DETERMINITATION OF RELATION BETWEEN INFLUENCE OF LASER PERFOMANCE CHANGE AND CUTTING SURFACE CHARACTER IN LASER CUTTING TECHNOLOGY

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The introduction of the submitted paper describes theoretical foundations of material laser cutting technology. The core analyses direct relation between influence of laser performance and cutting surface character when the cutting material thickness changes. The experimental measurements applied material S235JRG2 (according to EN 10025/90+A1/93) with thickness of 3 mm, 4 mm, 6 mm, 8 mm and 10 mm. The conclusion presents recommendations for entrepreneurial, research, and pedagogical sphere.

KEYWORDS

laser, surface roughness, sheetmetal, performance

1 INTRODUCTION

Laser radiation, contrary to other black body sources, allows high spatial coherence. Thus it can be transmitted as almost parallel beam and focused into the dimension comparable with the radiation wave length. For instance, beam of kilowatt performance can be transmitted via air and consequently focused into density of 10^6 Wcm^{-2} by which welding, melting, perforating or machining of objects might be carried out.

<u>*Laser Cutting Methods*</u>

Thermic splitting by laser beam can be classified as per three methods:

1. Sublimation cutting
2. Fusion cutting - high-pressure cutting
3. Reactive cutting

Laser cutting is typical for its possibilities of adjustment of diverse types of cutting quality. At all times the cutting is adjusted to achieve optimum quality depending on cutting thickness. Favourably, the smooth cutting is feasible up to thickness of ± 8 mm [Bicejova 2016a]. With the increasing thickness the quality deteriorates, diverse scales, lugs, and grooves occur [Gaspar 2013, Halko 2013]. Laser machines can achieve accuracy of ± 0.1mm.The structure of machined surfaces ranges from Ra 3.6 micrometres up to Ra 12 micrometres [Bicejova 2013b, Bicejova 2016b, Mascenik 2014a].

Economic efficiency of operation of the laser cutting technology is distinct especially in connection with optoelectronic robots, manipulators, and industrial robots into flexible production systems. Apart from direct production costs, the savings are achieved also for the application of laser cutting technology:

- saving of tools and tooling capacity,
- overall saving of material and energy,
- substantial saving of work and costs related to machining of thermally affected areas,
- energy and investment saving, investment into air-conditioning and ventilation is not needed,
- overall improvement of work environment and occupational hygiene,
- manipulation time saving,
- customer-oriented high productivity and flexibility of work,
- short time of production operations,
- low service costs,
- simple training [Novakova 2008, Mascenik 2014b].

Advantages and Disadvantages of Laser Cutting

Laser cutting shows the following advantages as well as disadvantages.

<u>*Advantages:*</u>

- Allows contactless and force-free machining of a workpiece.
- Machining speed is high by which significant acceleration of production process is achieved in comparison to, for instance electro-erosive cutting.
- Owing to high density of energy the affected surface can be maintained rather small.
- Inconsiderable thermally affected surface guarantees low protraction of the workpiece.
- Roughness of cutting edges is low by which additional machining can be omitted.
- Width of cutting groove is rather considerable and can be kept constant within the broad range.
- Observing the tolerances of up to 0.05 mm can be achieved in series production as well.
- Material hardness influences cutting speed only insignificantly [Mascenik 2011].

<u>*Disadvantages:*</u>

- In case of materials with high reflection coefficient the cutting is rather problematic.
- Thermally affected cutting edges.
- Formation of poisonous gaseous waste products in cutting of plastics.
- In application of oxygen as of a cutting gas an oxide layer develops on cutting edges [Bicejova 2013a, Mascenik 2012].

2 EXPERIMENTAL PART

2.1 Applied Devices

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

During laser performance change the surface roughness was detected in case of contact profilometer Surftest SJ400 (Fig.2) by the company of Mitutoyo.

Figure 2. Profilometer MiruoyoSurftest SJ400

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

Table 1. Parameters of profilometer MitutoyoSurfest 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 Applied Devices

The applied material is steel 11 375 according to STN standard marked also as S235JRG2 according to 10025/90+A1/93standard (Fig. 3). Thickness of steel is of 3 mm, 4 mm, 6 mm, 8 mm and 10 mm. Laser performance was changed with the individual values of thickness.

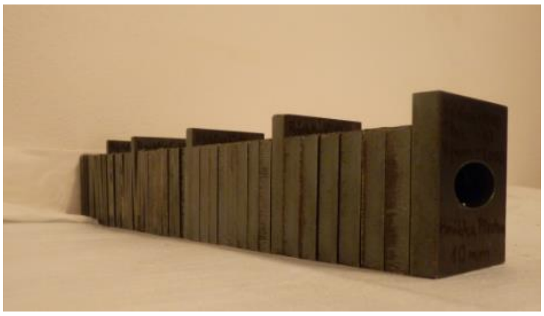

Figure 3. Experimental samples

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. 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.

Table 2. Cutting parameters related to sheetmetal with thickness of 3 mm with laser performance

Laser performance (W)	800	1000	1500	2000
Cutting speed (mm/min)	3200	3200	3200	3200
Gas pressure (bar)	0,7	0,7	0,7	0,7
Distance of a nozzle (mm)	1,2	1,2	1,2	1,2
Frequency (Hz)	5000	5000	5000	5000
Cutting width (mm)	0,28	0,28	0,28	0,28
Gas type	O_2	O_2	O_2	O_2
Load (%)	100	100	100	100
Acceleration (%)	50	50	50	50

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 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 for all samples.

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 is 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 prolong the measuring period.

2.4 Processing of the measured values

Laser parameters in production of the samples during performance change are shown in tab.2. With cutting material thickness of 4, 6, 8, and 10mm the monitored performance during laser cutting of the material is plotted into the graph only. Other technological parameters of the device remain constant.

2.5 Assemessment of the measured values

Following table 3 shows the measured surface roughness for the cutting material thickness of 3 mm and other measured roughness values with thickness of 4, 6, 8 and 10 mm are plotted into the graph only

Table 3. Measured roughness of the cutting surface during laser performance change with material thickness of 3 mm (Drsnost = Roughness)

Roughness Ra(µm)	10,76	0,69	0,63	0,26
Roughness Rz(µm)	32,1	3,3	3,1	1,5

The following figures 4-8 show graphical relations between the influence of laser performance change 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] [Krenicky 2011, Krenicky 2015].

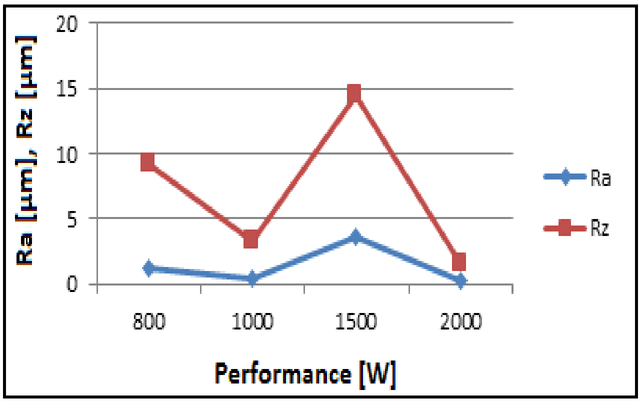

Figure 4 Graphical plotting of sheetmetal surface roughness with thickness of 3 mm during performance change

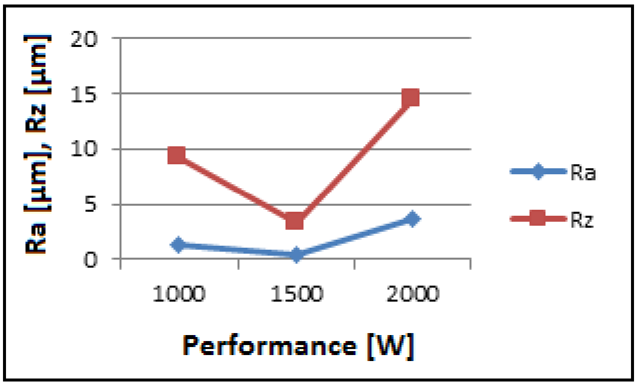

Figure 5. Graphical plotting of sheetmetal surface roughness with thickness of 4 mm during change

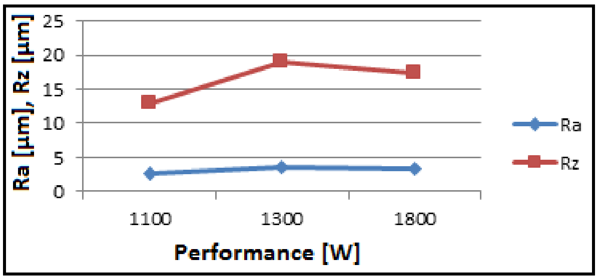

Figure 6. Graphical plotting of sheet metal surface roughness with thickness of 6 mm during change

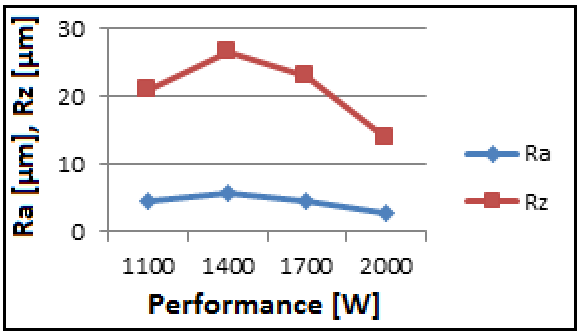

Figure 7. Graphical plotting of sheet metal surface roughness with thickness of 8 mm during performance change

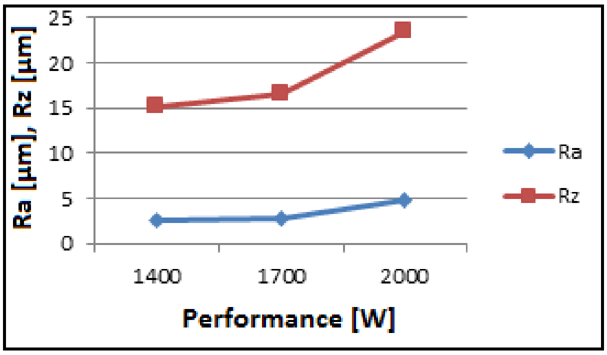

Figure 8. Graphical plotting of sheet metal surface roughness with thickness of 10 mm during performance change

3 CONCLUSIONS

On the basis of experimental measurement it can be stated that with the performance change the individual surface roughness values change as well. Graphical relations show the curves which indicate the individual surface roughness values with laser performance change. With the laser performance change the parameters of the individual thickness values of sheetmetal were similar. In case of sheetmetal thickness of 4 and 10mm these parameters were identical and the curves were increasing and of the same character. In case of other sheetmetals roughness decrease was observed. A significant discrepancy occurred with sheetmetal with thickness of 10 mm and 8 mm as right in this point at performance of 2000W increase in the first event and decrease in the other was apparent. The results of experimental measurements can contribute to further applications of unconventional technology of material laser cutting in practice.

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