Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
Make Harmony Between Technology and Nature, and Your Mind will Fly Free as a Bird
DAAAM Symposium

OPTIMIZATION OF CUTTING PARAMETERS IN LASER CUTTING OF HIGH ALLOYED STEEL 1.4828 (X15CRNISI20-12) USING O2 ASSIST GAS

CEKIC, A[hmet]; KULENOVIC, M[alik]; BEGIC, D[erzija] & BLIEDTNER, J[ens]

Abstract: *The main cutting parameters for evaluating the quality of the machined surface at the laser cutting are: kerf width, width of heat affected zone and surface roughness. It is imperative to get a product with a minimum kerf width and heat affected zone with achieving the required quality cut. This paper presents a comprehensive approach to optimization of processing parameters in laser cutting of alloy steel 1.4828* (X15CrNiMoSi20-12) *with a thickness of 3 mm. Cutting is carried out in the* CO_2 *laser with. Most influential parameters on the cut quality are varied such as: cutting speed, focus position and oxygen assist gas pressure. Significant improvements in decreasing the kerf width and width of heat affected zone as well as increasing the quality of the machined surface are achieved.*

Key words: CO_2 *laser cutting, cutting parameters, kerf width, HAZ, surface roughness*

1. INTRODUCTION

Due to the increased application of temperature resistance special alloyed steel in automobile industry, imposed the need for research aimed at optimization of cutting parameters in laser cutting of steel. Namely, in order to exploit the advantages that this technology allows primarily in terms of material savings and increase product quality is necessary to determine optimal cutting parameters for each processed material and thickness. The most important cutting parameters are: laser power, cutting speed, type and assist gas pressure, focus position, standoff distance and etc. (Al-Sulaiman et al., 2006). These parameters are set to ensure minimal trash of material and the required cut quality with maximum productivity.

The quality of cut can be evaluated according to standard procedures: by measuring the surface roughness, measuring the kerf width and deviation of kerf width in the length of cut, measuring of taper, determining the width of the heat affected zone, micro hardness measurements, metallographic examinations and the like.

The setting of process parameters which would satisfy both the desired cut quality and high productivity is specific problem (Rajaram et al., 2003). The influence of type and thickness material on the kerf width and heat affected zone during laser cutting of two high-strength steels is investigated (Lamikiz, et al., 2005).

The results show very different values of optimal cutting parameters when cutting thick and thin steel plates. (Avanish and Vinod, 2008) point out that so far carried out investigations of cutting parameters in laser cutting of certain materials and the influence of certain factors on the surface roughness, the heat affected zone, the kerf width, and productivity do not contain a comprehensive approach.

This paper presents a complete analysis of relevant influential parameters on the characteristics of the cut quality. The optimal cutting parameters in laser cutting of examined material 1.4828 (X15CrNiMoSi20-12) are defined with the aim of achieving the required cut quality with the maximum saving material.

2. EXPERIMENTAL PROCEDURE

Experimental investigations were conducted at the University of Applied Sciences Jena in Germany. The laser used in the experiment is a ROFIN DC020 CO_2 laser system with a nominal output power of 2000 W. Investigation of optimum cutting parameters was performed on high alloyed steel 1.4828 (X15CrNiMoSi20-12), with hardness of HB ≈ 252 and 3 mm thick. The geometrical shape of the sample and schematic illustration of various cut quality attributes is given in Figure 1.

During the experiment the following parameters are held constant: the laser power – 2000 W, mode of operation - cw, focal length of lens – 127 mm, focused spot size – 0,21 mm and nozzle diameter – 2 mm. Preliminary experiments were used to determine the best value of the standoff distance.

Namely, by increasing standoff distance increases the kerf width and heat affected zone, but it is possible to cut with less the assist gas pressure. Decreasing standoff distance leads to the partial absence of the continuous cutting process, especially when the focus position above the surface of workpiece. Therefore, the optimal value of standoff distance is 1 mm in laser cutting of the examined material by using oxygen as assist gas. Also, previous experiments have defined the acceptable intervals of variation of variable cutting parameters. In table 1 are shown the values of parameters that are varied during the execution of experiments.

Measuring the kerf width and width of heat affected zone was performed on the microscope, "Stem 2000 - C ZEISS" with magnification of 10x. Measurement of surface roughness is performed on Taylor Hobson device; it works on the principle of contact method. Ra value was measured at 18 locations and then the mean value was calculated (Cekic et al., 2008).

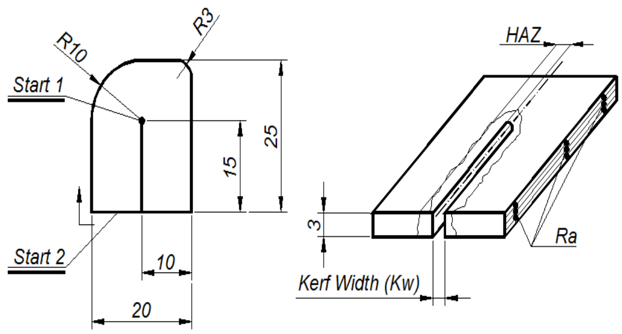


Fig. 1. The Sample Geometry and Schematic illustration of various cut quality attributes

Varied parameters	Values		
Cutting speed, V [mm/min]	2000	3000	4000
Focus position, FP [mm]	-1,0	0,0	1,0
Oxygen gas pressure, p [bara]	12,5	15,0	17,5

Tab. 1. Plan of the experiment

3. RESULTS AND DISCUSSION

In the figures 2, 3 and 4 are shown the influence of focus position, cutting speed and oxygen assist gas pressure (O2) on the kerf width, HAZ and Ra, respectively. Because of the clarity, the diagrams are shown in a combination of cutting parameters which are obtained the minimum and maximum values of these characteristics of the cut quality. It is evident that the smaller kerf width is obtained at cutting speed from 3000 to 4000 mm/min for all combinations of the position of the focus and pressure of used gas.

When cutting with the focus position FP = - 1 mm, heat affected zone decreases with increasing the cutting speed, it is particularly pronounced at lower gas pressures. Heat affected zone increases with increasing cutting speed of over 3000 mm/min for all combinations of gas pressure when the focus position on and above the surface of workpiece.

Minimum value of the parameter Ra is obtained when the focus position is above the workpiece with a maximum acceptable cutting speed.

In figure 5 are shown photographs of samples that are obtained with inadequate (figure 5a) and adequate (figure 5b) cutting parameters in CO_2 laser cutting of examined steel by using oxygen as assist gas.

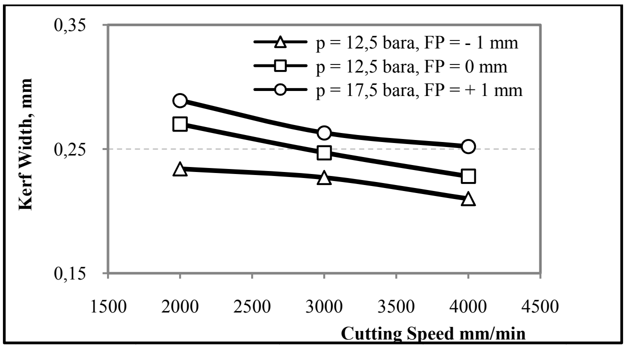


Fig. 2. Change the kerf width in cutting 3 mm thick steel 1.4828 using O2 as an assist gas

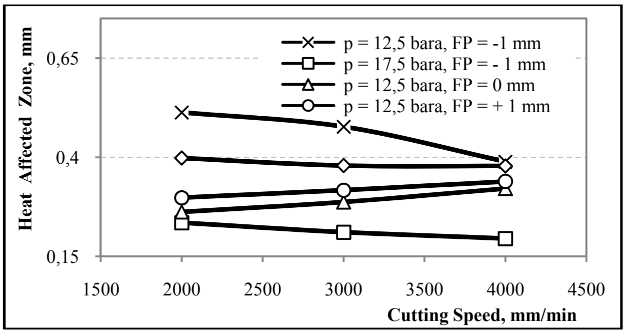


Fig. 3. Change the width of HAZ in cutting 3 mm thick steel 1.4828 using O2 as an assist gas

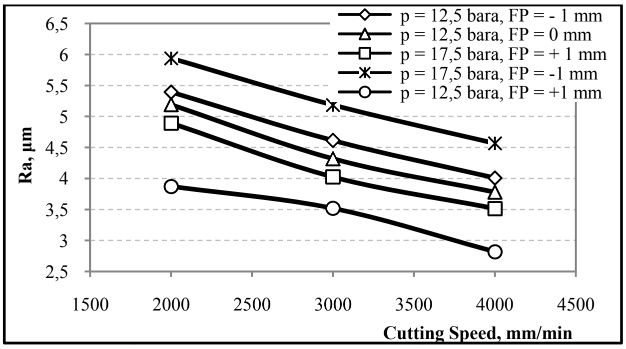
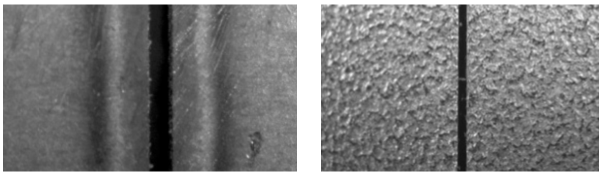


Fig. 4. Change the parameter Ra in cutting 3 mm thick steel 1.4828 using O2 as an assist gas



a) b)

Fig. 5. Photographs of samples during CO_2 laser cutting of high alloyed steel 1.4828

4. CONCLUSION

Impact of conducted research of cutting parameters on the quality of cut in CO_2 laser cutting of high alloyed steel 1.4828 using oxygen as assist gas is preformed. Conclusions are as follows:

- For these experimental conditions of research in laser cutting using oxygen as assist gas, the minimum kerf width (0.210 mm) is obtained when the following conditions: p=12.5 bar, V = 4000 mm/min, Wd = 1 mm and FP = - 1 mm.
- Width of HAZ decreases with increasing cutting speed and the minimum value (0.195 mm) is achieved under conditions: p = 17.5 bar, V = 4000 mm/min, Wd = 1.0 mm and FP = - 1 mm.
- Small variation of gas pressure is not getting a significant change in the quality of cut.
- Surface roughness increases from the entrance to the exit of the laser beam from the workpiece. To obtain a smaller value of the parameter Ra should strive as much as cutting speed, with the focus position above the workpiece.

The authors are planning further investigation based on cutting different thickness of material from related groups of alloy steels. Also, with consideration of different materials laminated form, it would be very interesting to perform additional testing cutting curved surfaces (pipes) and to different thicknesses.

5. ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support of the Department of Laser and Opto-Technologies at the University of Applied Science Jena, Germany for this work.

6. REFERENCES

Al-Sulaiman, F.A.; Yilbas, B.S. & Ahsan M. (2006). CO2 laser cutting of a carbon/carbon multi-lamelled plain-weave structure. *Journal of Material Processing Technology,* 173, (April 2006) page numbers (345-351), ISSN: 0924-0136

Avanish, K. D. & Vinod, Y. (2008). Laser beam machining-A Review. *International Journal of Machine Tools and Manufacture,* 48, (May 2008) page numbers (608-628), ISSN: 0890-6955

Cekic, A.; Kulenović, M. & Begic Dj. (2008). Roughness as parameter of cut quality during CO_2 laser cutting of high alloy steels for the special purpose. *Proceedings of the 19th International DAAAM Symposium*, Katalinic, B., pp. 225-226, ISBN 978-3-901509-68-1, Wienna, 2008, Published by DAAAM International, Austria

Lamikiz, A.; Lopez de Lacalle, L. N.; Sanchez, J. A.; Pozo, D.; Etayo.J. M. & Lopez. J. M. (2005). CO2 laser cutting of advanced high strength steels (AHSS). *Applied Surface Science,* 242 (April 2005) page numbers (362-368), ISSN: 0169-4332

Rajaram, N.; Sheikh-Ahmad, J. & Cheraghi, S. H. (2003). CO2 laser cut quality of 4130 steel. *International Journal of Machine Tools and Manufacture,* 43, (March 2003) page numbers (351-358), ISSN: 0890-6955