INFLUENCE OF SELECTED TECHNOLOGICAL PARAMETERS ON CUTTING SURFACE ROUGHNESS IN MATERIAL LASER CUTTING

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The paper deals with the influence of the selected technological parameters on cutting surface roughness in material laser cutting. It more closely examines and compares technological parameters such as cutting speed, laser performance, and gas pressure. The paper also contains the information on influence of the respective technological parameters on character of the material surface cut by laser S235JRG2 (according to EN 10025/90+A1/93) with change of the selected material thickness. The conclusion presents a discussion analysing the experimental measurements and their application in practice.

KEYWORDS

laser, surface roughness, sheetmetal, gas pressure

1 INTRODUCTION

What is a laser?

A laser is a device amplifying electromagnetic radiation. The radiation can have frequency of visible light. The laser emits considerably strong radiation with specific properties. Firstly, the radiation is monochromatic, i.e. a single-frequency radiation. In case of visible light it refers to mono-colour light – contrary to normal light which represents a mixture of rainbow colours. Monochromatic radiation is radiation with time coherence [Bicejova 2013a,b,c]. Furtherly, rather significant property is spatial coherence due to which radiation can be emitted by laser in a thin and non-dispersed beam and focused on a small point.

How does the laser cutting work?

The laser consists of three basic parts: energy source, active medium and optical resonator. Energy source is sometimes referred to as a pump the task of which is to supply energy to active medium to assure it gets into energized state. The source is often electric, light – for instance, a discharge lamp or different laser. Medium requires supply of sufficient amount of energy to provide higher number of particles in energized or excited state contrary to the basic state [Gaspar 2013]. A particle becomes energized by absorbing sufficient amount of energy for its single electron which thus can leap to a higher energy level occurring further from the core [Halko 2013]. After certain period of time the energized electron leaps back and the same amount of energy is emitted in the form of non-coherent form. The phenomenon is referred to as the spontaneous emission. The medium is usually placed in optical resonator consisting of two curved mirrors one of which is semi-transparent. The radiation produced during spontaneous emission with correct wavelength, direction and phase reflects from them and during every transition it interacts with the excited medium particles and causes their return back to the basic energy level. In case of such stimulated decrease to the previous energy level the particles emit photons with phase, frequency, polarization and direction identical with those of the transiting beam so the required radiation increases. Through a semi-transparent mirror part of radiation escapes in the form of focused laser beam and other part is reflected for further increase.

Achievement of the desired quality parameters of the laser cutting process requires setting of the optimum technological parameters. Basic technological parameters significantly influence surface roughness as well as change of micro-hardness of surface layers in the cutting area [Krenicky 2015]. Especially important are four groups of parameters presented in the following table [Novakova 2008, Bicejova 2016a].

Table 1. Basic technological parameters in laser cutting process

Laser parameters	Process parameters
• laser performance • repeated frequency • performance constancy • beam diameter	▪ cutting speed ▪ type of gas ▪ gas pressure ▪ focal point position
Workpiece parameters	**Machine parameters**
▪ material thickness ▪ type of material ▪ surface quality	▪ output mirror of a laser aggregate ▪ position of beam ▪ beam conduction ▪ beam adjustment ▪ drilling of nozzle

Laser Performance

Maximum continual performance is produced by the CO_2 lasers. The level of the desired lase performance results from data of optical and thermal properties of the machining material. The laser performance must be adjusted to the type and thickness of a workpiece. The performance can be varied within the range from 1 up to 100 %. The desired high accuracy of complicated geometries of the workpiece can be achieved by reduction of the laser performance through the change of impulse operation length [Novakova 2008, Bicejova 2016a].

Cutting Speed

Cutting speed substantially affects depth and quality of cutting from point of view of roughness and micro-hardness. Decreasing of speed causes considerable increase of cutting depth and improvement of cutting surface quality. In a high degree cutting speed depends also on the purity of applied cutting gases [Novakova 2008, Bicejova 2016a].

Gas Pressure

Gas pressure substantially depends on material thickness of the workpiece. In material cutting by burning the thin metal materials are cut by higher gas pressure contrary to the thicker workpieces as higher traverse speed of laser head is applied. Vice versa, in case of high-pressure material cutting the thicker workpieces are cut by higher gas pressure to expel the dense melt metal out of the cutting point. In case of metal materials the material thickness increases along with cutting surface roughness and laser performance [Novakova 2008, Bicejova 2016b].

2 EXPERIMENTAL PART

2.1 *Applied Device*

The experimental part of the paper deals with detection of surface roughness of materials with diverse thickness in case of laser cutting. The samples were cut by Laser Durma HD F 3015 (Fig. 1). The laser devices by the company of Laser Durma are classified into two categories marked as the HD and HD- F series. The HD series of CO_2 laser machines allow high quality cutting of both thin and strong materials. It offers maximal performance with minimal operational expenses.

Figure 1. Laser DURMA HD – F 3015

In case of laser cutting speed change the surface roughness was detected by contact profilometer Surftest SJ400 (Fig.2) by the company of Mitutoyo.

Figure 2. Profilometer MitutoyoSurftest SJ400

The device is characterized by the parameters shown in tab. 1.

Table 2. Parameters of ProfilometerMitutoyoSurftest SJ400

measurement speed	0.05; 0.1; 0.5; 1.0 mm/s
return speed	0.5; 1.0; 2.0 mm/s
measurement direction	backwards
positioning	± 1.5° (angle bevel), 10 mm (upwards/downwards)
range/resolution of measurement	800/0.01 µm; 80/0.001 µm up to 2400 µm
measurement method	s/without footing
radius of footing curvature	40 mm
type of connection	net adapter
data output	interface RS-232C/SPC
assessed parameters	P (primary), R (roughness), W (filtered waviness), digital filter 2CR, PC75, Gauss

Accessories of device MitutoyoSurftest SJ400 designed for roughness measurement:

- digital measuring apparatus with LCD touching screen,
- sliding unit holder for measuring stand,
- sliding measuring unit,
- special jig for a measured unit fastening.

2.2 *Preparation of Experimental Samples*

The applied material is steel 11 375 according to STN standard marked also as S235JRG2 according to EN 10025/90+A1/93standard (Fig. 3). Thickness of steel is of 8 mm and 10 mm. The selected parameters were changed with the individual values of thickness.

Figure 3. Experimental sample

2.3 *Roughness Measurement Procedure:*

Prior to measurement the samples were thoroughly cleaned. Impurities were removed with the application of technical benzine. The samples were arranged according to machining order of the measured surfaces. After switching the measuring device on, the measuring sample was fastened with a special jig [Mascenik 2012]. The device contains a tiny body fixed on the top of a holder of a sliding unit for the measuring stand. In clockwise rotation the measuring unit slid downwards. In anticlockwise rotation the measuring unit slid upwards. The rotation continued until the stylus of the measuring unit leant against the measuring unit [Salokyova 2016a,b].
To assure correct measurement the LCD display showed the most suitable approximation of the stylus. When the position had been reached, the measurement was triggered using the START button. The stylus of the measuring unit slid along the measured sample. The measured values Ra and Rz were read directly from the LCD display and consequently recorded. The measurement was discontinued by pressing the STOP button. Consequently, the sample was removed from the measuring device. The anticlockwise rotation of a tiny body on the holder of the sliding unit caused upward sliding of the stylus of the measuring unit. Afterwards the sample was removed from the jig in which it was fastened. The measurement procedure remained unchanged with all samples [Mascenik 2011].
Part of the measuring device SURFTEST 400 Fig.2 is a printer of the measured values. Pressing the PRINT button the individual values were printed which were applied in further analysis. Drawback of the device rests in a limited memory – 5 samples only. As the number of samples exceeded 5, the values were recorded into the table in fives to prevent interruption of the measurement and to assure printing of the values which can be recorded as well. The interruption would considerably prolong the measuring period.

2.4 *Processing and Assessment of the Measured Values*

The measured surface roughness values in case of cutting material thickness of 8mm and 10m are shown in the following tab.3 and tab.4 with gas pressure change [Mascenik 2014a,b]. Other measured roughness values in case of change of laser performance and cutting speed are plotted in graphs only.

Roughness Ra(µm)	4,61	2,66	6,36	10,46
Roughness Rz(µm)	25,3	13,9	35,7	44,8

Table 2. Cutting surface roughness of cutting sheetmetal with thickness of 8 mm in case of gas pressure change.

Roughness Ra(µm)	4,13	4,88	3,48
Roughness Rz(µm)	20,9	23,4	22,1

Table 3. Cutting surface roughness of cutting sheetmetal with thickness of 10 mm in case of gas pressure change.

The following figures show graphical relations between the influence of the selected technological parameters of laser and surface character, which are defined by values Ra and Rz with Ra referring to a mean arithmetical deviation of the profile [µm] and with Rz referring to the peak unevenness value [µm].

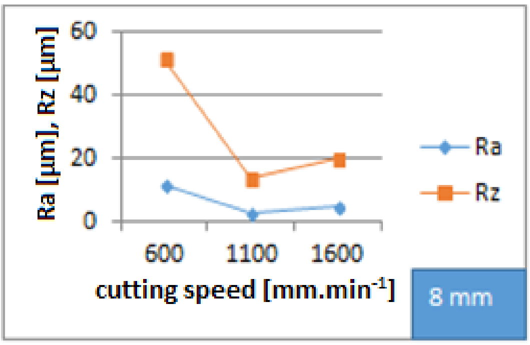

Figure 4. Graphical plotting of sheetmetal surface roughness with thickness of 8 mm during cutting speed change

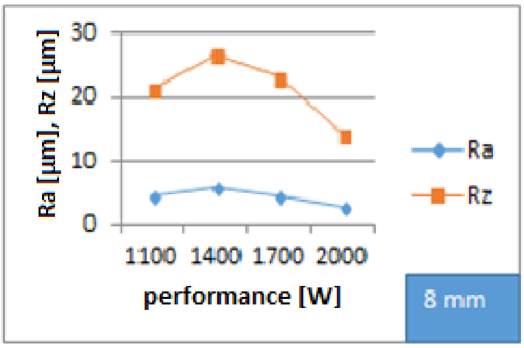

Figure 5. Graphical plotting of sheetmetal surface roughness with thickness of 8 mm in case of performance change

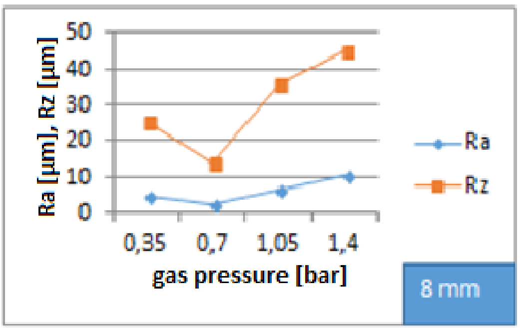

Figure 6. Graphical plotting of sheetmetal surface roughness with thickness of 8 mm in case of gas pressure change

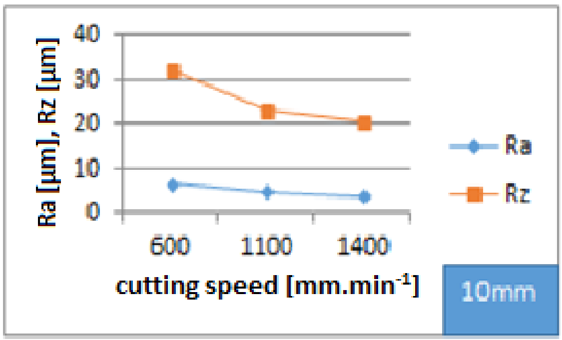

Figure 7. Graphical plotting of sheetmetal surface roughness with thickness of 10 mm during cutting speed change

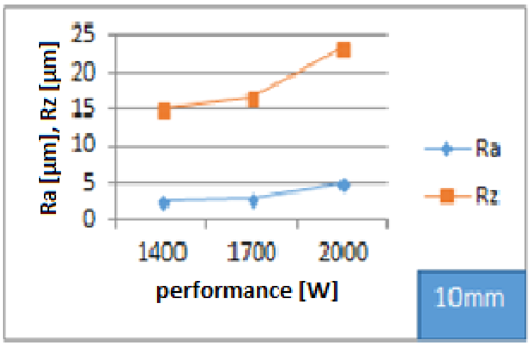

Figure 8. Graphical plotting of sheetmetal surface roughness with thickness of 10 mm in case of performance change

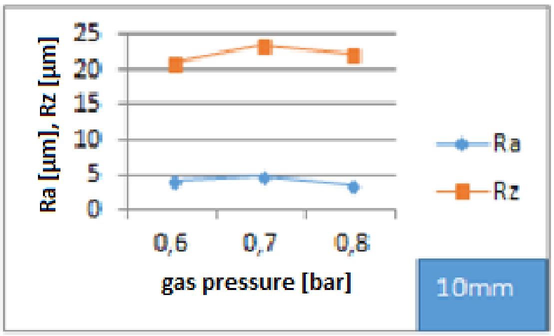

Figure 9. Graphical plotting of sheetmetal surface roughness with thickness of 10 mm in case of gas pressure

3 CONCLUSIONS

In case of the individual sheetmetal thickness values the occurrence of diverse values of surface roughness can be observed in relation to the change of parameters. The parameters are changed differently in each case, yet with the identical values the curves show similar surface roughness. With the change of the individual parameters the individual cases occurred. With the change of cutting speed the surface roughness increases from the value of 1400 mm/min. The decrease occurs from the value of 1100mm/min. It can be assumed that in the event of application of the identical cutting speed change the curves would appear to be developing in a like manner. The measured roughness values show similar development when the gas pressure is changed. With performance of 2000W during laser performance change the increase could be observed in the first case whereas the second one showed the decrease.
The research proved the change of the individual surface roughness values when the parameters were changed. The more similar or even identical the parameters appear to be in case of diverse sheetmetal thickness values; the curves tend to

develop in the same or in a completely different manner. The situation is caused by thickness and treatment of the particular material. The results of experimental measurements can contribute to further applications of unconventional technology of material laser cutting in practice.

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