ACTA TEHNICA CORVINIENSIS – Bulletin of Engineering
Tome VIII [2015] Fascicule 1 [January – March]
ISSN: 2067 – 3809

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SELECTION OF THE OPTIMAL PARAMETERS FOR LASER CUTTING

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Abstract: The current high requirements for quality, accuracy and durability of produced parts lead to a permanent improvement of the production process. For reasons of efficiency and competitiveness have become increasingly to the forefront of non-conventional machining methods. Non-conventional technology is characterized by the use, physical, chemical or a combination of these processes. Currently, the most commonly used for industrial cutting continuous CO2 laser with an average power. Because of the high requirements for the quality of the cutting edge is necessary to choose the optimal method of cutting either melting laser cutting or oxidizing laser cutting. The main parameters that we can significantly affect the quality of the cutting edges are: laser power, length of focal optics, cutting speed, gas pressure, gap between the nozzle and plate, shaped nozzles etc. If the cutting edge after laser cutting does not reach the required quality, it may negatively affect the price of the product, due to add additional operations, as may be chamfering, grinding, etc. For this reason, high demands are made to the professional knowledge on operator of laser equipment.

Keywords: CO_2 Laser, optimal parameters, quality of cutting edge

INTRODUCTION

Separation of materials is still a very important matter of public manufacturing operations. It is used to draw a number of methods, each of which has developed its area of optimum use.

In engineering is nowadays the most advanced laser technology between modes of action on human material in the production process. With their help it is possible significantly improve the quality, technology and productivity. Thermal cutting of materials can be used in within the engineering operations include the preparation of the material. Under this term we mean cutting technology, working on the principle of local melting, combustion, or evaporation, or a combination of these phenomena, the energy required to initiate the process and its process is supplied by various heat sources. Thermal cutting of materials can be used in within the engineering operations include the preparation of the material.

Generally, thermal cutting of materials applied to a wide range of engineering materials: unalloyed and low-alloy steels, high alloy steels and nickel based alloys, non-ferrous metals and their alloys (aluminium, copper) highly reactive materials and their alloys are sensitive to oxygen (magnesium, titanium) non-metallic materials (plastics, composites, wood, paper, glass)

PRINCIPLE OF LASER

Every laser system is comprised of three substantial parts. These parts include active environment (active substance), the excitation (pump) source and a resonant system. A suitable excitation of the active substance is achieved by the phenomenon that is called population inversion. If there are more atoms at higher energy levels than the lower, it is a state of imbalance. Population inversion is inside the active environment necessary condition for that there was a light amplification.

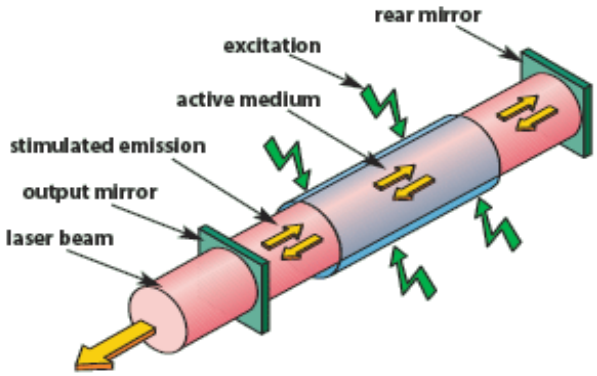

Figure 1: The resonator

Active medium is meant a substance, whether gaseous, solid or liquid, which is saturated with more atoms at higher energy levels. These atoms can also emit twice the light energy. The active medium is the most important part of the laser device because in it there is stimulated emission. The resonator is an optical cavity into which is inserted the active substance. In most cases, a resonator formed by two mirrors, one mirror is reflecting and second semi-permeable and from outside is equipped with a condenser. Due to the large number of photons and their accidental movement, some of them start to move in a direction perpendicular to both mirrors and begin to amplify larger and larger waves. This is enabled due to the metastable levels of electrons that will last for the surface until it hits them in some of the emitted photons. Other photons that are flying in a direction perpendicular to the mirror fly out a space between them, or are pulled down to just photons flying in the perpendicular

direction. When photon will increase to a certain level, a half mirror released out and it results required beam. This is coherent and monochromatic.

PRINCIPLE OF CO_2 LASER

With gas laser beam is formed in a gaseous environment, which is most commonly argon, helium or neon. The light emission occurs after applying a sufficiently high voltage to electrodes located inside the gas tube. Gas lasers for industrial use can achieve very high performance the disadvantage is the need for a complex cooling the relative expensiveness.

It is the most common gas laser, whose active medium consists of a molecule of dioxide excited by an electric the smoldering discharge. The radiation generated by this type of laser in the far infrared region. CO2 lasers are characterized by a relatively high efficiency of 8-10%. Currently, only CO2 laser reaches the desired range of output power of 1kW to 30 kW and therefore belongs among the most widely used lasers. Except for high performance and high efficiency excels CO2 laser still decent quality the laser beam. Other properties are not desirable. The wavelength is 10.6 µm, despite the fact that it does not pass through optical fibers and laser irradiation is necessary to destination transport system of mirrors, is not well suited for precision machining. Due to the small volumetric power density of the CO2 laser is based on high-performance laser systems and a lot of great material and equipment is not practical mobile. It is also dependent the coolant inlet and the supply of the working gas mixture which, except carbon dioxide also contains nitrogen and expensive helium. Given the complexity and operational performance of such devices requires uninterrupted inspection and maintenance. Despite these shortcomings has achieved maximum performance due to CO2 laser on competition and holds its place particularly in areas such as welding and cutting metal sheets of large thicknesses. The world-famous producer of CO2 lasers is mainly German company Trumpf.

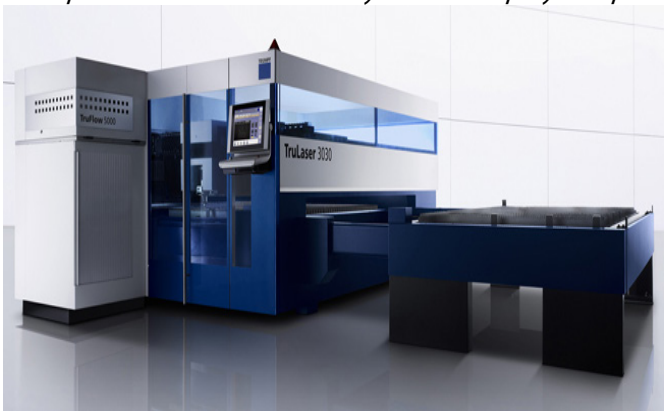

***Figure 2**: CO_2 laser*

METHODS FOR LASER CUTTING

Fusion cutting

Nitrogen or argon is used as the cutting gas here. The gas is blown through the kerf at pressures ranging from 2 to 20 bar. Argon and nitrogen are inert gases. This means that they do not react with the molten metal in the kerf. They simply blow it out toward the bottom. Simultaneously, they shield the cut edge from the air. The advantage of fusion cutting is the cut edges are oxide-free and do not require additional treatment. The laser beam supplies the energy needed for cutting. This is why cutting speeds as fast as those in flame cutting can only be achieved in thin sheets when fusion cutting. Piercing is also more difficult. Some cutting systems allow you to use oxygen to pierce the material and then switch over to nitrogen for cutting.

Flame cutting

In flame cutting, oxygen is used as the cutting gas. The oxygen is blown into the kerf at pressures of up to 6 bar. There, the heated metal reacts with the oxygen and it begins to burn and oxidize. The chemical reaction releases large amounts of energy – up to five times the laser energy – and assists the laser beam. Flame cutting makes it possible to cut at high speeds and handle jobs involving thick plates such as mild steel.

Sublimation cutting

In this process, the idea is to use the laser to vaporize the material with as little melting as possible. In the kerf, the material vapor creates high pressure that expels the molten material from the top and bottom of the kerf. The process gas – nitrogen, argon, or helium – serves solely to shield the cut surfaces from the environment. It ensures that the edges remain oxide free. For this reason, a gas pressure of 1 to 3 bar is sufficient. More energy is needed to vaporize metal than to melt it. Therefore, sublimation cutting requires high laser power and is slower than other cutting processes. However, it produces high-quality cuts. This process is rarely used in sheet metal fabrication. Its use, however, becomes attractive in applications involving particularly delicate cutting work.

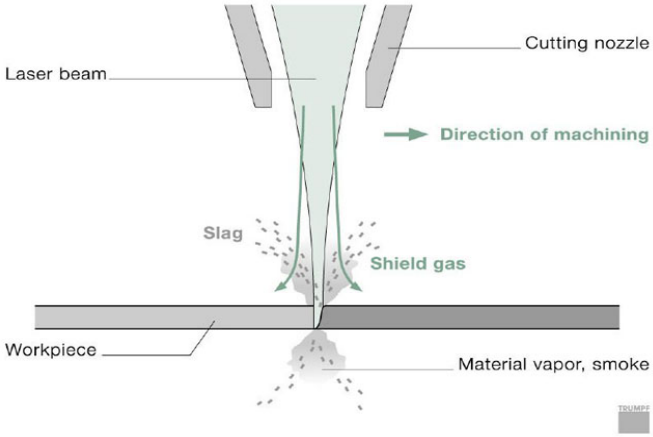

***Figure 3**: Principle of sublimation cutting*

PARAMETERS INFLUENCING THE QUALITY OF CUTTING

The experimental part was carried out at NC Line s.r.o., which deals with the processing of sheet metal components using laser technology for 20 years. Today, the company is a leading supplier of sheet metal parts to companies such as Linde, Still, Pro-Logic, Liebherr and many others. The essence of the experiment is to evaluate the surface roughness depending on the performance parameters of the laser. In the production of test samples in NC Line s.r.o. Company was used material Raex 250 C Laser. Evaluation of the samples was carried out in laboratories VSB-TU Ostrava.

The test material

Raex 250 C Laser is a high-strength and wear-resistant steel with favourable hardness and impact toughness. The plate thicknesses now range from 2 mm up to 80 mm providing a solution to all wear needs. With Raex wear plate you can extend the lifespan of machinery, decrease wear in structural components and save costs. Raex steel grades also enable innovative design and lightweight products improving energy efficiency and lowering fuel costs. Raex is utilised in various applications of mechanical engineering by, for example, the automotive, heavy lifting and transportation, and mining industries. Thickness of the test material was 10 mm.

Applications

- ✓ *Buckets and containers*
- ✓ *Cutting edges for earth moving machina*
- ✓ *Wear parts for mining machina*
- ✓ *Wear parts for concrete mixing plants and wood processing machina*
- ✓ *Platform structures*
- ✓ *Feeders, funnels*
- ✓ *Tipper bodies*

Device for measuring of roughness

For measuring of surface roughness was used Mitutoyo SJ-400. This is a portable device for measuring the roughness of the surface without sliding blocks with touch control panel and an integrated printer. Large 5.7 "color LCD display for easy navigation through the measurement conditions, results and graphs analysis. Possibility of sensor measurements without slip feet for the measurement of unfiltered profile (P), the roughness profile (R), filtered waviness profile (W), and others. This device complies with many standards, industrial DIN EN ISO, VDA, ANSI and JIS. Internal memory can store up to 10 different measurement conditions and up to 500 programs on an optional SD memory card.

***Figure 4**: Portable surface roughness tester Mitutoyo SJ-400*

Selection of optimal parameters

The procedure for selecting the optimal parameters was that the best sample cutted by operator experience and consequently there to modify parameters and evaluation of the sample. During the experiment, there was a change in focal length, power, feed rate, nozzle distance from the material and the gas pressure.

Sample No. 1 was cutted by experience of the staff, which was used parameters viz. table. During the gradual modification of parameters failed to achieve better surface roughness parameters. During the experiment, the different parameters at which the laser ceased to perform its function and scrapes material.

***Table 1**: Machine parameters*

	sample 1	sample 2	sample 3	sample 4	sample 5	sample 6
Length of focal optics [mm]	3,5	3	3.5	3.5	3.5	3.5
Performance [W]	4800	4800	4000	4800	4800	4800
Speed [m·min^{-1}]	2,4	2,4	2,4	2.2	2.4	2.4
Distance of the nozzle [mm]	1,2	1.2	1.2	1.2	0.8	1.2
Gas pressure [MPa]	0,8	0.8	0.8	0.8	0.8	0.9

When evaluating the samples in laboratories VSB-TU Ostrava focused on the arithmetic mean deviation of the profile Ra and Rz roughness of the profile. The best value of the sample was No. 1 and the worst value of the sample was No. 4 This showed that the set of parameters that can affect the quality of the cut staff is able to tune themselves according to their experience. Unable to clearly determine the parameters chosen for different materials such as aluminium, copper, stainless steel, because the cut quality is influenced by many other factors.

Generally not say that the reduction or increase of gas pressure there was a worsening of quality of cut as well as in increasing or decreasing the focal length.

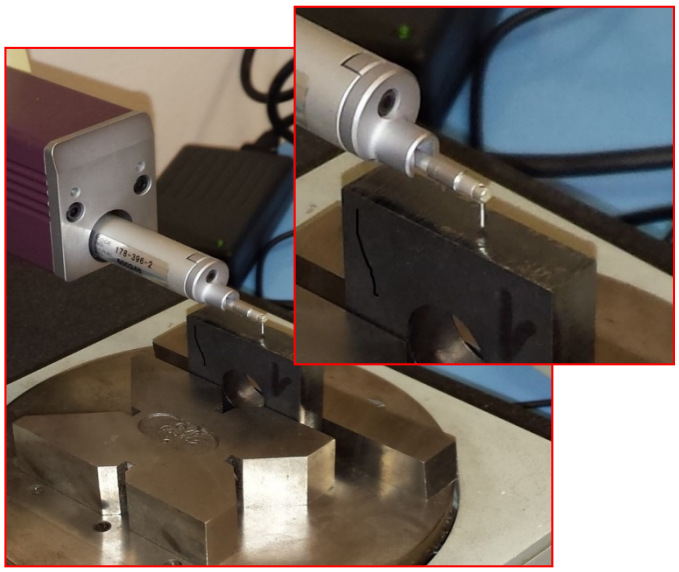

***Figure 5:** Measurement of sample*

***Table 2**: Values of roughness*

	sample 1	sample 2	sample 3	sample 4	sample 5	sample 6
Ra [μm]	2,65	4,12	7,09	25,10	8,83	7,09
Rz [μm]	14,50	22,30	37,40	95,10	43,20	37,40

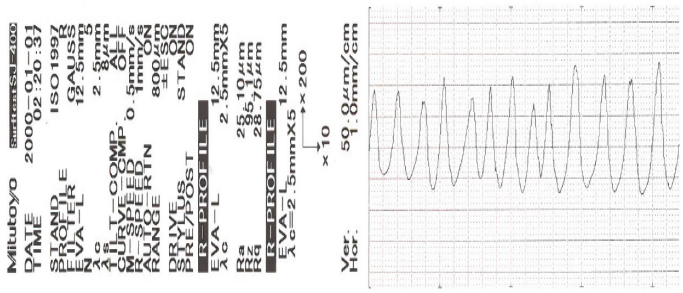

Figure 6: *The worst sample*

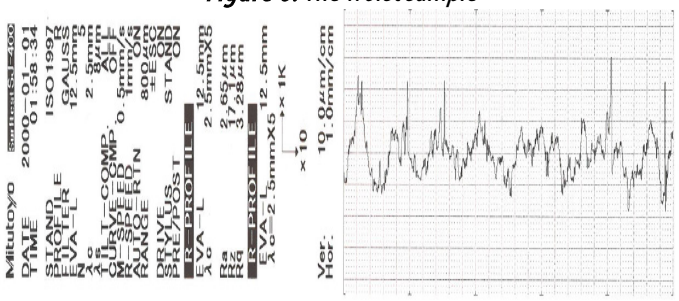

Figure 7*: The best samp*

CONCLUSION

In this article, the possibility was investigated how the operator can affect the laser cutting quality. As the test material was used Raex 250 C Laser thickness of 10 mm. The experiment was conducted on C02 laser manufacturer Trumpf in cooperation with NC Line s.r.o.

In the actual experiment, the focus was on the main parameters affecting the quality of the cutting area, namely: power of the laser beam focus position to the material being cut, cutting speed and cutting gas pressure and nozzle position on the material from depending on these variables was carved twelve samples which were subjected to measurement of the quality of cut surfaces and the results of these measurements are further processed and evaluated. For best quality results achieved sample cut with the following parameters (the sample number 1) :

- ✓ *Laser power 4800W*
- ✓ *Focal length 3.5 mm*
- ✓ *Cutting speed 2.4 m • min^{-1}*
- ✓ *Gas pressure 0.8 bar*
- ✓ *Distance of the nozzle 1,2 mm*

ACKNOWLEDGMENT

This paper was supported by the Students Grant Competition of the Ministry of Education, Youth and Sports and Faculty of Mechanical Engineering VŠB-TUO.

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ACTA Technica CORVINIENSIS
BULLETIN OF ENGINEERING
ISSN:2067-3809