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Experimental Research and Mathematical Modeling of Surface Roughness Parameters During Milling of Steel St 52-3

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Abstract

In this research is intended to investigate surface roughness parameters of material (St 52-3 according DIN standard) during milling process. For research are taken minimal and height parameters Ra, Rt and Rz, processing were conducted on CNC KNUTH X.mill 900 CNC drilling machine, while measurement were conducted with equipment TALYSURF for measurement of roughness parameters. The experiments were carried out on the samples (plates) of the materials mentioned above with dimensions L=20mm and a width b=60mm, while the roughness of the surface in this paper is experimentally presented with factors which have a more significant impact, and using the three-factor [2^3 + 4] plan.

Keywords: milling; surface roughness; roughness parameters; mathematical modeling.

1. Introduction

Milling process is one of the common metal cutting operations used for machining parts in manufacturing industry [5]. Milling is a machining operation in which a work piece is fed past a rotating cylindrical tool with multiple cutting edges [1]. No plains, which are created in the direction of the main movement, are mainly dependent on the splitting process, the formation of vibrations, and so on. It is very difficult to become a mathematical description of them [2].

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The sizes of these non-planes are considerably smaller than the plains in the direction of the auxiliary movement, which are mainly due to the kinematic cutting and the geometry of tool [3-4]. The roughness of the processed surface of steel St 52-3 is also dependent on other factors that have a major impact on the severity parameters. The parameters that affect the roughness of the surface are as many as p. sh. cutting mode elements, instrument cutter geometry, cutting vibrations, material properties, etc. Mathematical models represent the highest degree of approximation. They use certain mathematical symbols to mark variables or original parameters. The ratio between original variables and parameters is presented through mathematical logical relationships [6].

2. Experimental Setup

The chemical properties of steel St 52 - 3 - Based on the St 52-3 stainless steel literature, it is conventional constructive steel specially soiled, which has this chemical content [7].

Table 1: Chemical composition of steel St 52 – 3 [7]

Material	Chemical composition				
St 52 - 3	C% - max.	Mn % - max.	P% - max	S% - max	N% - max.
Percentage	0.20	1.6	0.045	0.045	0.009

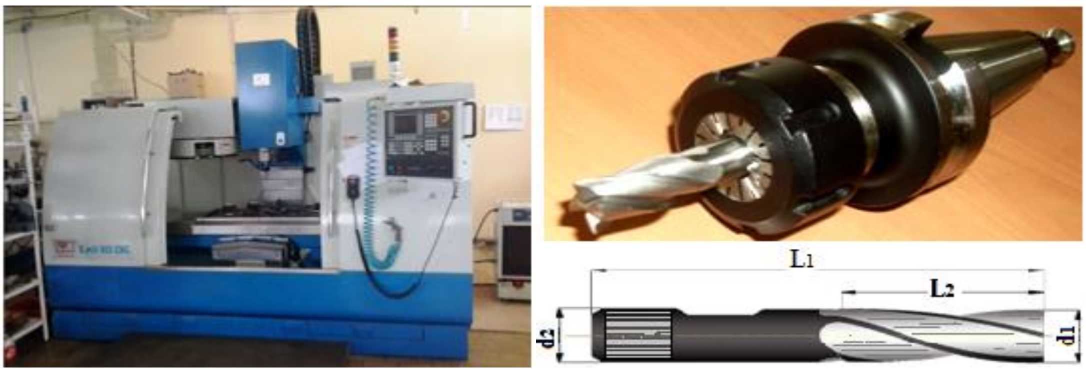

Figure 1: Machine and tool for milling process

Table 2: Milling tool parameters

d_1[mm]	d_2[mm]	l_1[mm]	l_2[mm]	z	Type
14	12	90	26	4	GWG N80 HSS

Experiments were planned using 3 levels for each input parameter as shown in table 3.

Table 3: Cutting parameters and regimes

Nr.	Parameters	Level - code	Max. +1	Med. 0	Min. -1
1. 2. 3.	Speed - v (m/min) Feed - s (mm/min) Depth - a (mm)	X1 X2 X3	105.557 100 1.5	87.964 80 1.0	70.371 60 0.5

2. Measurement Results

For the experimental realization, the experimental plan is set up of three orthogonal factors with a measurement at the points of the plan and repeating the zero point four times. The used combination of regimes changes of all point during the experiment for steel St 52-3 are presented in the table 4. After the roughness measurements of the processed surface in Table 4 are given the results.

Table 4: Cutting regimes and measured values

Nr.	Cutting regimes			Measured values		
	v[m/min]	s[mm/min]	a[mm]	R_a [µm]	R_t [µm]	R_z [µm]
1	70.371	60	0.5	1.252	13.3731	8.2238
2	105.557	60	0.5	1.4053	14.5624	9.064
3	70.371	100	0.5	1.5277	16.6499	9.6854
4	105.557	100	0.5	1.4178	16.8425	9.1599
5	70.371	60	1.5	1.4276	18.7181	9.0522
6	105.557	60	1.5	1.4706	15.2235	9.3628
7	70.371	100	1.5	1.9063	15.0225	9.5981
8	105.557	100	1.5	1.5158	13.2465	8.8791
9	87.964	80	1.0	1.6438	16.9388	9.892
10	87.964	80	1.0	1.7594	17.04	10.2029
11	87.964	80	1.0	1.568	17.3665	9.7647
12	87.964	80	1.0	1.736	19.6136	10.4707

According the measured values can be obtain graphic of surface roughness of steel St 53 – 2 using cutting regimes given on table 3.

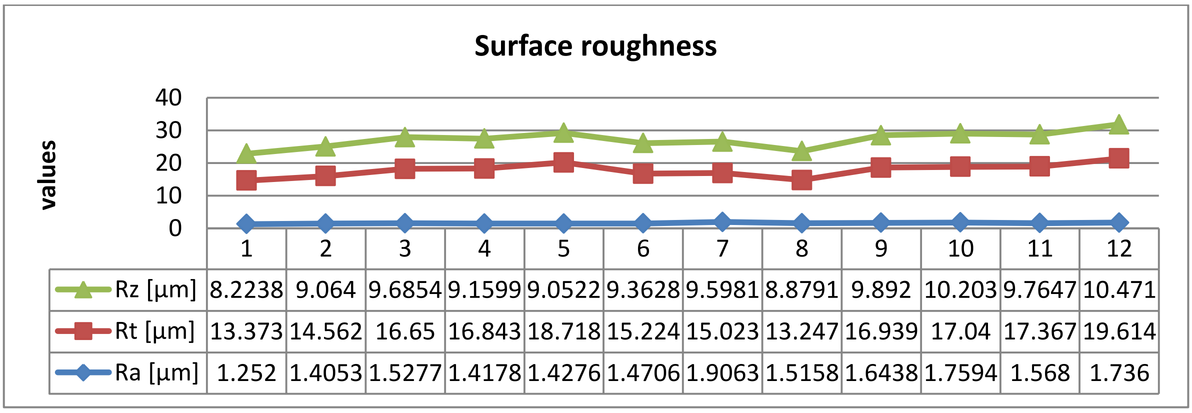

Figure 2: Measured value of surface roughness.

After all calculation using above method were obtained all mathematical models. Graphical presentation of mathematical model (1) using wolfram mathematica for three maximal values of cutting regimes is presented on figure 3.

$$R_a = 0.640 \cdot v^{-0.069} \cdot s^{0.278} \cdot a^{0.116} \tag{1}$$

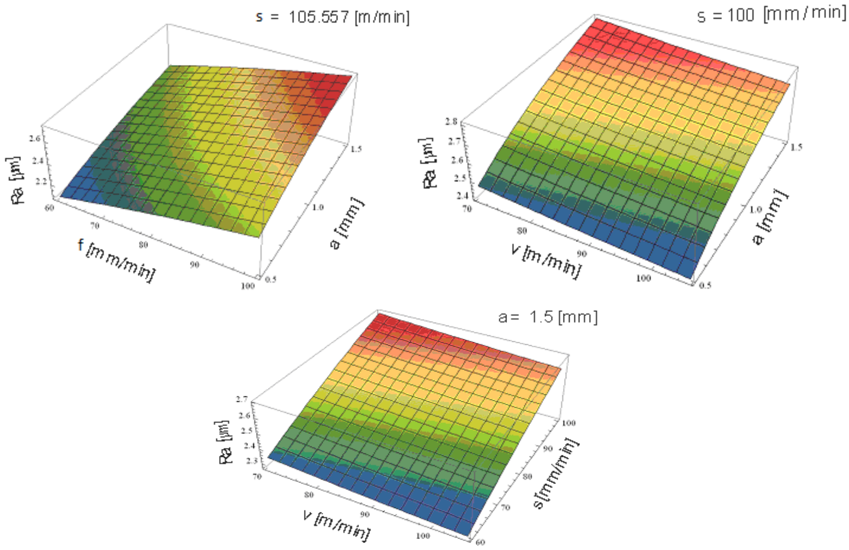

Figure 3: Graphical presentation of mathematical model (1)

Graphical presentation of mathematical model (2) using wolfram mathematical for three middle values of cutting regimes is presented on figure 4.

$$R_t = 30.447 \cdot v^{-0.144} \cdot s^{0.003} \cdot a^{0.009} \tag{2}$$

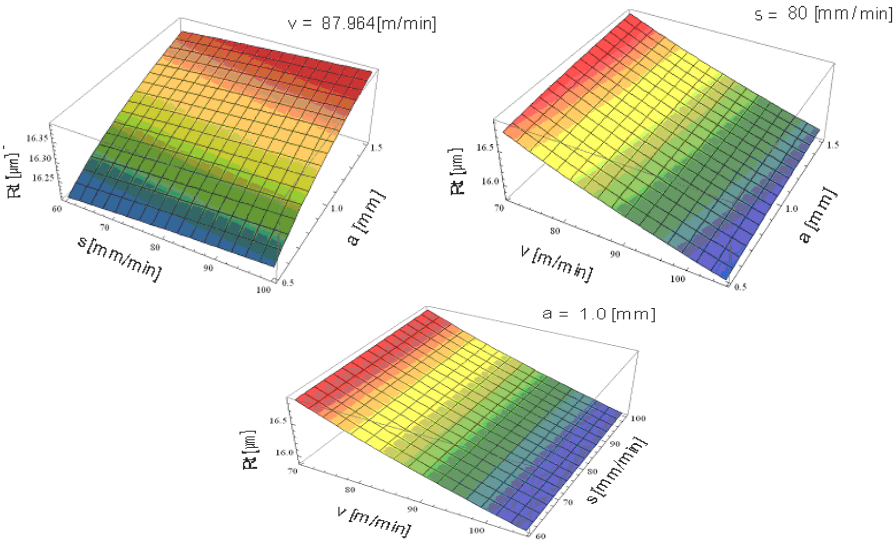

Figure 4: Graphical presentation of mathematical model (2)

Graphical presentation of mathematical model (3) using wolfram mathematical for three middle values of cutting regimes is presented on figure 5.

$$R_z = 6.937 \cdot v^{-0.014} \cdot s^{0.086} \cdot a^{0.020} \qquad (3)$$

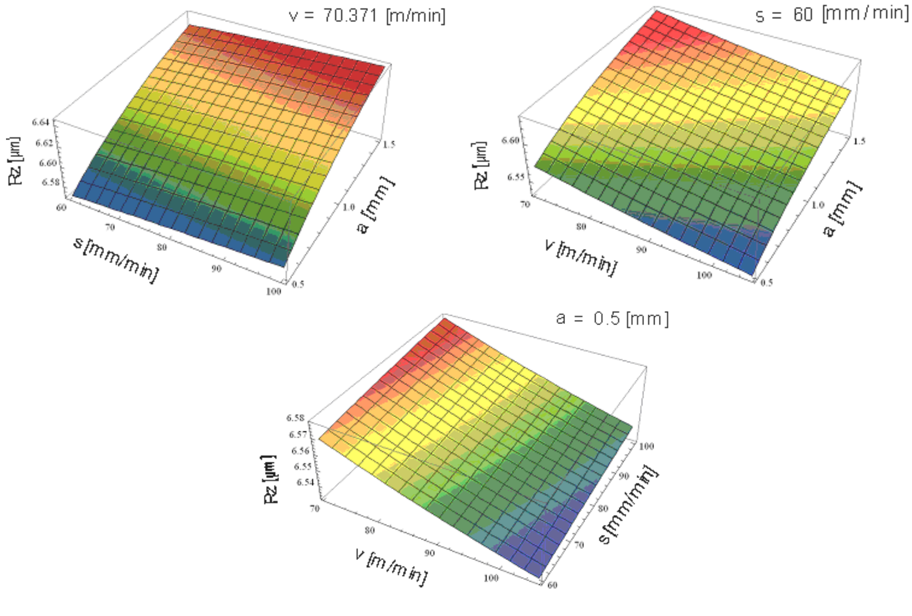

Figure 5: Graphical presentation of mathematical model (3)

4. Results And Discussions

Based on the experimentally obtained results and based on the mathematical models obtained and their graphical interpretation, we can see that the in surface roughness affects many parameters but those that have a more pronounced influence are the speed (v), feed (s), and depth (a). From the results and mathematical model (1) we can see that for the average deviation of the profile (Ra) for the manufacturing regimes it is seen that the greatest impact is the step, then the depth of the cut and finally the speed. For maximum non-planar heights (Rt) the greatest impact is from the depth of the cut, feed and the end speed. In the case of average non-planar heights (Rz) it is seen that the greatest impact have feed, the depth then the speed.

Figure 6: Measured value of first experiment.

5. Conclusion

The use of current literature as well as the realization of experiments tell us how complicated is the process of metal cutting process. Especially in this cases we can say how complicated is the process of metalworking to achieve the best roughness of the surfaces that are processed. It is seen that with the increase of the cutting speed (v) and the reduction of the cutting step (s) as well as the cutting depth (a), the arithmetic deviations of the Ra profile, the maximum height of the Rt, and the average altitude of Rz, as well as reverse speed reduction increased pitch and depth increases the roughness of the processed surfaces. From the above, we conclude that the cutting step is the parameter that has the greatest effect on surfaces roughness of the processed steels in this case of roughness of manufactured surfaces.

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