ALUMINUM AND STEEL WELDING WITH 500 W FIBRE LASER
ALUMĪNIJA UN TĒRAUDA METINĀŠANA AR 500 W ŠĶIEDRAS LĀZERI

Author: **Raitis Dudenkovs**, e-mail raitezo3@inbox.lv, phone: +37125242603
Scientific supervisor: **Luybomir Lazov, Dr.sc.ing., Prof.**, e-mail lyubomir.lazov@rta.lv
Rēzeknes Tehnoloģiju akadēmija
Atbrīvošanas aleja 115, Rēzekne, LV-4601

Abstract: The study of the process of laser welding of various aluminum-steel joints is necessary to promote the possibility of realization of new products and designs in instrumentation and mechanical engineering. Laser welding, due to its many advantages, is considered a very promising process of joining different materials, although its application in industry is still limited. Welding aluminum with steel using laser sources is a challenging task mainly due to the formation of brittle intermetallic joints (IMC) at the joint interface. This paper aims to give a brief overview of some new research on laser welding of aluminum to steel, as well as to point out some of our initial laboratory research in this direction.[1]

Keywords: laser welding, aluminum, steel, welding load testing, lightweight manufacturing

Introduction

About a third of the emitted global anthropogenic greenhouse gases are due to modern industrial production. As a solution to the problem today, the development of new green technologies and the creation of new materials is proposed at all world forums related to environmental issues. The lightening of various product designs in mechanical engineering is considered an important strategy [2,3], which potentially leads to a significant reduction in greenhouse gas emissions [4]. In order to support multi-material design in industrial production, it is necessary to develop technologies for connecting different materials. In order to support multi-material design in industrial production, it is necessary to develop technologies for connecting different materials.

Recently, multi-material design in the construction of new products in the industry has received a great impetus to development, as a way to reduce weight, improve the productivity of technical products and limit costs [5]. This approach and research bring improvements in the overall effectiveness of the product, as it allows the application of the most appropriate material for each component according to the requirements of the technology and its practical application [6].

In construction, instrumentation, transport and mechanical engineering, steels and aluminum alloys are among the most important metals for various engineering applications [7]. Due to their relatively low price, high strength, strength, ductility, good weldability, etc. properties, steels are extremely attractive and widely applicable for various technical applications [8,9]. Aluminum alloys, in turn, are also preferred because they combine light weight, good molding, excellent thermal and electrical conductivity, high strength-to-weight ratio, and corrosion resistance and etc.[10].

Laser welding machine SUNTOP ST-FW500

A suitable laser was selected for the scientific experiment, which is designed for welding different materials. The power of this laser allows you to make welds in aisles of 1mm. This laser is located at the Rezekne Technology academy laser center and serves to educate students in laser work.

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Fig. 1. **SUNTOP FIBER LASER**

Key parameters:

Table 1.

Equipment model: SF-FW500	**Imput voltege : AC380V +- 5%, 50HZ**
Imput power : 14KW	**Max laser power : 500W**
Laser wavelenght : 1064nm	**Max. Current: 40A**

Material and parameters

Samples are prepared for experiments in steel and aluminum, material thickness 1mm and width 20mm, the length of the blanks is not an important parameter, because it does not affect the results in any way.

Steel S275 was used, which is used for tensile testing on the Zwick / roell z150 equipment, which is located in the Rezekne Faculty of Engineering building.

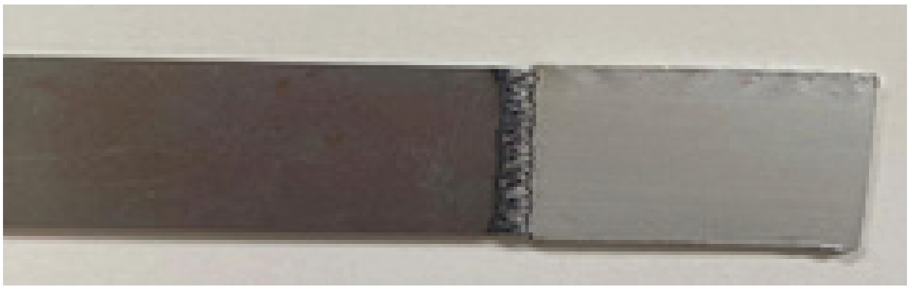

Fig.2. **Sample of aluminum and iron welding**

One of the most important factors to get a good weld is that the place where the weld will be made should have a well-ground edge of both blanks so that both materials touch as close as possible, if there are gaps of at least 0.5mm between them, then welding will not be possible.

Optimal parameters for the laser welding process

The main parameters of the welding laser are:

Table 2.

Current	Frequency	Pulse time / length	Laser head speed	Focusing area

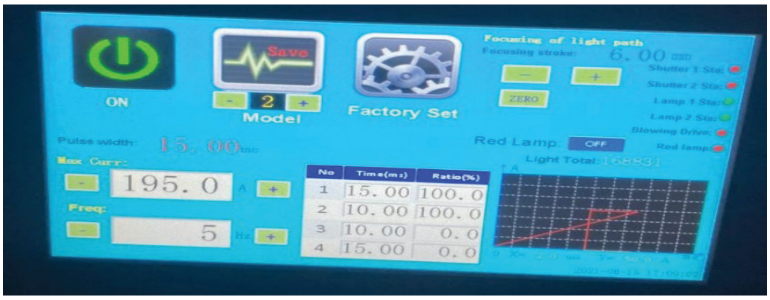

Fig.3. **Fibre laser control panel**

That also has two parameters that are not in the control panel, but are very important in the course of the experiment they are:

1) Direction of air discharge flow
2) G code and beam trajectories in motion

Table 3.

Parameters that managed to get the best results:

Current: 195A	Frequency: 5Hz	Laser head speed: 100%
Pulse time / length: 15ms (Table: 1-15ms; 2-10ms; 3-10ms; 4-15ms)		
Focusing time: 6.00mm	G code: ZIGZAG from right to left	
Air flow from the left side, distance from the work piece 100mm, angle 60 degrees.		

Experiment progress

All parameters were changed during the experiment, because initially it was not possible to obtain a welding seam at all. When the first results appeared, the parameters were divided into two groups: constant parameters - parameters that are adjusted and give the required result and the second group of parameters: variable parameters - parameters that can be changed. Changing these parameters had the most significant effect on the weld quality				
constant value	1) Focusing time: 6.00mm	2) Pulse duration / length: 15ms	3) G code: ZIGZAG from right to left	4) Air flow from the left side, distance from the workpiece 100mm, angle 60 degrees.

Table 4.

Changing the current and frequency are the two parameters that have a wide operating range and a visually visible effect when changes are made to these parameters.

Table 5.

Current	180A	185A	190A	195A	200A
Laser head speed:100% and Frequency: 5Hz	not enough	not enough	84kg tear resistant	102kg tear resistant	Too high

Table 6.

Frequency:	1Hz	3Hz	5Hz	7Hz	10Hz	15Hz
Current: 195A and Laser head speed: 100%	Too low	Too low	102kg tear resistant	86kg tear resistant	Too fast	Too fast

Not enough - power directly depends on the amperage during pumping, the laser beam has enough power to melt the material!
Too high - Too high temperature, metals melt and split in different directions!

Too low - The speed of the laser head is constant and the frequency is too low to heat the material in relation to the distance traveled by laser head per unit of measured time.

Too fast - Too high a frequency simultaneously makes the weld and at the same time destroys it by making through holes!

Tensile testing of welds
The computer program of the Zwick / roell z150 device constructed the following graphs:

In the weld test, the tensile strength test was performed on a Zwick / roell z150 machine, thanks to which it is known how much load a welding seam made of steel and aluminum can withstand. From the obtained graphs it is possible to obtain accurate results and perform data analysis and draw a conclusion. A total of five blanks were tested for strength. All five blanks have identical parameters. From which the approximate average result can be deduced.

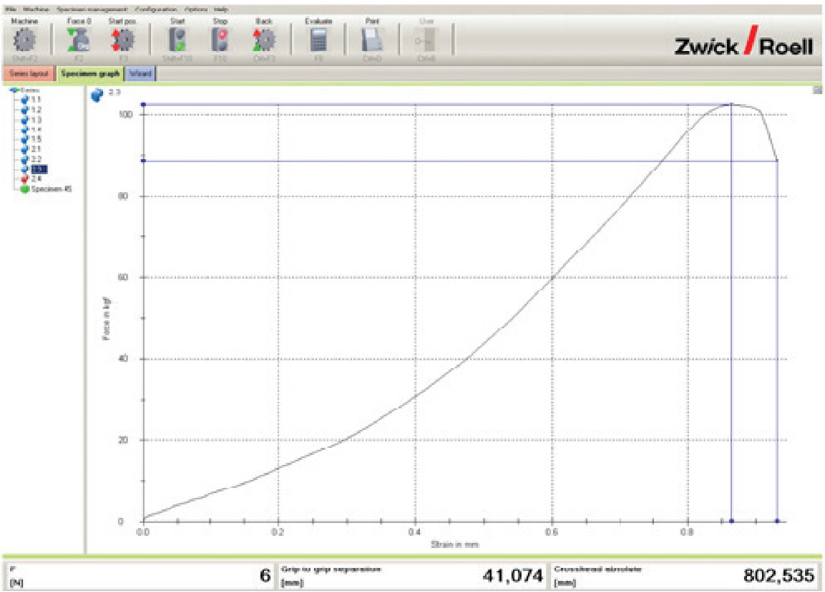

Fig.4. **Results for tensile test**

Conclusions

Analyzing the graphs, it can be concluded that on average in steel and aluminum welding the seam withstood 90kg tensile load, which is a good indicator, considering that the thickness of the workpiece is only 1mm.

However, it should be noted that the weld is fragile and if such a weld were used in structures where there is a risk of oscillation or impact, the weld will quickly lose its mechanical properties and crack.

In the future, it is necessary to perform experiments with more powerful welding lasers, and with different material thicknesses. To get more information about aluminium and steel welding.

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