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
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DAAAM Symposium

LASER CUTTING OF TUNGSTEN ALLOY USING NITROGEN ASSIST GAS

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Abstract: *In this paper, CW CO_2 laser cutting of tungsten alloy is considered and effect of cutting parameters on the size of heat affected zone (HAZ), kerf width and surface roughness is investigated. The cutting parameters considered include laser power, cutting speed and nitrogen assist gas pressure. Results show that good quality cuts can be produced in CO_2 laser cutting of tungsten alloy thin sheets, at the cutting speed of 1000 mm/min and at the laser power of 2000 W under a nitrogen assist gas pressure of 15 bars.*
Key words: *CO_2 laser cutting, tungsten alloy, cutting parameters, cut quality*

1. INTRODUCTION

Laser beam machining is a modern processing that is mainly used for machining of all materials. A laser beam is utilized for material removal, such as operations for cutting, drilling, marking and welding, sintering, heat treatment. Laser is also used to perform turning and milling operations but the laser beam is often mainly used for cutting metal and non-metal plates and other shapes. So more than 60% of industrial lasers are used for cutting of which 85-90% are high power lasers (Gross, 2006). Of particular interest to manufacturers using laser cutting are the productivity and the quality of components made by laser cutting process. Both aspects are managed by the selection of appropriate laser process parameters, which are unique for each material and thickness. Consequently, investigation into the affecting parameters in laser cutting process is necessary to improve the final product quality. Most work reviewed in the literature considers only one or two characteristic properties of the laser cut surface to describe quality (Avanish & Vinod, 2008). Size of heat affected zone, kerf width, surface roughness and dross formed at the exit side are often used to describe laser cut quality. Some researchers (Hanadi et al., 2008) showed that the size of heat affected zone increases with increasing the laser power and decreases with increasing cutting speed and gas pressure. Oxygen gas as assist gas produces better surface roughness compared to air and nitrogen during laser cutting of tungsten composite materials using pulsed Nd: YAG (Uebel et al., 2008). They also observed that the nitrogen assist gas has developed an oxide free surface and a low discoloration, while the oxygen assist gas surface is strongly oxidized and discoloured. (Begic et al., 2009) analysed the effect of laser power, cutting speed and oxygen assist gas pressure on the cut quality in laser cutting of tungsten alloy. They defined the optimal cutting parameters in laser cutting examined alloy in using oxygen as assist gas.

However, we did not find in the literature many studies that consider the CO_2 laser cutting of refractory materials. Accordingly, the aim of this paper is to study the effect of the cutting parameters such as cutting speed, laser power and assist gas pressure on the kerf width, surface roughness and size of heat affected zone (size of HAZ) in CO_2 laser cutting of tungsten alloy in using nitrogen as assist gas, and hence obtain the optimum ranges of laser power, cutting speed and nitrogen assist gas pressure.

2. EXPERIMENTAL SETUP

In order to achieve the stated objective, laser cutting experiments were carried out using 1 mm tungsten alloy sheets to investigate the effect of laser cutting parameters on the cut quality. Experimental investigations were conducted at the University of Applied Science 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. The laser beam was focused using a 127 mm focal length lens. Nitrogen assist gas was used coaxially with the laser beam via a 2 mm exit diameter nozzle. Three main parameters have been selected for the present study. These are laser power, cutting speed and assist gas pressure. The laser power was varied within the range from 1500 to 2000 W, the cutting speed varied within the range from 1000 to 2250 mm/min, and the assist gas pressure from 7.5 to 20 bars. Testing the effect of one parameter on the cut quality requires the variation of one parameter while keeping the other two parameters at the pre-selected values.

The controlled parameters have been the top surface kerf width, the size of heat affected zone and the surface roughness. Fig. 1 shows examples of the measurements taken. Surface roughness on the cut edge was measured in terms of the average roughness Ra, using a Taylor-Hobson stylus instrument. Roughness was measured along the length of cut at approximately the middle of thickness. The kerf width was measured using a Stemi microscope fitted with a video camera and a zoom lens. It was also used for measuring size of heat affected zone as indicated by a distinct blue band.

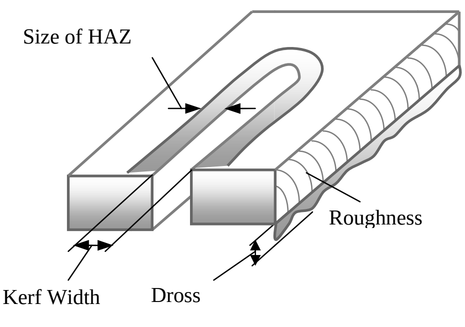

Fig. 1.The measured characteristics of the cut quality

3. RESULTS AND DISCUSSION

The effect of the laser power and the cutting speed on the heat affected zone and surface roughness is illustrated in figure 2 and 3, respectively. Experiments show that the size of heat affected zone depends of the cutting speed and laser power. Generally, an increasing in cutting speed and a decreasing in power results in a decreasing in the size of heat affected zone for the power range from 1500 to 2000 W. This can be explained in terms of the material ability to conduct heat. As the cutting speed increases, the time for heat conduction is lowered and the spread of heat damage is reduced.

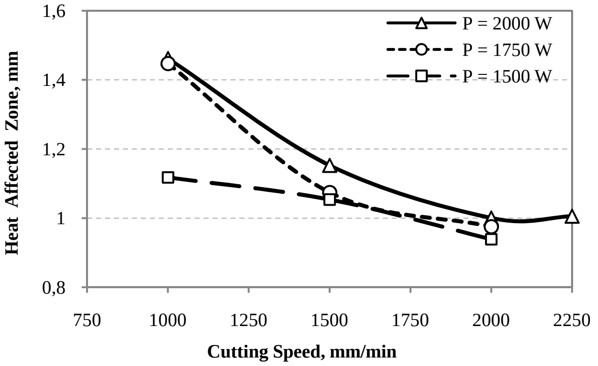

Fig.2.The effect of the laser power and cutting speed on the size of heat affected zone with other constant parameters

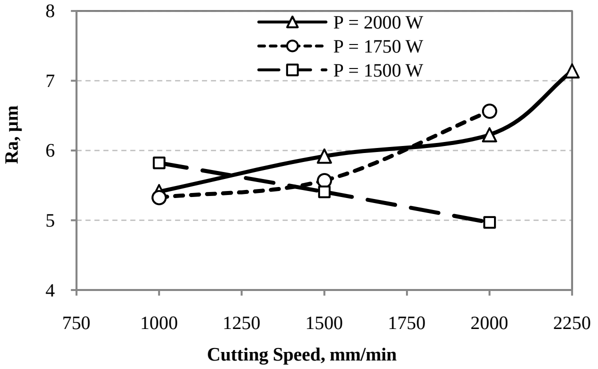

Fig.3.The effect of the laser power and cutting speed on the surface roughness with other constant parameters

In figure 3 can be seen that the surface roughness changes very slightly with increasing cutting speed and decreasing laser power during laser cutting of tungsten alloy in using nitrogen as assist gas. Also very small difference between the maximum and minimum kerf width is obtained when using nitrogen as assist gas.

In analyzing the effect of nitrogen assist gas pressure on the cut quality, the samples that are cut in pressure of 7.5 bar and 20 bars were excluded because of incomplete cut. In figure 4 can be seen that the size of heat affected zone and the kerf width decreases with increasing pressure of nitrogen. This conclusion is valid for the pressure range varied from 10 to 15 bars, while at the pressure of 17.5 bar comes to a sudden increase in the size of heat affected zone and the kerf width. The minimum size of heat affect zone is obtained at a pressure of 15 bars.

Furthermore we can conclude that the surface roughness changed slightly with a slight increase with increasing pressure of nitrogen, figure 5. The obtained values of the parameter Ra belong to the same class of roughness.

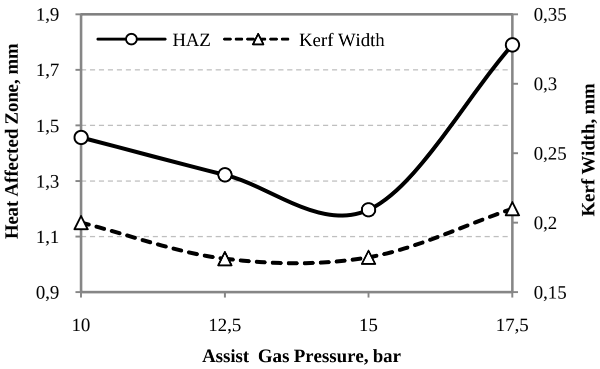

Fig. 4. The effect of the assist gas pressure on the size of heat affected zone and the kerf width with other constant parameters

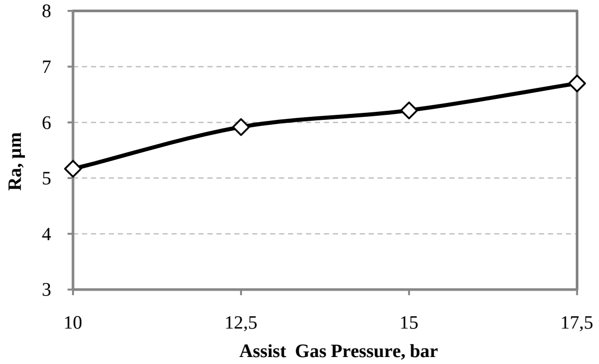

Fig. 5. The effect of the assist gas pressure on the surface roughness with other constant parameters

4. CONCLUSION

The effect of laser power, cutting speed and nitrogen assist gas pressure on the quality characteristics of laser cut tungsten alloy specimens studied in this paper. Based on the conducted investigations, the following could be concluded:

- Size of heat affected zone increases with increasing the laser power and decreases with increasing cutting speed and gas pressure.
- Kerf width decreases with increasing nitrogen gas pressure, while it slightly changes with increasing cutting speed and decreasing laser power.
- Surface roughness changes very slightly with increasing cutting speed and gas pressure and decreasing laser power.
- Based on the above conclusions, for laser cutting of tungsten alloy of 1mm thick, it is recommended to use the laser power of 1500 W and cutting speed of 1000 mm/min when nitrogen is used as assist gas at 15 bars.

Influence of assist gas kind on the cut quality in laser cutting of tungsten alloy, it is recommended to further investigations and a comparison with these results.

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.

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