

EXPERIMENTAL INVESTIGATION OF CHOICE TECHNOLOGICAL MATERIAL AND QUALITATIVE PARAMETERS IN TECHNOLOGY OF LASER CUTTING

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ABSTRACT

The paper presents experimental research results of influence selected technological parameters and the depth of machined material to roughness by Laser Beam Machining. Contains illustrations of mathematical and graphical dependence, which generates basic of mathematical model for simulation of technological parameters to quality parameters influence. Knowledge presents results dissertation and research problem solution at the Department of Technological System Operation.

KEYWORDS surface roughness, cutting area, material thickness, steel, graph, heat affected area, laser beam machining.

1 INTRODUCTION

Laser Beam Machining technology factors group significantly influenced quality of products. Objective of that work is quick estimation optimal values in dependence asked quality cutting material significantly influence economic efficiency and concurrent ability firm using LBM productions systems. The estimation mathematical, simulation and optimization model allows efficiency estimation optimal values technology factors are to make measurement and evaluation. This is the purpose of that article that deals with technology factors analysis to quality cutting surface.

2 CUTTING SURFACE QUALITY PARAMETERS

Quality of cutting surface in LBM technology is possible evaluated according set of parameters [14]: average roughness Ra, surface hardness, beam deflection and irregularity of the kerfs.

3 TECHNOLOGY FACTORS

Technology factors of Laser Beam Machining are divided into four groups. The first group is laser factors, which directly influence the microgeometrical or macrogeometrical quality of machined workpiece through the initial tool Laser. Through proces factors, created tool

hits the workpiece the at upper base, where photone erosion process begins. These factors create surface as area of trajectory working movement Laser Beam.

Table 1 shows set of those LBM technology factors structure [11].

Table 1 LBM technology factors division

Laser factors	Laser output
	Repetition pulses frequency
	Beam diameter
	Divergence
	Polarization
Process factors	Rate of speed
	Position ganglion
	Gas pressure
	Gas class
Workpiece factors	Thickness of the workpiece
	Workpiece surface
	Workpiece geometry
	Material sort
Equipment factors	Beam locating
	Astigmatism
	Beam Driving Mirrors
	Focus lens
	Nozzle boring
	Outlet mirror laser assembly

Selected factors for evaluation in the (table 1) are pointed as bold

according German standard DIN 17 100-80 agree to steel 11 375 signature RSt 37/2.

4. SAMPLE MATERIAL

Samples for measurement average roughness has been made from steel – 11 375 and 14 331, for measurement heat affected area only the steel 11 375. More details about experimental samples material (steels) are explained in table 2 [20].

Table 2 Evaluated experimental material sample characteristic

	11 375 (RST 37/ 2)	14 331
Steel status	heat lost, flame-patterned	enriched, rare stripped
Chemical properties	max.0,17C; max.0,045P max.0,045S	0,28-0,35 C; 0,80-1,10 Mn; 0,90-1,20Si; 0,80-1,10 Cr; max.0,40 Ni; max. 0,25 Cu; max 0,035 P; max 0,03 S
Metal properties	standard quality warrant welding ability	warrant welding ability thermoplastic and good machine ability
Using	welding bridge design, machine parts, heat parts, pressure vessel with limited pressure up to 300°C	fly constructions, machine parts, e.g. pins, shafts, clutch, screws, nuts.

Note: 11 375 – the signature of experimental materials agree to standard STN 41 1375,

4.1 Technical facilities used for production and measurement samples [12].

- a. *Measurement Ra* – average roughness. Samples for measurement have been made in full operation at laser cutting equipment Trumatic L 3030 (TLF 3030) from German company TRUMPH. The main technical parameters of the Trumatic L 3030 are listed in the table. 3.

Table 3 Technical parameters of the Laser CO₂ Trumatic L 3030 [19]

Technical parameters	TLF 3000t
Total Weight	11 500 kg
Working area	x - 3000mm, y - 1500mm, z - 115mm
Transitional area	x - 3104mm, y - 1580mm, z - 117mm
Proportions	length - 9 800mm, width - 5 300mm, highness - 2000mm
Operating system	TRUMPF - CNC - SIEMENS SINUMERIC 840D
Driving mechanism	x,y,z axes: three phase servomotor
Speed	parallel 60 m.min ⁻¹ ; simultaneously 85 m.min ⁻¹
Precision	position error ± 0,1 mm, position dissipation ± 0,03mm
Maximal output	3000 W
Max.material thickness	20 mm

Average roughness measurement has been performed at mechanical surface electronic profile meter SURFTEST-201 from Japanese company Mitutoyo.

- b. *Heat affected area* – samples production: Samples have been made at thickness 3, 4, 5, 6, 10 a 15 mm, material 11 375 at laser cutting equipment L 3030 (TLF 3030t) at firm Casspos, Inc., in Košice. Measurement and evaluation of metallographic structure of the heat-affected area has been realized at samples by metallographic microscope NEOPHOT 21. Size of heat-affected area

has been measured. Micro hardness values are shown in HM₁₀₀ (hardness **5 MEASURING DATA**

Average roughness of profile cutting surface has been measured and evaluated according standard STN 4287 (DIN 2310). Measured data of surface roughness and heat-affected

according HANEMANN) measured in load 100p.

area have been tested according Grubbs test with the purpose to reject from measured data set extreme data.

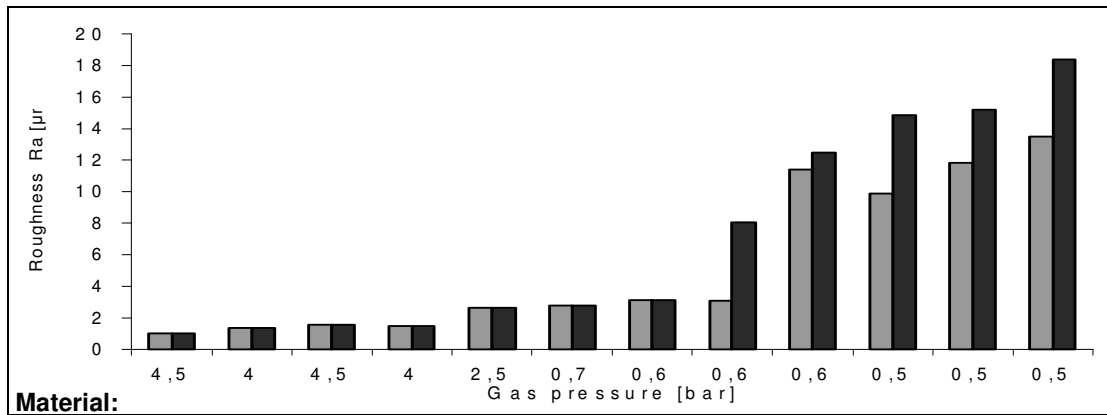
The measured data of the average roughness Ra for 10 thicknesses are shown in the table 4.

Table 4 Table of measurement data average roughness Ra material 11 375

MT [mm]	Average roughness R_a [μm]										NM	Arithmetic mean
	Measurement item number											
	1	2	3	4	5	6	7	8	9	10		
2	1,36	1,98	1,74	1,24	1,42						5	1,548
2,5	1,58	1,35	1,44	1,29	1,51	1,38	1,6	1,47	1,745		9	1,485
3	1,37	0,86	0,55	2,89	3,89	3,45	3,75	3,44	2,85	3,2	10	2,63
4	1,74	1,15	2,52	2,66	4,26	2,50	2,68	2,35	3,32	4,6	10	2,778
5	3,14	5,20	3,86	3,41	1,35	1,56	3,58				7	3,157
6	3,11	3,93	3,45	6,11	5,69	4,54	8,61	9,155	8,865		9	5,94
8	14,0 7	9,97	11,7	12,2	13,5	10,1					6	11,94
10	15,9 5	11,7	9,36	12,3	13,6	9,04	14,4				7	12,36
12	15,2 6	14,3	11,5	12,6	13,6	15,8	12,3	12,67			8	13,53
15	12,7 1	7,76	18,9	17,2	17,5	21,2	21,4	7,35	19,20		9	15,94
Sum											80	

Table 5 Sample number 3 – Measured data of microhardness. [HM100]

Thickness h = 5 mm					
Grinding part			Perpendicular cut		
Measurement number	HM ₁₀₀	Standoff	Measurement number	HM ₁₀₀	Standoff
1	279	0,07	1	373	0,06
2	221	0,17	2	264	0,17
3	183	0,27	3	186	0,27
4	176	0,38	4	186	0,38
5	176	0,49	5	186	0,49
6	176	0,60			



Material:

11 375 (M1)

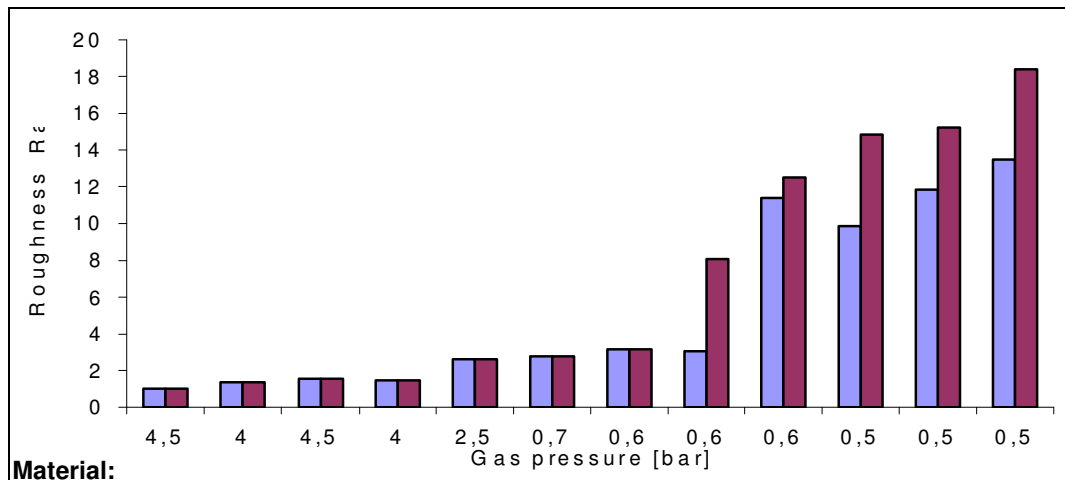
14 331 (M2)

Cutting gas:

for M1 – O₂

for M2 – N₂

Fig 1 Influence of thickness material to surface roughness Ra



Material:

11 375(M1)

Cutting gas:O₂

Laser output and cutting speed and nozzle diameter is changing with the thickness material.

Note: From thickness 6 mm roughness has been measured in upper and lower part of sample

Fig.2 Influence of gas O₂ additional pressure to surface roughness Ra

6 MEASUREMENT DATA EVALUATION

Evaluation consists of:

1. Estimation mathematical functions for determination among individual technology factors for material 11 375 and 14 331.
2. Graphical illustration of two parametrical functional dependence, which statements influence of cutting material thickness to
3. Estimation and creation of two parametrical functional dependence that shows influence or pressure to average roughness surface for two selected experimental materials.
4. Illustration of graphical dependence (fig.3) of three parametrical functional dependence (3D surface plot), that statements influence individual cutting material

thickness and gas pressure to surface roughness for material 11 375. Estimation and graphical illustration two parametrical functional dependence, that statements hardness of head affected area influence at thickness cutting material 11 375.

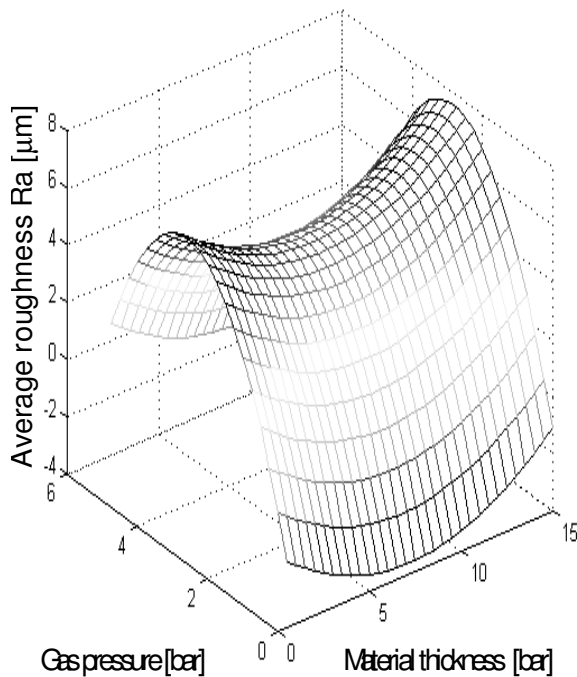


Fig. 3 Dependence of surface roughness Ra at gas pressure and thickness material

7 ACHIEVED RESULTS AND FORMULATIONS

- With the raising thickness of cut material (steel 11 375) the average roughness – the quality of cut material decrease in scale from 1 mm to 5 mm softly, at 6 mm depth up to 100%. 8 mm 4 - 5 times till 15 mm.
- More adverse influence to average roughness cutting surface has changing depth of the material 11 375 beside with material 14 331
- vice – versa with the pressure raising of additional gas (O_2) at material 11 375 the surface roughness decrease – the quality increase from value Ra 16 [μm] – to value Ra 1 – 3 [μm] from value pressure additional gas 0,7 bar and higher 4,5 bar.

At upper sample part has been measured the lowest average roughness as in the lower part of the sample with the constant pressure additional gas (O_2) (fig 1).

Results showed in the point a) and b) are reliable for thickness cutting material in the range of 1 – 15 mm.

8. BENEFITS

Realization achieved knowledge presented in the paper is possible achieve mainly at areas:

1. Reduction of number rejects,
2. Increase cutting accuracy,
3. Time programming reduction,
4. Time production reduction,
5. Cost operation reduction,
6. Raising cost economic efficiency,
7. Raising of concurrent company ability

CONCLUSIONS

The quality factor taper has been calculated according to measured experimental data the average roughness Ra.

The paper contains graphic illustrations and mathematical description original function dependence average roughness and technological parameters of equipment for laser cutting. Presents multi-parametrical mathematical model for simulation alternatives values of technological factors, that gives assume for reach optimal average roughness asked by customer.

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