INFLUENCE OF GAS PRESSURE CHANGE ON CHARACTER OF CUTTING SURFACE IN MATERIAL LASER CUTTING

LUBA BICEJOVA

Technical University of Kosice,

Faculty of Manufacturing Technologies with a seat in Presov

Department of Technological Systems Design, Slovak Republic

DOI: 10.17973/MMSJ.2016_09_201644

e-mail: luba.bicejova@tuke.sk

The submitted paper deals with the issue of unconventional technology of material laser cutting. The paper presents particular relations between the influence of gas pressure change and character of cutting surface after experimental measurements.[Gaspar 2013] Gas pressure change was applied in case of the selected sheetmetal thickness. The samples taken during experimental measurements were prepared in cooperation with the private sector which employs the laser cutting technology directly in production. The conclusion contains the results of the measurements and discussion on the respective issue.

KEYWORDS

laser, surface roughness, sheetmetal, gas pressure

1 INTRODUCTION

The unconventional technologies relate to a term possible to be explained diversely. One definition refers to the unconventional technologies as to technologically advanced systems and methods of industrial processing of material which are based on the principle of utilization of physical or chemical mechanism of material removal [Salokyova 2016a,b].

The fundamental feature of all unconventional technologies is absence, i.e. non-occurrence of classic chips produced in case of conventional processing and cutting of material.

Broad scope of parameters is rather typical for the unconventional methods. The parameters can be classified according to two aspects, i.e. conditions and outputs of the respective processes. These parameters include the following:

- parameters such as speed, efficiency, and possibilities of machining are independent from mechanical properties of the machining material,
- material of a tool does not need to be harder in comparison to machining material,
- more complicated operations are acceptable, e.g. cavity formation in material with high values of mechanical properties,
- possibilities of automation and mechanization of workplaces [Murcinkova 2013],
- limitation of reject production with the increase of technological rate of production,
- with the application of some of the methods parallel occurrence of change of mechanical properties of the affected surface can be observed as well as resistance to corrosion and increase of vibration fatigue limit,
- productivity growth [Novakova 2008, Mascenik 2014a]

Laser Cutting Methods

Fusion Cutting

In case of this cutting type the material is molten locally with a laser beam and consequently blown from the point of cutting with assist gas. Contrary to other laser cutting methods, the fusion cutting allows achieving the lower cutting speed only [Bicejova 2013a,b,c]. Direct linearity can be observed between increase of laser performance and maximal cutting speed, and approximate linearity occurs between decrease of cutting material thickness and its temperature. Due to high-quality cutting surface the method is suitable especially when desirable is to achieve the cuttings without oxidizing of metal material surface such as in case of stainless steel, aluminum, brass, copper, etc. [Novakova 2008, Mascenik 2012].

Oxidation Cutting

In principle, the oxidation cutting is identical with the fusion one, yet the difference stems in application of oxygen as of assist gas. As a consequence of oxygen use, the exothermic reaction occurs in the cutting point, which further on heats the material and facilitates fusion and blowing of the molten material. Owing to the phenomenon, the oxidation cutting is faster in comparison to the fusion one yet at the expense of worse surface quality, wider heat-affected zone, and wider cutting kerfs [Krenicky 2015]. The method is not suitable for accurate burns and sharp geometric shapes [Bicejova 2016a,b]. Oxidation cutting is employed especially in cutting of low alloy and unalloyed steel which is not as prone to oxidation as high alloy steel. High alloy steel requires decrease of speed or transition to pulse mode of laser, which eliminates these parameters [Novakova 2008, Mascenik 2012].

Sublimation Cutting

Nowadays, it represents rarely employed method of cutting in case of which the material is evaporated right in the cutting point without necessity to use assist gas. Due to minimization of melting zone the laser beam with high energy density must be assured. At the same time the cutting material thickness must be lower contrary to laser diameter otherwise the material vapors would condensate and weld the cut. However, these limitations are not applicable in case of materials with absent liquid phase such as wood and ceramics. Maximal cutting speed is indirectly proportional to evaporating heat of material or directly proportional to speed of migration of cutting gas [Novakova 2008, 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 performance of 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 gas pressure change the surface roughness was detected in case of contact profilometer Surftest SJ400 (Fig.2) by the company of Mitutoyo.

Figure 2. Profilometer MitutoyoSurfest SJ400

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

Table 1. Parameters of profilometer MitutoyoSurftest 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	± 1.5º (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 Mitutoyo Surftest 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 10025/90+A1/93 standard (Fig. 3). Steel thickness is of 3 mm, 4 mm, 6 mm, 8 mm and 10 mm. Gas pressure was changed with the individual values of thickness.

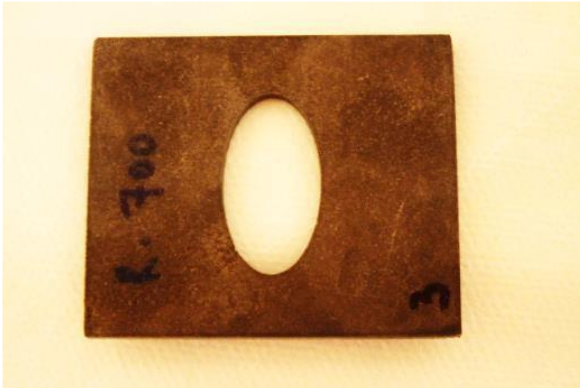

Figure 3. Experimental Sample

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 2014b]. 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 [Mascenik 2011].

Table 2. Cutting parameters related to sheetmetal with thickness of 3 mm with gas pressure change

Gas pressure(bar)	0.1	0.3	0.5	0.7	0.9	1.1	1.3
Cutting speed(mm/min)	3200	3200	3200	3200	3200	3200	3200
Laser performance(W)	2000	2000	2000	2000	2000	2000	2000
Distance of a nozzle(mm)	1.2	1.2	1.2	1.2	1.2	1.2	1,2
Frequency(Hz)	5000	5000	5000	5000	5000	5000	5000
Cutting width(mm)	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Gas type	O2	O2	O2	O2	O2	O2	O2
Load(%)	100	100	100	100	100	100	100
Acceleration(%)	50	50	50	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 [Halko 2013]. The anticlockwise rotation of a tiny body on the holder of the sliding unit caused upward sliding of the stylus of the measuring unit. Consequently, the sample was removed from the jig, in which it was fastened. The measurement procedure remained unchanged with 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 measurement period.

2.4 Processing of the Measured Values

Laser parameters in production of the samples during gas pressure change are shown in tab.2.

With cutting material thickness of 4, 6, 8, and 10mm the monitored gas pressure during laser cutting of the material is plotted into the graph only. Other technological parameters of the device remain constant.

2.5 Assessment of the Measured Values

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 gas pressure change with material thickness of 3 mm

Roughness Ra(µm)	0.64	0.57	0.94	0.26	0.32	1.83	0.39
Roughness Rz(µm)	3.6	3.3	5.8	1.5	2.5	2.1	2.4

The following figures 4-8 show graphical relations between the influence of gas pressure 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].

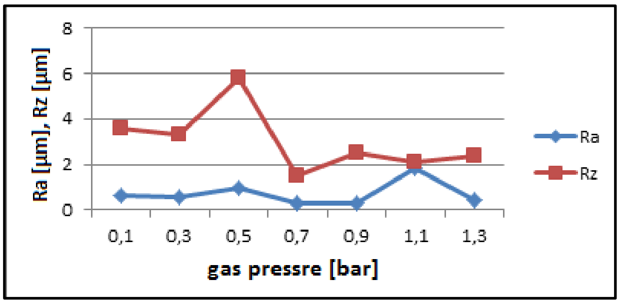

Figure 4. Graphical plotting of surface roughness of sheetmetal with thickness of 3 mm during gas pressure change

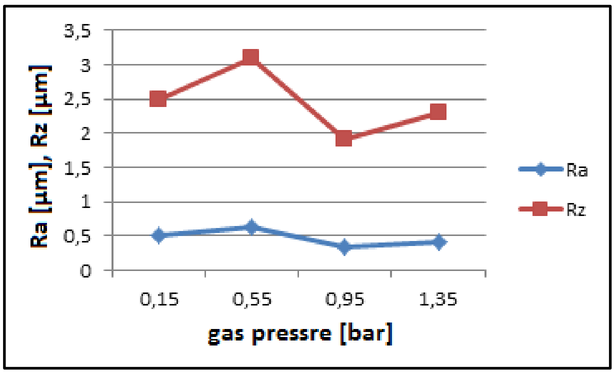

Figure 5. Graphical plotting of surface roughness of sheetmetal with thickness of 4 mm during gas pressure change

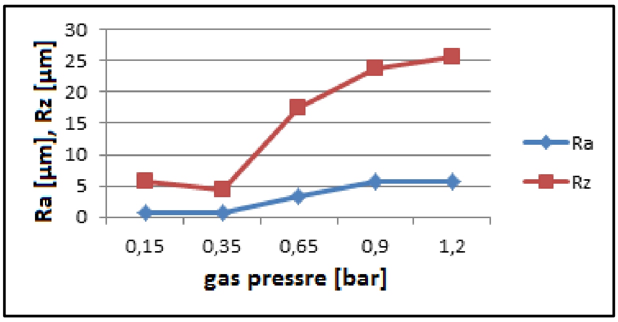

Figure 6. Graphical plotting of surface roughness of sheetmetal with thickness of 6 mm during gas pressure change

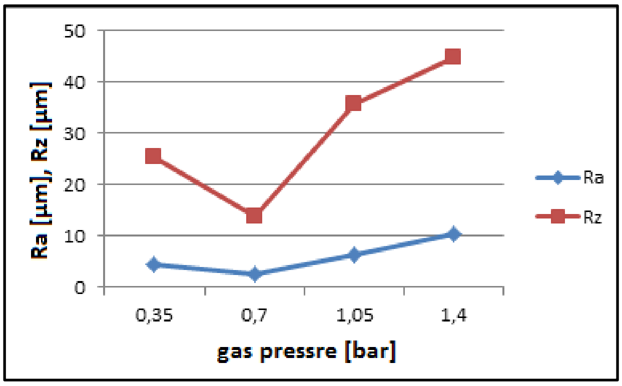

Figure 7. Graphical plotting of surface roughness of sheetmetal with thickness of 8 mm during gas pressure change

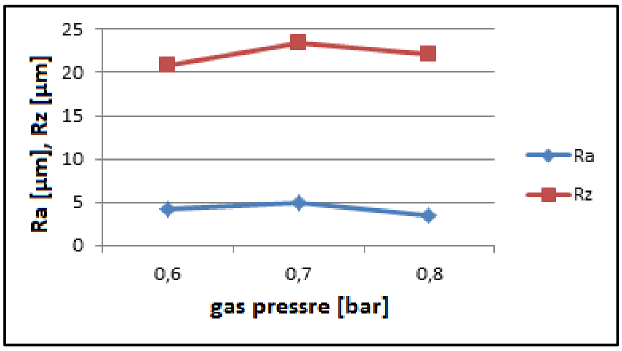

Figure 8. Graphical plotting of surface roughness of sheetmetal with thickness of 10 mm during gas pressure

3 CONCLUSIONS

On the basis of experimental measurement it can be stated that with the gas pressure change the individual surface roughness values change as well. Graphical relations show the curves which indicate the individual surface roughness values during gas pressure change. Apparently, sheetmetals with thickness of 6 and 8 mm show similar curves. Their roughness decreases initially and consequently it increases. Similar curves can be observed also in case of sheetmetals with thickness of 3 and 4 mm with increasing surface roughness, as in previous events. Decreasing character is typical only for surface roughness of the sheetmetal with thickness of 10 mm. The results of experimental measurements can contribute to further applications of unconventional technology of material laser cutting in practice.

ACKNOWLEDGEMENT

This article has been prepared within the project VEGA 1/0904/13 and KEGA 080TUKE-4/2015.

REFERENCES

[Bicejova 2013a] Bicejova, L., Pavlenko, S., Mascenik, J. Abrasive Granularity Impact on Water Jet Technology Head Vibrations During Cutting Steel, Applied Mechanics and Materials, 2013, p. 304-309, ISSN 1660-9336

[Bicejova 2013b] Bicejova, L. Water jet technology head vibration generation due to selected technology parameters fluctuation effect during alloy cutting. In: Applied Mechanics and Materials. Vol.308 2013, p. 81-86. ISSN 1660-9336

[Bicejova 2013c] Bicejova, L. Abrasive kind and granularity changes affects to water jet technology head vibration during cutting HARDOX material thickness alternation process, In:

Applied Mechanics and Materials. Vol. 308 2013, pp. 75-79. ISSN 1660-9336

[Bicejova 2016a] Bicejova, L., Pavlenko, S., Mascenik, J. Measuring, processing and evaluating of technology head water jet vibration signal. In: Key Engineering Materials: Operation and Diagnostics of Machines and Production Systems Operational States 3. Vol. 669, 2016, pp. 205-211. ISBN 978-3-03835-629-5. ISSN 1013-9826

[Bicejova 2016b] Bicejova, L., Pavlenko, S. Experimental investigation and determination of abrasive granularity change impact to technology head vibration generating during awj technology steel cutting. In: Key Engineering Materials Vol. 669 2016, p. 220-227. - ISBN 978-3-03835-629-5. ISSN 1013-9826

[Gaspar 2013] Gaspar, S., Pasko, J. Influence of technological factors of die casting on mechanical properties of castings from silumin, 2013. In: Lecture Notes in Electrical Engineering. Vol. 240, pp. 713-722. ISSN 1876-1100

[Halko 2013] Halko, J., Mascenik, J. Differential with an integrated, newly - developed two-stage transfer, In: Applied Mechanics and Materials: Materials Engineering for Advanced Technologies ICMEAT 2013. Vol. 510 2014, pp. 215-219. ISSN 1662-7482

[Krenicky 2015] Krenicky, T. Non-contact Study of Surfaces Created Using the AWJ Technology. In: Manufacturing Technology Vol. 15 No. 1 (2015) pp. 61-64. ISSN 1213-2489

[Mascenik 2011] Mascenik, J., Gaspar, S. Experimental Assessment of Roughness Changes in the Cutting Surface and Microhardness Changes of the Material S 355 J2 G3 after Being Cut by Non-Conventional Technologies, 2011. In: Advanced Materials Research. Vol. 314-316, ISSN 1022-6680

[Mascenik 2012] Mascenik, J. The evacuation of pressure moulds as progressive developments of die casting process, 2012. In: Acta Technica Corviniensis : Bulletin of engineering. Vol. 5, no. 3 (2012), pp. 25-26. ISSN 2067-3809.

[Mascenik 2014a] Mascenik, J., Pavlenko, S. Aspects of alternative dispute creating bolted joint technology flowdrill, In: Applied Mechanics and Materials: 2nd International Conference on Mechanical Structures and Smart Materials, 2014, Kuala Lumpur, Malaysia. Vol. 680 (2014), pp. 186-189. ISSN 1660-9336

[Mascenik 2014b] Mascenik, J., Pavlenko, S. Determining the exact value of the shape deviations of the experimental measurements, In. Applied Mechanics and Materials, Vol. 624, 2014, pp. 339-343, ISSN 1660-9336

[Murcinkova 2013] Murcinkova, Z., Krenicky, T. Implementation of virtual instrumentation for multiparametric technical system monitoring. In: SGEM 2013: 13th Int. Multidisciplinary Sci. Geoconf. Vol. 1: 16-22 June, 2013, Albena, Bulgaria. Sofia: STEF92 Technology, 2013. pp. 139-144. ISBN 978-954-91818-9-0.

[Novakova 2008] Novakova, M., Pavlenko, S. Comparison of production parameters in cutting of material by laser and plasma. In: Management of Manufacturing Systems: 3rd Conference with international participation. Presov: FVT TU, 2008 pp. 276-278. ISBN 9788055300696

[Salokyova 2016a] Salokyova, S. Measurement and analysis of mass flow and feed speed impact on technological head vibrations during cutting abrasion resistant steels with abrasive water jet technology. In: Key Engineering Materials. Vol. 669 2016, pp. 243-250. - ISSN 1013-9826

[Salokyova 2016b] Salokyova, S., Krenicky, T. Analysis of the effects of factors in relation to vibration of technological head during the splitting of construction steels through hydro-abrasive splitting. In: Key Engineering Materials. Vol. 669 2016, pp. 216-219. ISSN 1013-9826

CONTACTS:

M.Sc. Luba Bicejova, PhD.
Technical University of Kosice,
Faculty of Manufacturing Technologies with a seat in Presov,
Department of Technological Systems Design,
Bayerova 1, 080 01 Presov, Slovak Republic
Tel.: +421 51 772 6313
e-mail: luba.bicejova@tuke.sk