Kerf Profile Analysis and Acceleration Modeling Based on Material S235 Thickness CO2 Laser-Cut Sheet Metal Neural Networks

Ciobanu Ana-Maria[1], Ciobanu Ioana Arabela[2]

Abstract: *I believe that laser power, laser cutting speed, position and CO2 pressure with which to cut S235 steel material of different thicknesses have a great contribution to be able to set the best parameters for laser cutting that influences the kerf. I did an experiment to optimize laser cutting with a 4020-watt laser. Three new steps were established to estimate a cutting profile deviation response (KPD) by estimating the total cutting area of the laser cut, characterizing these steps due to the difference between the resulting cutting profile and a straight cut. We concluded that the deviation of the kerf improved by 23.2 for the 2 mm sheet thickness, by 41.8 for the 6 mm sheet thickness, by 13.8 for the 10 mm sheet thickness, by 25.4 for sheet thickness of 15 mm.*
Keywords: *cutting, kerf, optimization, parameters, S235.*

1. INTRODUCTION TO LASER CUTTING

The great development of laser cutting is more developed than other cutting techniques because it has a higher power and is much easier to manage the cutting area [1,2].

In recent years, the engineering of known a development that could be observed in the improvement of the characteristics of the materials, which at present are produced on a larger scale [3]. S235 materials are used in the manufacture of rolled products for the construction of welded steel structures and other joints. [4]. In general, materials such as S235 have a low thermal conductivity that makes the laser cutting very good in terms of energy coupling which can be concluded that the cuts will be free of impurities and will be made without weight [5]. But at thicknesses exceeding 8 mm, mouth marks can be observed if the speed is not in accordance with certain standard parameters [6].

In order to solve these problems, it is recommended to have as many samples as possible in order to find the optimal cutting parameters for certain types of thicknesses for the S235 material [7]. The experiment can be validated only if it has been found that the best cut has been made in terms of quality [8].

2. PLANNING EXPERIMENTS

Typically, those that influence the S235 material are the following parameters: the power of the laser measured in watts, the speed at which it moves measured in millimeters per minutes, the position of the nozzle (it must be checked that it is not moved, or the nozzle is affected) and the pressure of the gas with which it is flowed.

Experiments will be made to find out the best position of the kerf on the following sheet thicknesses:

- 2 mm
- 6 mm
- 10 mm
- 15 mm.

3. DETERMINATION OF PARAMETER LEVELS

S235 plates with a thickness of 2, 6, 10 and 15 mm were used during the experiments that were performed. With the help of the developed cutting head, which precisely adapts the focal point of the laser beam to match the thickness and material of the sheet. This allows the fiber laser cutting system to consistently achieve optimum processing quality, despite its different thickness and sheet metal. The S235 material is processed in the production line.

In Table 1 you can see the parameters chosen for the thicknesses 2, 6, 10, 15 of the material sheets. The resulting values can be found in the table. Laser power is 4020 W for level - 1, 0, 1. Cutting speed: the highest speed for an entire cut. The values were disturbed by 13% and 42% decreasing. The gas pressure is between 3 and 8 bar. The position in which it was placed is as follows:

- level zero means half the thickness of the plate
- level minus one means 25% of the plate
- level plus one means 75% of the board.

Factors that have been chosen at certain levels to ensure that all reductions made will be successful. Table 1 shows the parameters selected for each sheet thickness. These values are justified as follows:

Laser power : A value of 2800 W was selected for level - 1 as a conservative number because the maximum laser power is 4020 W. It was increased to 115% (3220 W) and 135% (3900 W) for levels 0 and , respectively, 1.

Cutting speed : A proposed regression model indicated the maximum speed for a complete cut. These values were disturbed by 20% and 40% down.

Gas pressure : Within a typical range of 3 to 8 bar, the 5 bar medium was chosen and disturbed in steps of ± 2 bar.

Focal position : Zero level was assigned as half of the plate thickness, level - 1 was set as 25% of the plate and +1 was set as 75% of the plate.

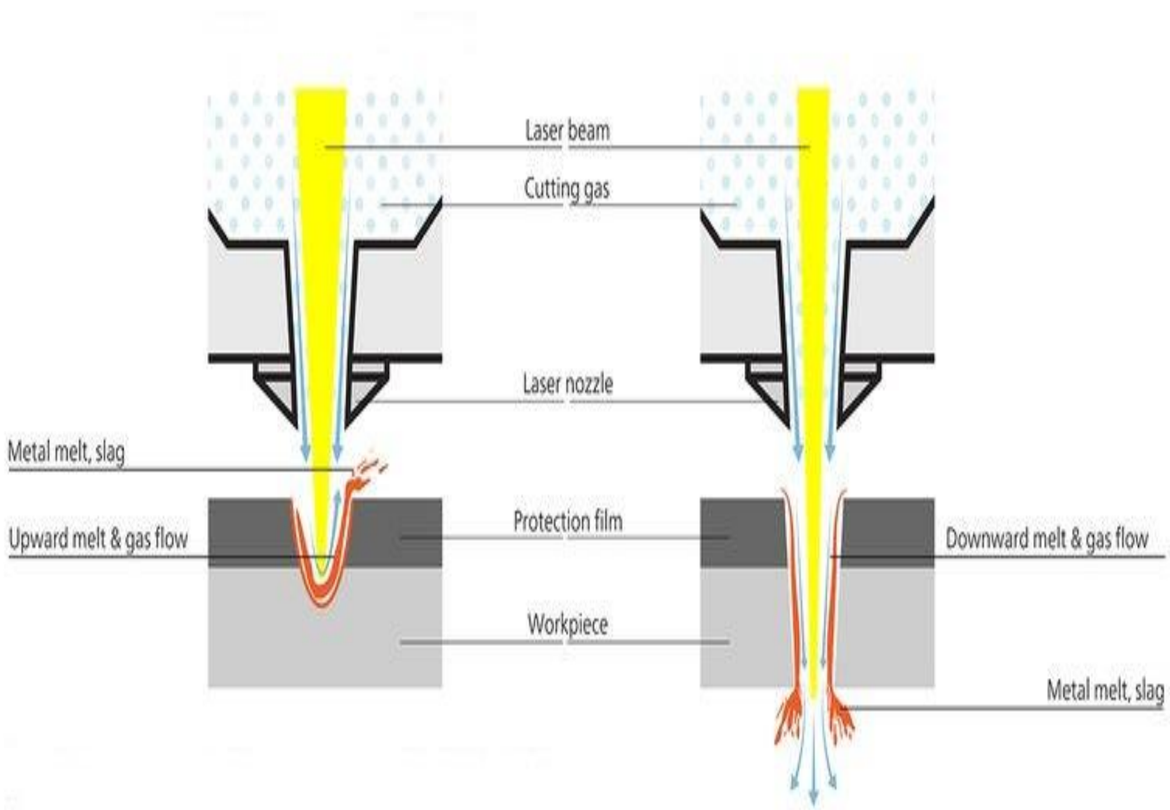

Fig. 1. Cutting gas and melt flow during the laser cutting process

Table 1. For the thicknesses of 2 mm, 6 mm, 10 mm, 15 mm of S235 material, the input level of the parameters -1, 0, +1.

Laser parameters	*Levels of input parameters*												*Unit of measurement*
	-1				0				+1				
	Thickness (mm)				Thickness (mm)				Thickness (mm)				
	2	6	10	15	2	6	10	15	2	6	10	15	
Cutting speed	16,3	6,3	3,8	2,1	22,4	8,3	5,7	3,5	26,3	9,8	6,4	3,1	MM/ MIN
Laser power	2,8	2,8	2,8	2,8	3,4	3,4	3,4	3,4	4.1	4.1	4.1	4.1	WATI
Gas pressure	3.1	3.2	3.3	3.4	5.1	5.2	5.3	5.4	7.1	7.2	7.3	7.4	BAR
Focal position	1	2	3	4	2	4	6	8	3	6	9	12	MM

4. PRINCIPLES FOR DETERMINING THE RESPONSE TO THE DEVIATION OF THE CUTTING PROFILE

To find the best combination of values for the process parameters, there were two criteria (surplus criterion, deficit criterion) for Kerf Profile Deviation (KPD) introduced.

The fit can be seen in fig. 2 was compared to the desired straight cut profile. Each criterion was established according to a different position of the straight cut in relation to the mounted curve in fig. 3. The requirements were based on the calculated distance between each point of the matching curve and the straight line of the profile. KPD is measured in mm.

From 0.2 mm to 0.2 mm the distance between the mounted curve and the laser cut was calculated and added together to obtain KPD. The distance in millimeters does not represent any physical value, ideally it would be to take into account the size of the measurements and the length of the piece to calculate a volume in cubic millimeters. In conclusion KPD is left in units of length for simplicity.

The surplus criterion refers to the KPD when it is set as the accumulated distance between the profile cuts and a straight profile fixed at the minimum measured point. This is the amount of material that could not be removed in time laser cutting process to get a straight cut.

The deficit criterion refers to the KPD when it is set as the accumulated distance between the profile cuts and a straight profile fixed at the maximum measured point. This is the amount of material unintentionally removed during the laser cutting process.

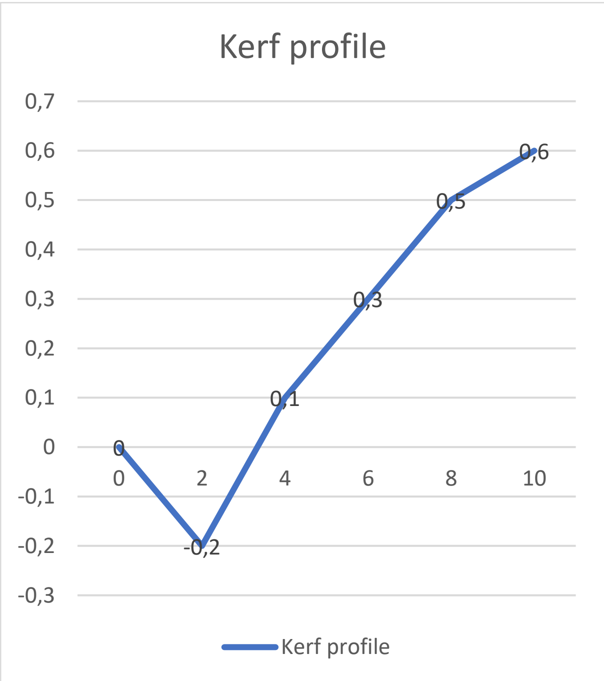

Fig. 2. The measured kerf profile representation graphical

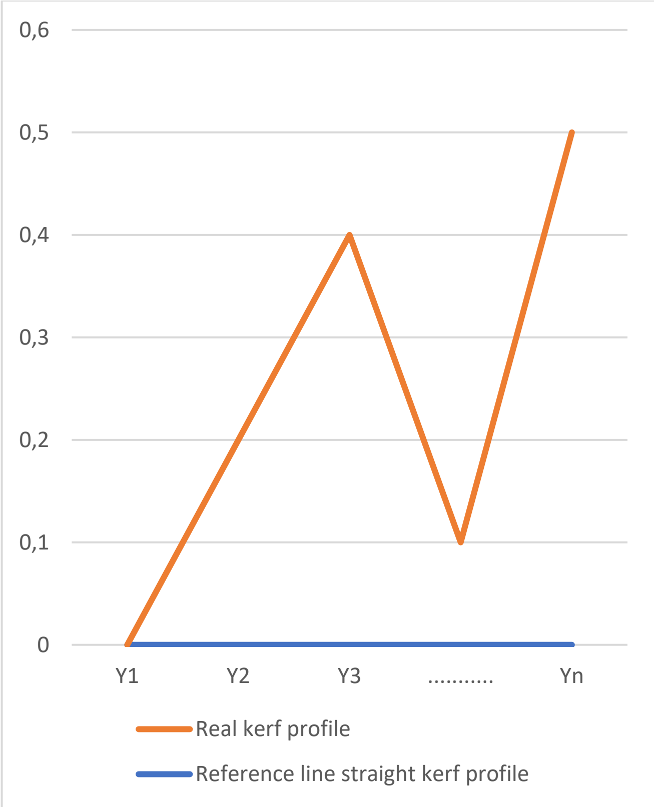

Fig. 3 . Graph of KPD measurements represented graphically

5. CONCLUSIONS

I came to the following conclusions:

1. Parameters were optimized by 23.2 for 2 mm sheet thickness, by 41.8 for 6 mm sheet thickness, by 13.8 for 10 mm sheet thickness, by 25.4 for 15 mm board.

2. It also matters a lot if the sheet is clean, dirty or rusty.

3. The sheet must not be deformed on a flat surface.

4. The nozzles must be cleaned and focused.

5. By studying the importance of the method variables under the two KPD response criteria that have been established, optimal levels have been found that improve the cutting profile where possible.

6. To reduce KPD, the optimal levels of the position point of interest parameters should increase. For laser cutting speed power, parameters must be increased and decreased for thicker plates, respectively, except for certain optimal parameters.

REFERENCES

[1] Z. Shang, et al., (2019) On modelling of laser assisted machining: Forward and inverse problems for heat placement control, Int. J. Mach. Tools Manuf 138. p. 36–50.
[2] M. Moradi, H. Abdollahi, (2018) Statistical Modelling and Optimization of the Laser Percussion Microdrilling of Thin Sheet Stainless Steel, Lasers in Engineering 40 (4–6) (2018) p. 375–393.
[3] A.B. Khoshaim, et al., (2021) Experimental investigation on laser cutting of PMMA sheets: Effects of process factors on kerf characteristics, J. Mater. Res. Technol. 11 p.235–246.
[4] E. Haddadi, et al., (2019) Experimental and parametric evaluation of cut quality characteristics in CO2 laser cutting of polystyrene, Optik 184 p. 103–114.
[5] T.H. Nguyen, et al., (2021) Artificial intelligence-based modeling and optimization of heat-affected zone and magnetic property in pulsed laser cutting of thin nonoriented silicon steel, Int. J. Adv. Manuf. Technol. 113 (11) p. 3225–3240.
[6] S. Xiong, et al., (2020) Numerical study on an electroosmotic micromixer with rhombic structure, J. Dispersion Sci. Technol. p. 1–7.
[7] S. Xiong, X. Chen, (2021) Numerical simulation of three-dimensional passive micromixer with variable-angle grooves and baffles, Surf. Rev. Lett. 28 (05) 2150037.
[8] S. Xiong, X. Chen, (2021) Numerical study of a three-dimensional electroosmotic micromixer with Koch fractal curve structure, J. Chem. Technol. Biotechnol. 96 (7)

Authors addresses

[1]*Ciobanu Ana-Maria, Kerf profile analysis and acceleration modeling based on material S235 thickness CO2 laser-cut sheet metal neural networks, University of Petrosani, strada Universității, nr. 20, 0747964022, ciobanu_ana_marya@yahoo.com*

[2]*Ciobanu Ioana Arabela, Kerf profile analysis and acceleration modeling based on material S235 thickness CO2 laser-cut sheet metal neural networks, University of Petrosani, strada Universității, nr. 20, 0732903829, arabelaciobanu@yahoo.com.*

Contact person

[*]*Ciobanu Ana-Maria, Kerf profile analysis and acceleration modeling based on material S235 thickness CO2 laser-cut sheet metal neural networks, University of Petrosani, strada Universității, nr. 20, 0747964022, ciobanu_ana_marya@yahoo.com*