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The impact of selected CNC machining parameters on the surface roughness of the 7075 aluminium alloy

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Abstract. Modern machining operations are characterized by very high precision and high quality of the surface. In order to achieve such surface quality, many factors influencing the tested parameters should be taken into consideration. The most important parameter that allows estimating surface quality after machining is the roughness parameter, and more precisely arithmetical mean deviation of the assessed profile - Ra. The paper titled "The impact of selected CNC machining parameters on the surface roughness of the 7075 aluminum alloy" describes the test process, which aims to set parameters of machining that allow obtaining the highest quality of the surface of the processed material. During the research, a number of tests were carried out. The tests were carried out with various machining parameters. During the research cycle, two main parameters were taken into consideration that have an impact on the quality of the surface. The research process assumed a change of the speed and feed parameters. Afterward, a dependence between them and surface quality was assessed. Other parameters such as the cutting direction, the number of tool blades and the depth of cut remained unchanged. All tests were carried out on samples made of 7075 aluminum alloy (PA9, AlAnMgCu1,5). The samples were made using the MAZAK VTC-530C CNC machine. A portable surface roughness measuring device MarSurf PS10 was used for data acquisition. Further testing will also include other parameters. Such an approach will allow gathering a full set of information about proper processing of that particular material. Designed testing process will be also possible to apply to any other material.

1. Introduction

Over the last few decades, huge progress in the area of the broadly defined industry was easy to be noticed. The main branches have a big influence on such a pace of development. This group includes very dynamically developing groups, i.e. automotive, aerospace and space industry. They are at the forefront of the most prospering areas of the market. The railway and machine industries are just behind them. Regardless of the level of development, all these areas are characterized by one very important thing. Companies working in these areas are very demanding in the context of the quality of products made for their needs by their contractors. [1-7]

The quality of the workmanship of the object, part or subassembly is very important not only from the point of view of the aesthetics. It has a huge impact on the component's durability and on the security of the entire system in which the particular part enters. If it is necessary to obtain a high-



quality surface of a given item, it is obviously made in CNC technology. Thanks to the computer control, this technology guarantees high quality of detail and high repeatability. However, it does not solve many of the technological problems that you have to deal with while processing the part.

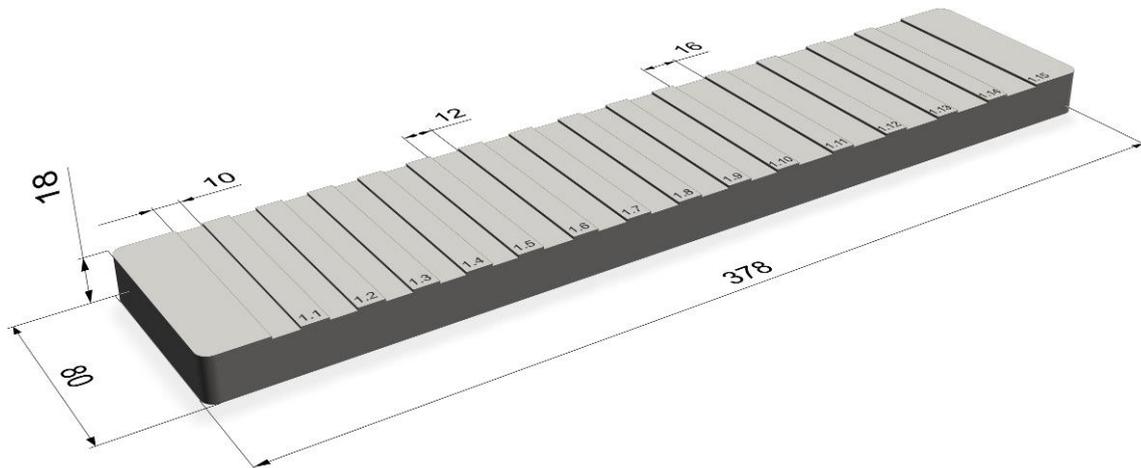


Figure 1. A 3D model of a test sample with measuring slots visible.

One of the most important parameters of the part after machining on CNC machines is surface roughness. This parameter may affect other phenomena occurring on the surface of the workpiece, eg its susceptibility to corrosion etc. The quality of the surface obtained after processing is undoubtedly influenced by the parameters with which it will be made. In the case of parameters, ie feeds or speeds, the effect of changing individual parameters on the workpiece or tool is known. The problem arises when changes are made in several parameters at the same time, additionally, the influence of other parameters that can not be controlled during machining, eg tool wear, is not excluded. Therefore, it is important to have knowledge about the effects of several of these parameters at one time. [1-12]

When considering the surface roughness parameter and its measurements, there are several values that can be measured:

Ra – arithmetical mean deviation of the assessed profile;

RSm – mean peak width;

Rz – the average distance between the highest peak and lowest valley.

Often, however, this parameter Ra is mainly taken into account when assessing the surface roughness. This paper discusses the problem of the impact of machining parameters on aluminum 7075 series due to the high proportion of this alloy in the total material processed by the Gatner Technology Group. The planned effect of the research was to obtain a matrix of cutting parameters thanks to which it will be possible to obtain a surface with the lowest roughness parameter value.

Table 1. Configurations of machining parameters and tools used during the tests.

Tool	4 flutes Ø10					4 flutes Ø12					4 flutes Ø16				
	200	250	300	500	600	200	250	300	500	600	200	250	300	500	600
Cutting Speed	200	250	300	500	600	200	250	300	500	600	200	250	300	500	600
Feed rate per tooth - fz [mm]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

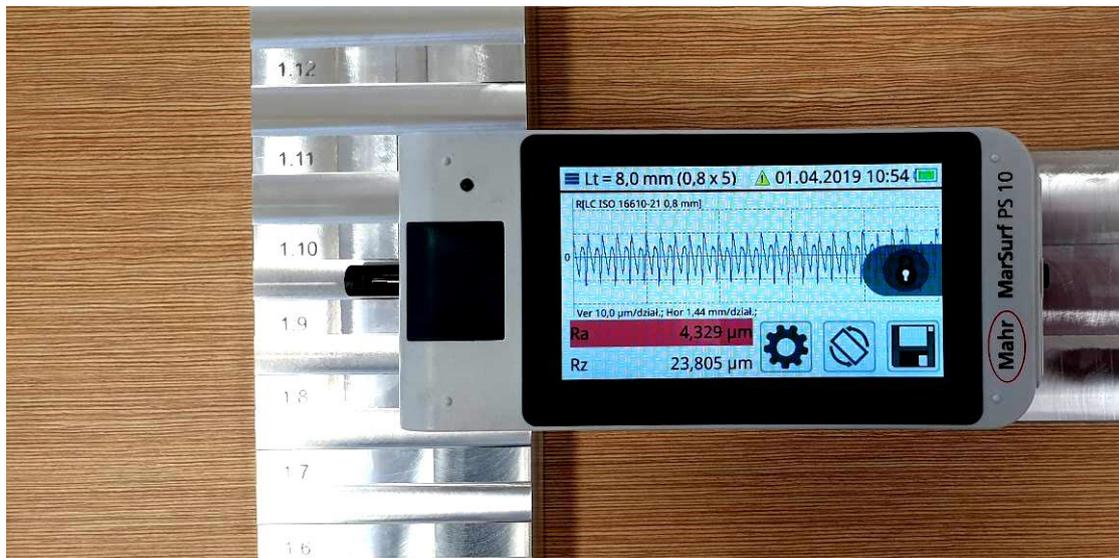


Figure 2. An example of a measuring protocol from a MarSurf Ps10 profilometer.

Table 2. Parameters of a 7075 aluminium.

Standard	PN	PN EN	Werkstoff	DIN	ASTM	GOST				
Name	PA9	7075	900019	AlZnMgCu1.5	7075	(~W95)				
Particle	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Zr	
Value	Max	Max	1.2	Max	2.1	0.18	5.1	Max	-	
	0.4	0.5	2	0.3	2.9	0.28	6.1	0.2		

2. Research overview

For the needs of answering questions about the impact of processing parameters on surface roughness, a test plan was prepared. The individual configurations of machine and tool settings are presented in table 1. During the tests, three changed parameters were taken into account: speed, feed and tool diameter. The work began with modelling the sample shape in the CAD Nx software CAD environment (figure 1). Five samples of aluminium 7075 were made, which is characterized by high strength properties, very good thermal conductivity and medium corrosion resistance as well as very good machinability and polishability.

The parameter table for aluminium 7075 is shown in table 2. The samples were made on the MAZAK VTC-530C numerical machine.

Table 3. General parameters of a MarSurf PS10 profilometer.

Measuring principle	Probe	Measuring units	Profile resolution	Traversing length according ISO 12085 (MOTIF)	Stylus	Measuring force (N)	Measuring range (mm)
Stylus method	Inductive skidded probe	metric/ inches	8 nm	1 mm, 2 mm; 4 mm; 8 mm; 12 mm; 16 mm	2 µm	0.00075	0.35

On each of the five samples, measuring grooves were made using constant feed for a given sample. So the cutting speed parameters and the tool were changed. Each measurement sample, therefore, contained measuring grooves on which three measurement areas were subsequently separated. As a result, 225 measurements were obtained from all samples.

The measurements were made with the MarSurf PS10 profilometer (figure 2), which allows you to generate a report from each measurement in the form of a PDF file (figure 3) Along with a graph containing the profile of a measured surface. Table 3 shows the basic parameters of the device.

Three measurements were made for each tool configuration, which resulted in 225 results. The obtained results were imported into a spreadsheet where the analysis of received values was analyzed.

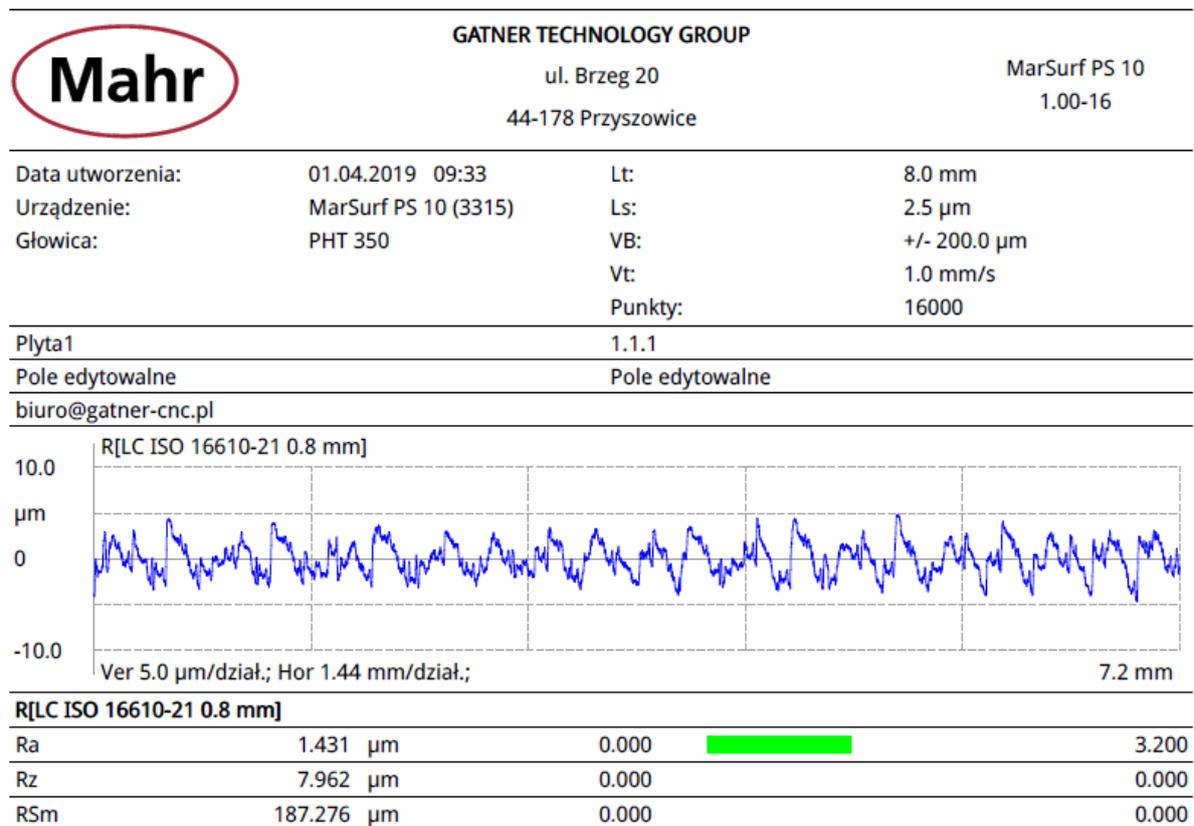


Figure 3. An example of a measuring protocol from a MarSurf Ps10 profilometer.

Table 4. Results of surface roughness measuring – best for each tool with parameters.

	Tool 1	Tool 2	Tool 3
Ra	1.11	0.12	0.30
Rz	6.950	1.406	265.789
Rsm	146.670	265.789	63.741
Vc	500	600	600
Fz	0.5	0.5	0.5

3. Tests results

After entering the results of an individual surface roughness measurements using built-in Microsoft Excel tools, they were processed to obtain the desired information. The values from three measurements for each measurement area were averaged, thanks to which most of the possible measurement errors were eliminated. Table 4 presents the best results obtained for each Ra, Rz and Rsm parameter for the tool as well as the machining parameters at which they were achieved. Then, the charts for all results were generated. Figures 4-6 show the relationships between the machining parameters and the obtained mean roughness value for individual tools.

Roughness value depending on the machining parameters for tool 1

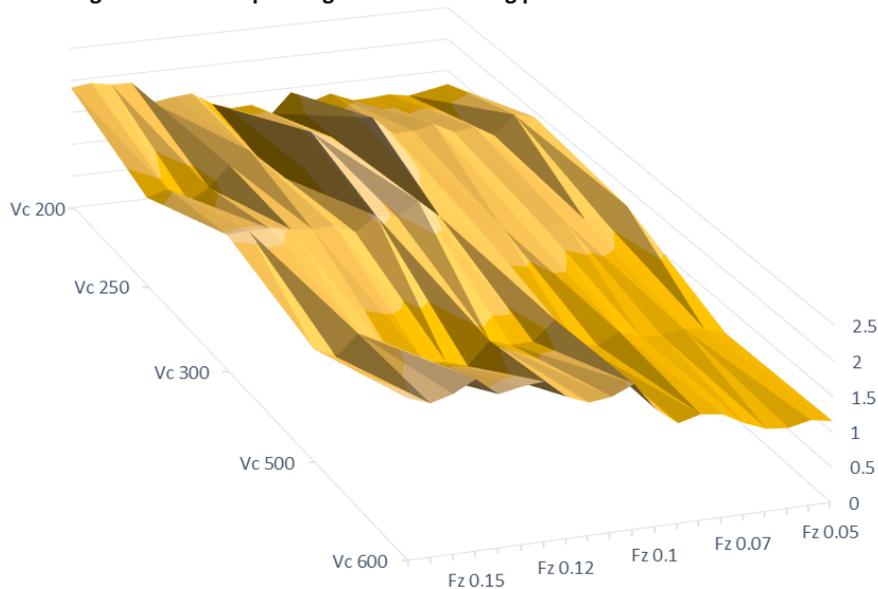


Figure 4. The reference between the machining parameters and the obtained mean roughness value for Tool no.1 – 4 flutes Ø10.

Roughness value depending on the machining parameters for tool 2

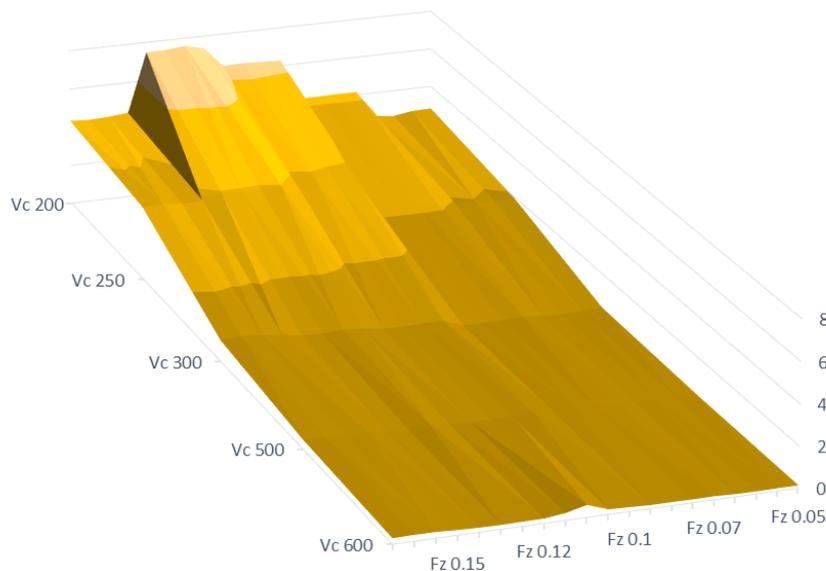


Figure 5. The reference between the machining parameters and the obtained mean roughness value for Tool no.2 – 4 flutes Ø12.

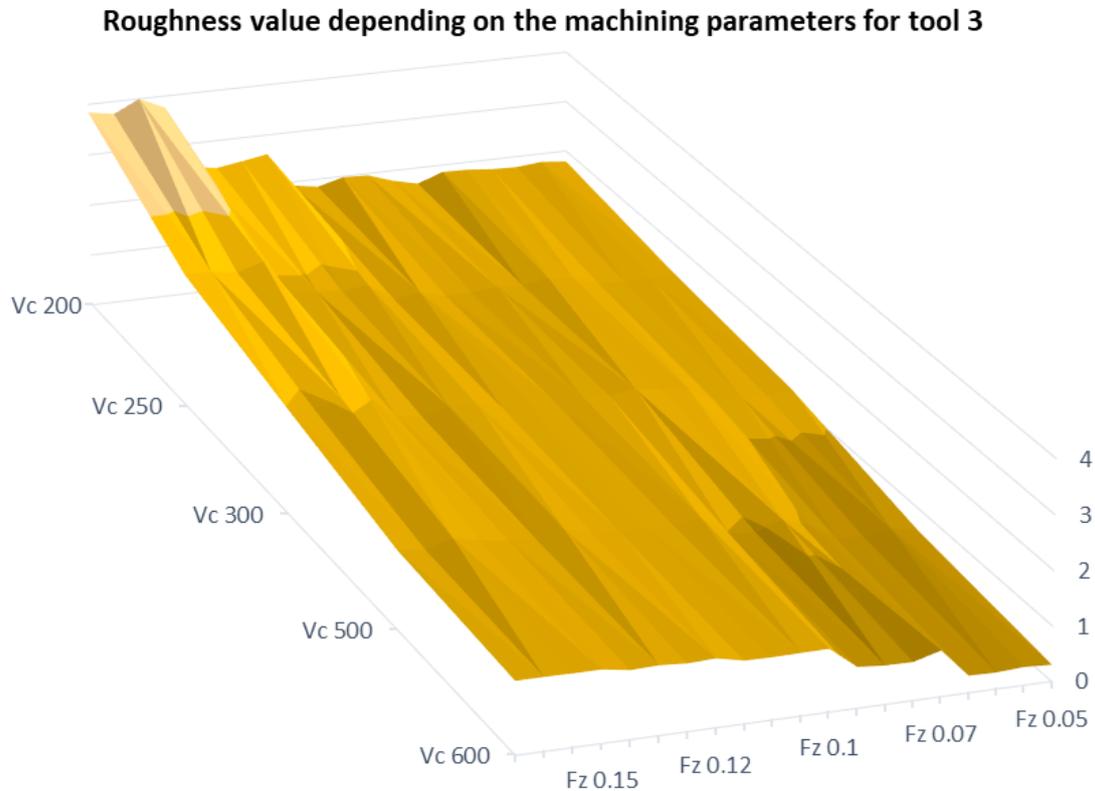


Figure 6. The reference between the machining parameters and the obtained mean roughness value for Tool no.3 – 4 flutes $\text{\O}16$.

4. Conclusions

The carried out tests were aimed at determining the best parameters for machining 7075 aluminium to minimize the surface roughness parameters Ra. Based on them, it can be stated that in the cutting speed range available at the MAZAK VTC-530C, the best roughness parameters were obtained for the lowest feed Fz and the highest cutting speed Vc. This is a fairly popular phenomenon, but in the case of high-volume production, it is not necessarily possible to keep such parameters. This is obviously due to an economic factor.

However, the conducted research proves that in the case of the need to modify any of the parameters, a definitely better surface quality in terms of its roughness is obtained by reducing the cutting speed Vc than in the case of increasing the feed per tooth Fz.

Research also indicates that in this case there is no unambiguous relationship between the size of the tool and the obtained surface quality. In the case of the number 1 tool, the surface quality was significantly lower for all measurements. This effect may be caused, for example, by excessive wear of the tool.

Further work in the area of investigations of machined surfaces will aim at broadening the results table in order to create a matrix of knowledge and adding further parameters (eg ambient temperature) that may affect the quality of the surface.

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