THE MACROSCOPIC ANALYSIS OF SAMPLES CUT WITH A CO_2 LASER TYPE TC L4003

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Abstract. In industrial practice, metal materials such as steel, tool steel, stainless steel, aluminium and aluminium alloys are cut using laser (considered an allied welding process). But laser can also cut materials such as titanium, silicon steels and titanium alloys. Laser radiation is used also for cutting non-metallic materials such as wood, leather, glass, ceramics and plastics (polyethylene, polyamide). Compared with other methods of cutting (plasma, oxyacetylene, erosion), laser cutting process has the advantage that the material processing is possible without contact or forces. To observe the thermal influence of the laser beam on the material there were carried out nine tests at different processing speed and laser powers. The tests were performed on different sheet thicknesses.

Keywords: macroscopic analysis, samples, laser

1. Introduction

Modern processing of metallic and nonmetallic materials is closely linked to the great discoveries of physics, development that in the twentieth century had excelled. This phenomenon had as a result remarkable applications of electronics, electro-magnetism, electronics and microelectronics, atomic and nuclear physics, thermodynamics, materials science, fluid mechanics, quantum physics etc.

The considerable expansion of top-level domains such as nuclear energy, microelectronics, cosmic flights, medical techniques, measurement techniques, have triggered the emergence of materials and, by default, of processing procedures which had created significant changes in design concepts, namely processing of products and parts. Ultra high level of experimental researches had greatly increased the performance of relatively new tools used in processing materials, such as electron beam, laser radiation, light radiation or thermal plasma.

Laser processing represents a special category characterized by a high energy density per unit area that lies on, in this regard placing this procedure on the first place. As a defining feature, the radiation energy is converted into heat, which is why, in general, the category of work which may be made through these kind of processes are related to heat treatment, welding, drilling, cutting, engraving, burning, meaning all those proceedings in which the intervention on the material is made by heating transfer at temperatures lower then, equal to or higher than the melting point temperature (in which case the vaporization of the cut material appears) [1].

Of course, the decision for choosing radiant energy laser processing, instead of a classic manufacturing process must take into account the investment opportunity in this type of equipment, namely the degree of profitability [2].

Although recently developed, laser thermal processing procedures hold an important place among industrial processing, especially for welding, cutting and drilling metal, covering in less than 60 years all stages from research to routine application in industry. We can say that without the existence of laser thermal processing certain operations could not be performed. Entire areas of activity, such as high-performance telemetry, medicine, holographic three-dimensional representations, thermal processing of refractory materials used in nuclear engineering and research in space, super alloying and alloying, high precision cutting and drilling, special processing in microelectronics and computing, are dominated and dependent on the laser.

Together with the development of laser power in the early 1970s, their use in the process of cutting materials had a limitless scope. Today it is estimated that about 60% of the uses of lasers in materials processing are in the process of cutting, regardless of the gauge parts of the charge.

In the last decade, laser-machining processes have experienced explosive growth, with areas such as microelectronics, robotics, obtaining super alloying materials for medical or cosmic research, which are inconceivable without these possibilities [3].

Laser cutting is a process of thermal separation in which laser radiation is seen as a tool. Laser radiation is aimed by the laser unit through a focusing system within the machine, to an external optical system built through a series of mirrors. Focusing equipment of the machine is made of lenses whose purpose is to focus the laser ray within a single point.

Within this point, densities of 10^7 [W/cm^2] power are achieved. The position of the focal lenses from the material that is to be processed is controlled in such manner so the focal point is positioned on the surface of the part. The high amount of density leads to heating, melting and partial or total vaporization of the material. A gas is released coaxial with the radiation removing the material left from cutting [4].

2. Experimental setup

To observe the thermal influence of the laser beam on the material there were carried nine samples of S 355 J2 G3 (OL 52) with the dimensions of 100 × 100 [mm] with variable thickness (2, 8, 12 [mm]) provided with an inside hole of ϕ 30 [mm]. Tests were performed on different sheet thicknesses. The samples were marked with v – the cutting speed [m / min] and P – the laser power [%].

Thermal laser cutting applications were run on a TRUMPF TC L4003 cutting device, equipped with a specialized laser TLF1500-2000 (figure 1), used on “Intreprinderea Mecanica” Bistriţa-Năsăud, Bistriţa - Romania, manufactured in 1999, which is a laser cutter by gas with up to 2600 [W] using a mixture of CO_2, N_2, He [5, 6].

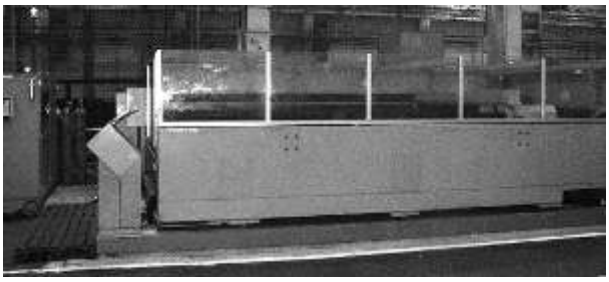

Figure 1. The TLF 1500-200 laser

The presented laser offers solutions for any application, from a simple cut to complex proceedings of cutting up to five axes, the machines being equipped with 3D cameras for processing materials.

The machines powered by the "flying optics" principle, which consists on moving the cutting head, thereby achieving high processing speeds regardless of the size or weight of the plates.

The TCL 4003 system can be equipped with pneumatic devices for loading and unloading the materials, thus resulting the complete automation of the process.

Together with turbochargers, which generate very low vibration and sound, and using a high frequency generator to achieve very high efficiency and productivity, and because of these low vibrations, a very good stability and precision is obtained when machining.

The possibility of power control from 0 to 100%, the solutions that can be optimized for any application, these generators are best suited for cutting stainless steel sheets, carbon steel, non-ferrous materials, even glass and ceramics.

TC L4003 can process a large amount of material of different sizes in a short period, with a high quality laser cutting, without the further need for finishing of parts, being ready for assembling.

The most important piece, except the laser generator, is the cutting head (figure 2) that represents a subset of the main system.

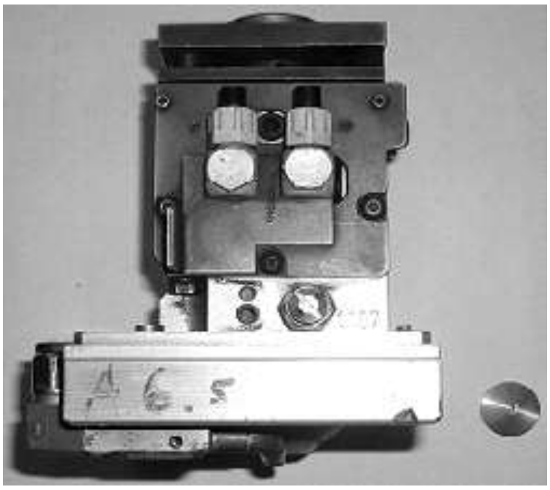

Figure 2. Laser cutting head unit

3. Results and discussion

Analyzing samples results leads to the following observations:

1. Sample 1 (Figure 3):
   - dimensions: 100 × 100 × 2 [mm],
   - v = 2.5 [m / min],
   - P = 100 [%].

Note that the edge has no burr, no material burnings thought the laser power is at maximum.

2. Sample 2 (Figure 4):
   - dimensions: 100 × 100 × 2 [mm],
   - v = 2.5 [m / min],

Figure 3. A macroscopic view of an area of sample 1

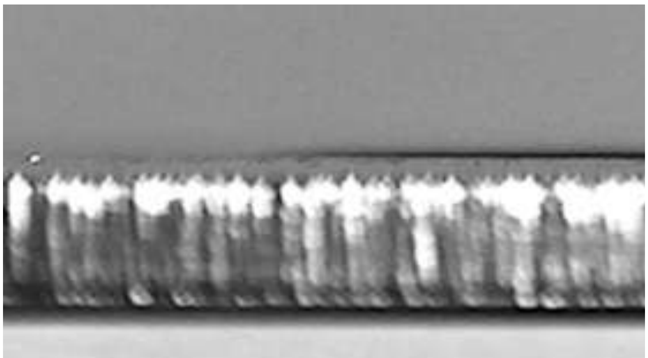

Figure 4. A macroscopic view of an area of sample 2

- P = 80 [%].

High similarity with sample 1. Edge does not presents this time either burr or material burnings.

3. Sample 3 (Figure 5):
 - dimensions: 100 × 100 × 2 [mm],
 - v = 2.5 [m / min],
 - P = 60 [%].

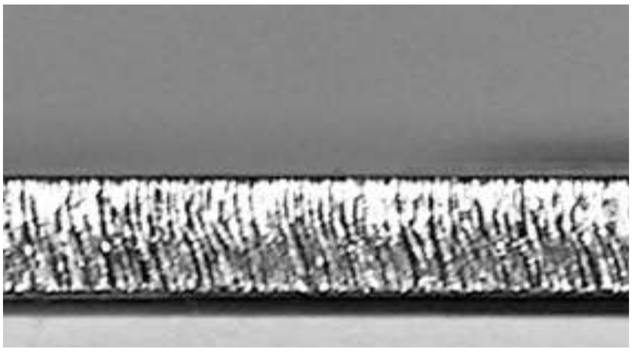

Figure 5. A macroscopic view of an area of sample 3

It is noted that using P = 60 [%] the traces led by laser radiation are more obvious, the lines are more pronounced.

4. Sample 4 (Figure 6):
 - dimensions: 100 × 100 × 8 [mm],
 - v = 1.25 [m / min],
 - P = 60 [%].

Figure 6. A macroscopic view of an area of sample 4

In this case laser radiation failed to penetrate the whole material. By observing the ridge, we can see that the molten material was not removed by the cutting flow of the gas.

5. Sample 5 (Figure 7):
 - dimensions: 100 × 100 × 8 [mm],
 - v = 1.25 [m / min],
 - P = 80 [%].

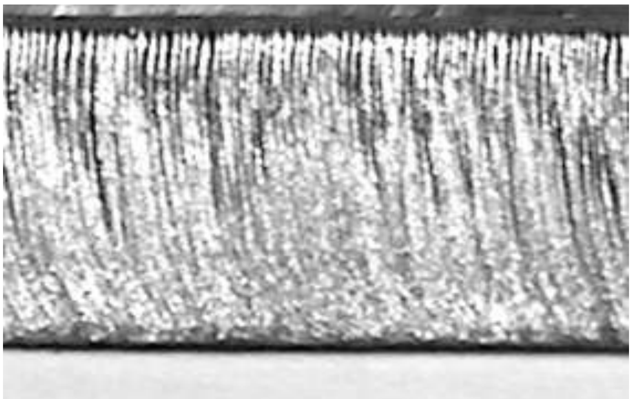

Figure 7. A macroscopic view of an area of sample 5

Using an 80 [%] power results an improvement of the machined surface, and no more burrs.

6. Sample 6 (Figure 8):
 - dimensions: 100 × 100 × 8 [mm],
 - v = 1.25 [m / min],
 - P = 100 [%].

Using a 100% power, the thermal influence of laser radiation is bigger, so there is a pronounced burning of the material.

7. Sample 7 (Figure 9):
 - dimensions: 100 × 100 × 12 [mm],
 - v = 0.99 [m / min],
 - P = 60 [%].

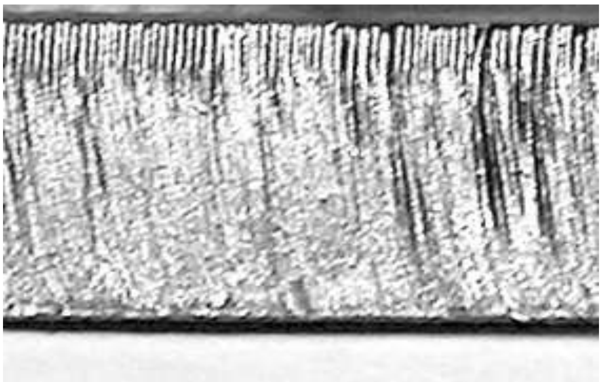

Figure 8. A macroscopic view of an area of sample 6

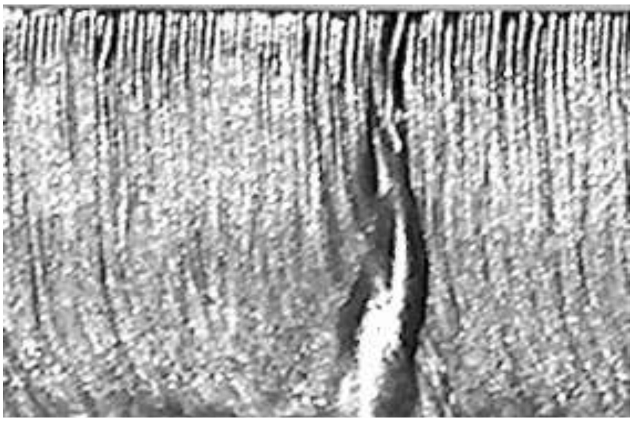

Figure 9 A macroscopic view of an area of sample 7

The material is not homogeneous. In this case, laser radiation encountered structural imperfections, which do not have the same properties with the rest of the material. This shows how the burning was more pronounced in the area.

8. Sample 8 (Figure 10):
   - dimensions: 100 × 100 × 8 [mm],
   - v = 1.25 [m / min],
   - P = 80 [%].

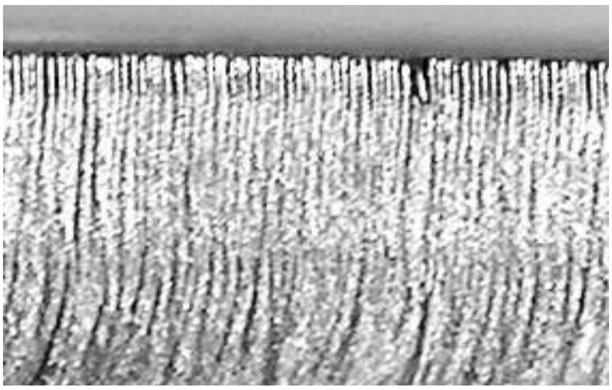

Figure 10. A macroscopic view of an area of sample 8

In this case, the quality improvement of the cut is obvious. Laser radiation has penetrated through the material; there is no burrs or burned material.

9. Sample 9 (Figure 11):
   - dimensions: 100 × 100 × 8 [mm],
   - v = 1.25 [m / min],
   - P = 100 [%].

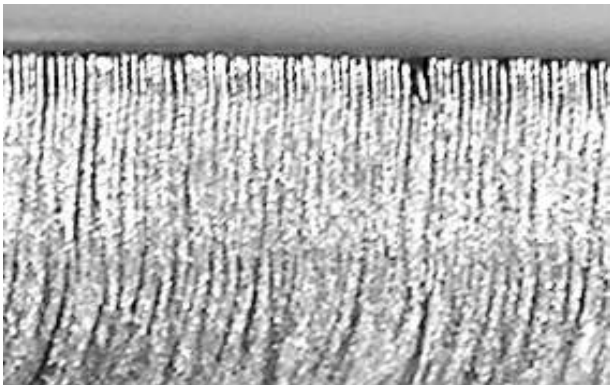

Figure 11. A macroscopic view of an area of sample 9

The quality of cut is evident. Roughness is very small, the lines are not strongly highlighted. No burrs occur, or material burnings. The vaporized material is completely removed by the cutting gas.

Additional comments can be made on sample 7. For plate thickness 12 [mm] is not sufficient using a power of 60%.

In figure 12 it is observed how the laser radiation has not penetrated through the material and the vaporized and melted material is not removed by the cutting gas. Even if the material has not penetrated, the thermal influence zone of the laser is noticed.

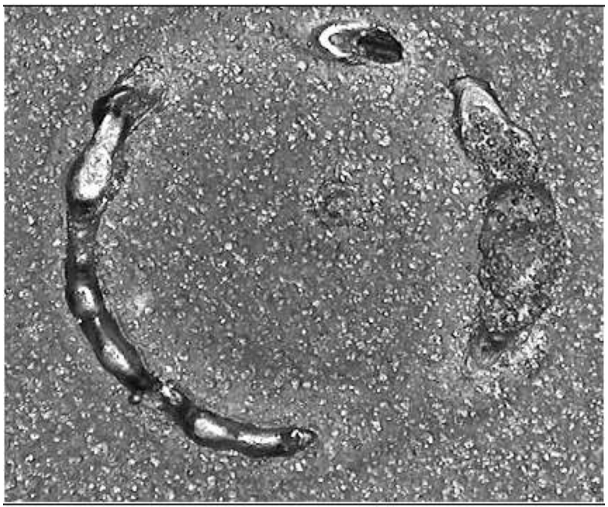

Figure 12. The laser radiation did not penetrate through the material

In figure 13 the same sample is presented after cutting, and it is noticed the area in which the drilling took place and the molten metal drops which do not appear in the case of optimum cutting process.

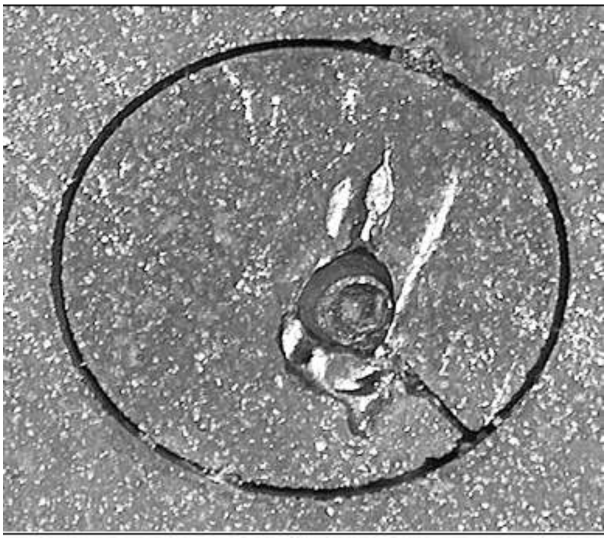

Figure 13. The same sample presented after cutting

4. Conclusions

If the parameters are set properly, it is observed that the cut quality is remarkable and that any other kind of processing is not necessary. This can be observed on a sample of 12 [mm] thickness at maximum laser power and 1.25 [m/min] cutting speed. It is shown in this way that using laser it can be cut thick materials with high technical and economic efficiency.

In comparison to other cutting procedures (plasma, oxyacetylene and erosion), cutting with the laser have the following advantages:

- The material can be worked on with no direct contact and force;
- The speed of processing is high, so in comparison to erosion processing the productivity can be considerably increased;
- Because of the energy density, the area thermical influenced can be low;
- The small area where the thermic influence can be sensed guarantees small deformities of the parts;
- It can be observed the tolerance levels are kept at 0.05 [mm] even in high quantities;
- The obtained roughness is small, which means there will not be a need for ulterior processing.

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