Determination of Power Value Effect in Laser Welding Method on Strength of AISI 430 Ti Stainless Steel

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Abstract
A Laser is a device that means light amplification by stimulated emission of radiation, can be obtained in various ways, and strengthens electromagnetic heat. The usage area of titanium alloys has been limited to only special production vehicles in recent years due to their high costs. Today, one of the most advantageous metals for the automotive and aerospace industry due to the advances in production techniques and low weight and high resistance against corrosion. The Laser welding method is one of the most important joining techniques due to its fixed properties. Power values one of the most effective parameters for joint strength. In this study, the effect of the power factor on joint strength during the welding process of the AISI 430 Ti stainless sheet was investigated. According to tensile test trials, observed that the rupture strength increases with the parameter of increased laser power but the value has been down after a certain point.

Keywords: Laser Welding, Titanium Alloy Metals, Tensile Test, Laser Welding Power, Laser Technology, Metal Joining.

Nomenclature			
P_d	power density	A_G	tensile elongation
P_{in}	laser beam power	R_B	rupture strength
D_b	focus point diameter	A_{80mm}	elongation at rupture
m_E	elasticity module	L_0	measuring length
$R_{p0.2}$	value of 0.2% permanent elongation amount	a_0	thickness
R_m	tensile strength	b_0	width
F_m	maximum force	S_0	breaking surface area of the sample

1. Introduction

Metal joining with the laser welding method is one of the production methods used in the sheet metal industry.[1](Fig. 1) According to other welding methods limited welding zone, precise adjustability, and capable of different types of metals special properties of laser welding technology.[2, 3, 4]

Titanium metal was discovered in 1791 by William Gregor. The specific gravity of the titanium material is 4.51 g / cm[3] and the melting temperature is 1680˚C. AISI 430 Ti is one of the most common Titanium alloys. The steel stabilization is enhanced with Titanium. It contains X3CrTi17.

[5, 6, 7] Titanium and its alloys can be used surgical splints, vascular stents, metal, automotive, and aerospace industry.[8] Titanium alloys have mostly usage areas with laser welding technology. It has strong resistance, high corrosive resistance, high-temperature resistance, easy soldering, and easy welding.[9, 10, 11]
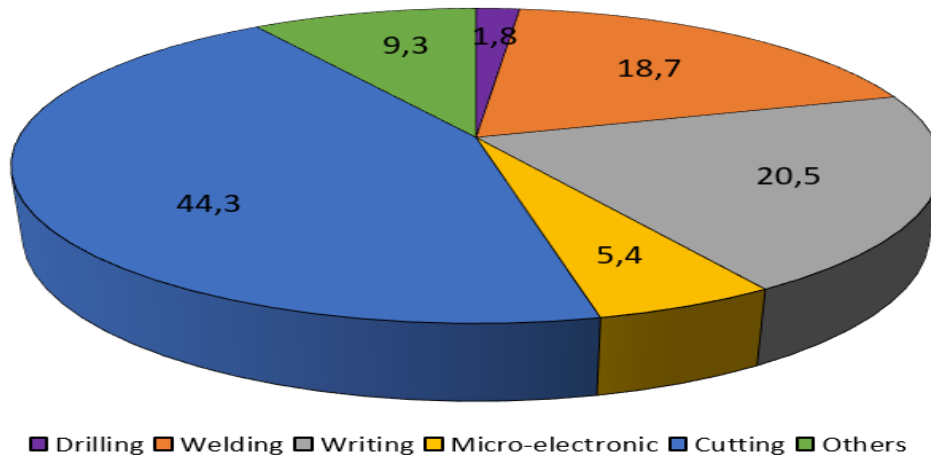
Fig. 1: Distribution in the usage areas of lasers[12]

Laser power, welding speed, and focus point are the most important parameters for joint strength at laser welding.[11, 13] The parameters affect strength of the joint due to mostly penetration depth and melted area. Beneficial of this method, interface reaction is less than the others.[14, 15, 16]

In this study, as mentioned above, samples that have been prepared with two different laser welding powers were subjected to tensile tests. Investigations were made to define how metal joint strength is affected by laser power. Thus, the effects of laser power on joint strength were examined by comparing two different values; the data has been reported with experiments and investigations.

2. Materials and Experiments

In this study, AISI 430 Ti ferritic Titanium alloy stainless steel that chemical composition is given in Table 1, is used. The sheet used has 0.6 mm thickness. The sheets are welded with TRUMPF LASER argon gas welding machine in different laser beam powers, without using additional metal.

Table 1: Chemical composition of AISI430 Ti alloy[17]

Chemical Element	Carbon (C)	Chromium (Cr)	Titanium (Ti)	Manganese (Mn)	Phosphorous (P)	Silicon (Si)	Sulfur (S)	Iron (Fe)
Percentage%	0.0 - 0.05	16.00 - 18.00	0.50 - 0.80	0.0 - 1.00	0.0 - 0.04	0.0 - 1.00	0.0 - 0.02	80.0-84.0

Determination of mechanical properties of joints, welded tensile test samples were made according to DIN EN ISO 6892-1. Three samples have been were prepared for both conditions.

Table 2: Parameters for study

Laser Power (Watt)	Welding Speed (m/min)	Shielding Gas	Focus Point Diameter (mm)
1350	5	Argon	0,9
1450	5	Argon	0,9

The experimental study has been done with two laser power values to a determination of power value effect on joint strength. The used laser welding parameters were saved in Table 2. Samples have been cut as are given in Figure 2.

Fig. 2: Sample pieces for tensile test

Tensile tests were applied 90° perpendicular on the machined samples to rolling direction accordance with DIN 50125 and DIN EN ISO 6892-1. Tensile tests were performed with ZWICK / ROELL 20kN tensile device. The mounted samples on the device have been shown in Figure 3.

Fig. 3: Mounted samplebefore tensile test

3. Results and discussion

$R_{p0.2}$ has been investigated between 1350W and 1450Wand downward trend was seen. In a similar study Uyguntürk et al., produced titanium alloy samples which were with different laser welding powers, applied tensile tests and they reported that R_p and R_B values with laser power downward trend after a certain point.[14]

Similar behaviour was seen for R_m at results. It was seen that the value decreasing with the increasing power parameter. It has been seen that when the material was welded by using higher power, it directly affects joint area its strength down after a certain value. In accordance to Akkurt et al., heat input rises up due to laser power increasing that causes negative effect Rm value.[18] Kökey et al. made similar researches, they verified positive relationship to a certain value between laser power and Rm.[19] R_B value was similar to the other strength values had a significant decrease in 1450 W.

Table 3: Tensile test results with different Laser welding powers

Power W	Sample Number	m_E GPa	$R_{p0.2}$ MPa	R_m MPa	F_m kN	A_G %	R_B MPa	A_{80mm} %	L_0 mm	a_0 mm	b_0 mm	S_0 mm^2
1350	1	170	402	489,5	5,7	12,8	386	25,3	80	0,6	20	12,8
1350	2	190	405	490,6	6	12,2	385	23,8	80	0,6	20	12,2
1350	3	183	409	494,6	5,9	11,9	392	24,4	80	0,6	20	12,1
1450	1	107	293	350,9	5,6	12,9	275	25,2	80	0,6	20	16,4
1450	2	140	320	380,2	6,1	12,1	335	24,9	80	0,6	20	12,1
1450	3	143	325	385,3	6,1	12,1	345	24,5	80	0,6	20	12,1

4. Summary

In this study has been experienced that titanium alloys with laser welding can be implemented a wide range of applications in the metal industry successfully. Effect of different laser welding power has been investigated on titanium alloy samples' strength. In comparison with 1350 W and 1450 W values, it was observed a significant difference at strength values in tensile tests. It has been proved strength trend has dropped after a certain point. For future steps, the effects of welding speed and focus point on joint strength additionally relationship between each other could be investigated.

Acknowledgement

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