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ANALYSIS OF THE INFLUENCE OF GAS DURING CARBON DIOXIDE LASER CUTTING

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ABSTRACT

The objective of this paper is to analyze the influence of gas during carbon dioxide laser cutting process. A variety of cutting conditions like variation of pressure and velocities were applied to steel to analyze the effect of these mentioned parameters. It is observed through experiments that the most effective cut was at 1 bar pressure with 0.5m/min velocity. This is also supported by microscopic images for measuring the kerf width and the heat affected zone.

Key words: Carbon dioxide laser cutting, HAZ, Kerf width, laser cutting, Steel.

Introduction

In the recent days of machining technology, laser cutting plays an important role in ability of powerful lasers to concentrate optical energy radiation in space, in time and spectral interval and on the interaction of radiation with the material. Laser technology of cutting is the method of thermal parting of material with no material removal due to the use of mechanical work; it uses physical and chemical processes or the combination of both. As a result, only minimal deformations arise both in the process of division and after it has finished. The cutting process is based on the interaction of laser beam, cutting gas and cut material. It utilizes high concentration of the energy produced by laser radiation which enables to divide all technical materials, regardless of their thermal, physical and chemical properties; the division process is fast, which ensures high productivity. It is especially used for materials with low thermal conductivity. The effort is to evaporate the material as quickly as possible while maintaining the area affected by thermal effects as small as possible. This results in a high quality cutting edge. Cutting with laser has a wide range of uses for production on a small scale as well as for large-scale production in batches. Laser cutting technology offers a major advantage in speed, quality and accuracy of burnouts; it achieves low manufacturing cost and minimizes the amount of waste, which is associated with the best possible use of the materials and energy. [1]

Considerable research studies have been carried out to examine the laser cutting process, with some of the findings summarized in recent comprehensive review papers [2-4]. Of particular interest to manufacturers using laser cutting technology are the maximization of productivity and quality and minimization of cost. Each of these goals often requires "optimal" selection of the laser cutting parameter set-tings.(5). When the cut quality is considered, in most reported studies, kerf width, surface rough-ness, and size of the HAZ, were commonly used as cut quality characteristics (6).

Experimental Procedure

Care is taken to ensure that the gases helium, neon and carbon dioxide laser beam are aligned with color to identify the laser for safety purpose. It is also ensured that the focusing optical parts are cleaned and loaded into the holder. A stand off distance of 0.75 mm is fixed as the distance between the nozzle and the workpiece. In order to obtain omni- direction properties, it is essential that the beam is centered properly. Pressure of the gas is varied (0.5, 1, 2, 4 and 6 bar) and with a variation of velocity (0.5 and 1m/min), the cut is performed.

Analysis and Discussions

The figure shows the various cut performed in the material with varied pressure and velocity as discussed in experimental details. Quality of the cut varies with the pressure and velocity of the gas used. The following criteria were used in inspection for identification of good cut

1. Absence of dross or removable dross.
2. Through cut and low taper
3. Kerf width and Minimum heat affected zone
4. Smooth cut.

Figure 1 : cut for 0.5 bar pressure

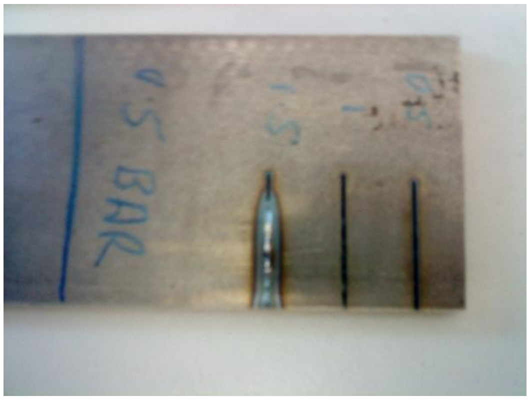


Figure 2: cut for 1 bar pressure

Figure 3:Cut for 2 bar pressure

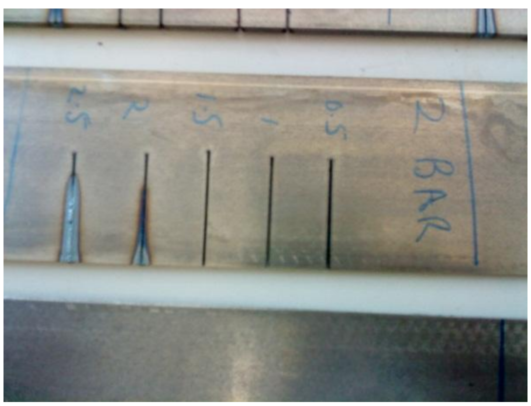


Figure 4 :cut for 4 bar pressure

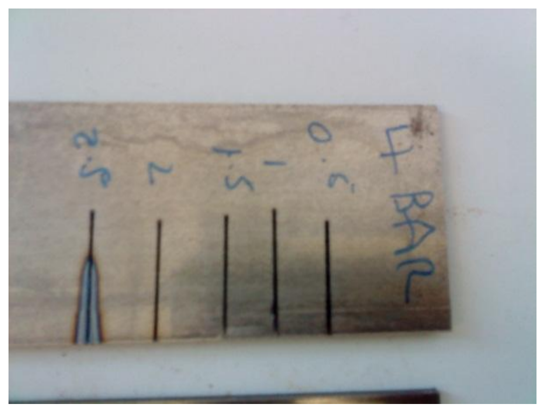
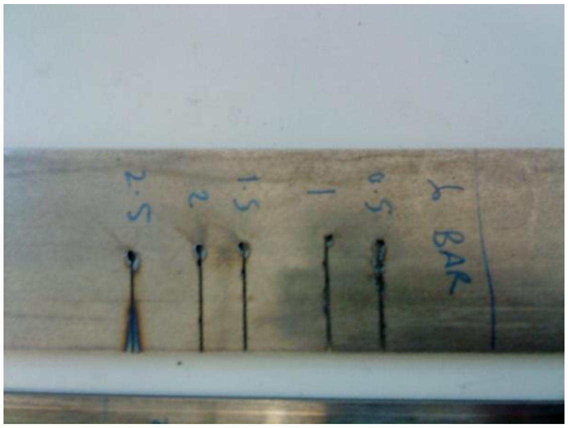
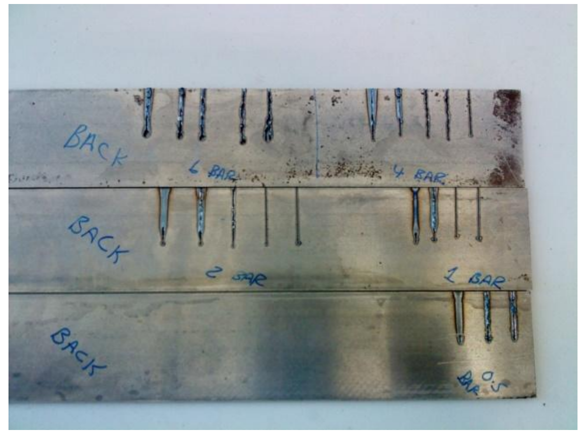


Figure 5: Cut for 6 bar pressure **Figure 6: Rear side view**

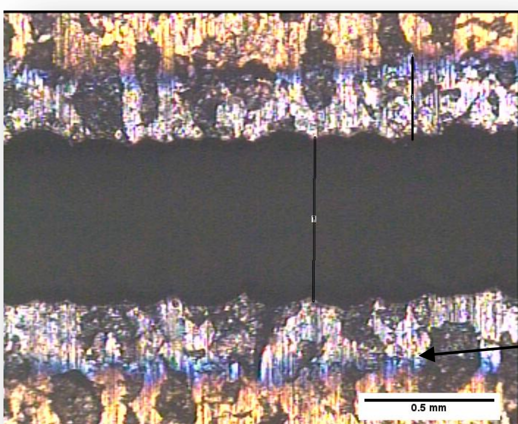




It is clearly observed that, at 0.5 bar the material not at all removed from the material but at 6 bar pressure, too much material removed from the work piece. Cut at 4 bar pressure was also produced poor quality.However the following cuts produced good cut and were selected for microscopic analysis.

1. 1bar and 0.5m/min.
2. 1bar and 1m/min.
3. 2bar and 0.5m/min.
4. 2bar and 1m/min.

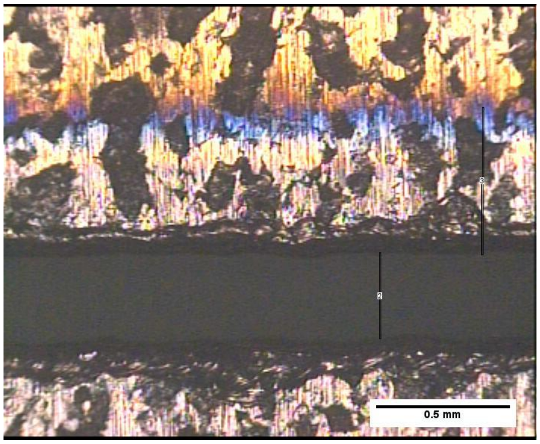
Figure 7: 1 bar 0.5 m/min top view



Heat affected zone 0.33 mm

Kerf width 0.634mm

Figure 8: 1 bar 0.5 m/min bottom view **Figure 9 : 1 bar& 1 m/min top view**



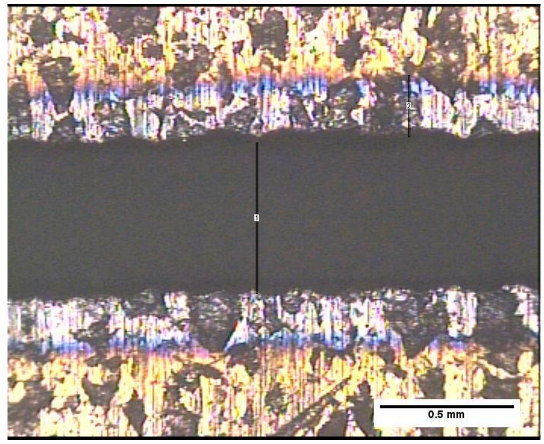
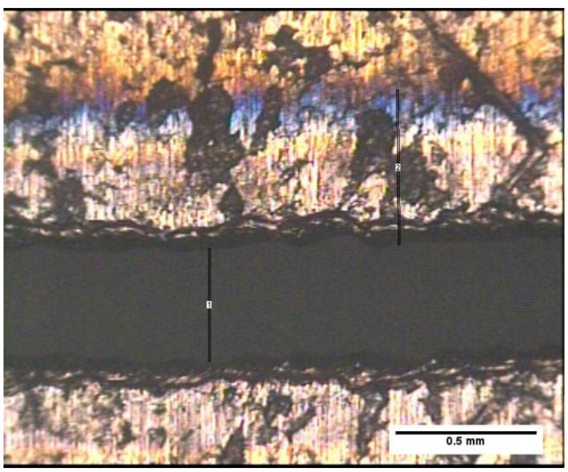


Figure 10: 1 bar & 1 m/min bottom view **Figure 11: 2 bar & 0.5 m/min top view**



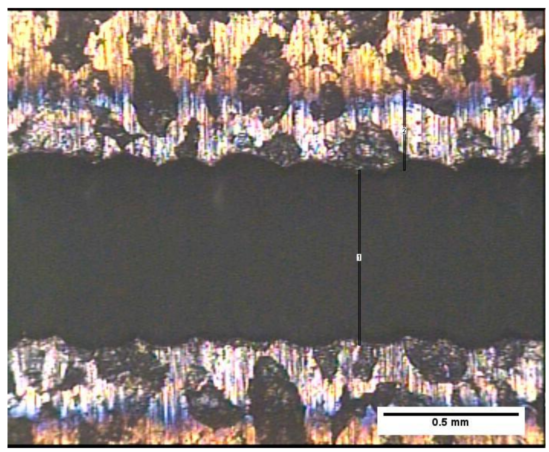
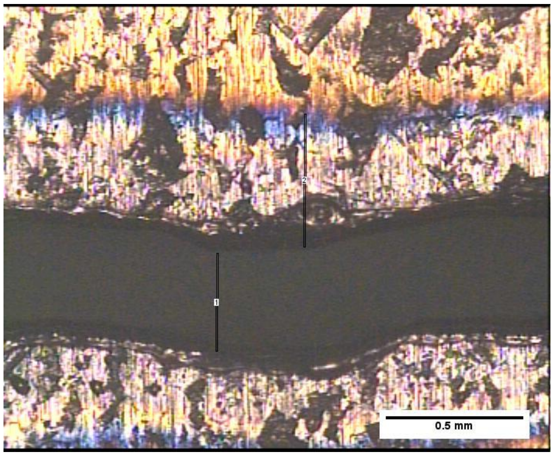
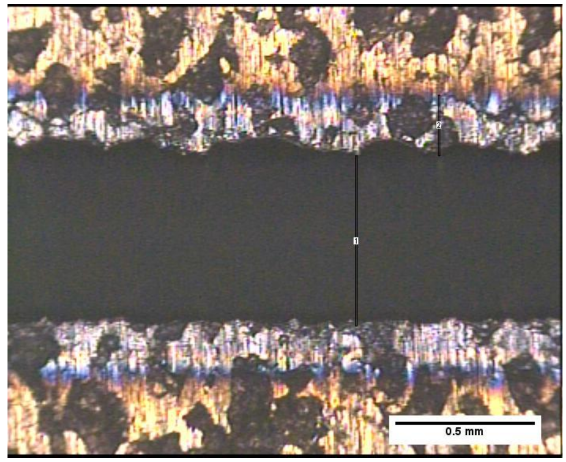


Figure 12: 2 bar & 0.5 m/min bottom view **Figure 13: 2 bar & 1 m/min top view**





The following table (table 1) gives the data pertaining to Kerf width and different heat affected zones.

Table 1

Pressure (Bar)	Velocity (m/min)	Kerf Width (mm)			Heat affect zone (mm)		Cut condition
		top	bottom	average	top	bottom	
0.5	0.5	-	-	-	-	-	Material not removed.
1	0.5	0.634	0.321	0.477	0.33	0.549	Good cut(straight cut)
1	1	0.561	0.355	0.458	0.228	0.482	Good cut (zigzag effect)
1	1.5	-	-	-	-	-	Material melted, but no cut taken
1	2	-	-	-	-	-	Not even melted
2	0.5	0.645	0.397	0.521	0.293	0.547	Good cut
2	1	0.608	0.454	0.531	0.217	0.380	Good cut, No effect on increase in pressure
4	0.5	0.792	0.449	0.620	0.233	0.427	Good cut
4	1	-	-		-	-	Poor result
6	0.5	-	-		-	-	Too much material removed

From the above observation, the best quality and most cost effective cut was at 1.0 bar at 0.5 m/min. Laser cutting has high cutting speed, low distortion, high edge quality and minimal heat affected zone. Laser cutting systems are effective when producing a precise cut because of the accuracy of the fine laser contact [5]. The experimental results also show that the cut quality includes roughness, heat affected zone, zigzag effect, ripple structure. These vary with gas pressure and velocity.

Conclusions

Experimental result shows that the most effective cut was at 1 bar gas pressure with 0.5 m/min velocity. The cut at 1 bar and 1 m/min was also good but some zigzag effect was noticed in the microscopic analysis. However it is highly recommended that for optimum cutting with as being used in the laser cutting process, gas pressure at 1 bar with a velocity of 0.5m/min is optimum.

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