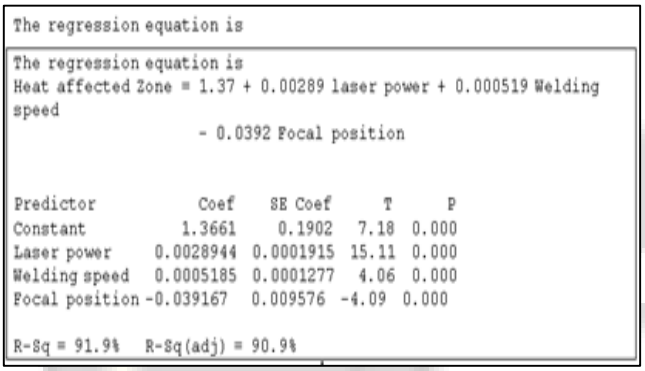

Fig. 7: Regression Equation

Predictor	Coefficient	SE Coef	T	P
Constant	1.3661	0.1902	7.18	0.000
Laser Power	0.0028944	0.0001915	15.11	0.000
Welding Speed	0.0005185	0.0001277	4.06	0.000
Focal Position	-0.039167	0.0095	-4.09	0.000

Table 7: Regression Coefficient for heat affected zone

VIII. CONCLUSION

Experimental investigation on Stainless steel grade 309 and Medium Carbon Steel material has been done using laser welding. The following conclusions are made.

1) The tensile strength increase with increase laser power and welding speed 400 to 600 watt and 300 to 600 mm/min respectively but tensile strength decrease with increase focal position from 14 to 18 mm.
2) While studying the effect of the process parameters on the tensile strength, it was observed that focal position and laser power play crucial roles in the effect on the tensile strength. The role of the welding speed is not crucial to the same extent.
3) The optimum condition for heat affected zone would be A1 B1 C3. The laser power kept at 400 watt, the welding speed kept 300 mm/min and focal position are 18 mm.
4) Through use of regression equation, engineer can manipulate range of process parameters for this particular work- material. Also it has been find out and predicted tensile strength and heat affected zone at any combination of process parameter.
5) Through use of response surface methodology, engineer can predicted and visualize manipulate range of process parameters for this particular work-material. Also it has been given intermediate value of process parameters which carried out the accurate study.
6) It has been seen that global solution for tensile strength are following: Laser power 600 watt, welding speed 600 mm/min and Focal position 14 mm. At these level, tensile strength are 466.722 Mpa
7) It has been seen that global solution for hardness are following: laser power 400 watt, welding speed 363.636 mm/min and Focal position 18 mm. At these level, heat affected zone is 2.09.

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