TiAM kwartalnik naukowo-techniczny
TECHNOLOGIA I AUTOMATYZACJA MONTAŻU
ZESPOŁÓW • MASZYN • URZĄDZEŃ

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DOI: 10.7862/tiam.2022.2.2

ANALYSIS OF THE INFLUENCE OF TURNING PARAMETERS OF CUZN39PB3 AND AW 6060 MATERIALS ON SURFACE ROUGHNESS

ANALIZA WPŁYWU PARAMETRÓW TOCZENIA MATERIAŁÓW CUZN39PB3 I AW 6060 NA CHROPOWATOŚĆ POWIERZCHNI

Abstract

The article presents an analysis of the turning parameters of two non-ferrous materials. The tested materials were: brass CuZn39Pb3 and aluminum alloy AW 6060. A Kyocera turning knife and a WNMG 080404 AH plate were used to make the samples. Three parameters were tested: rotational speed, feed and depth of cut at three levels of variability. The roughness parameters Ra and Rz were selected for the analysis. On the basis of the obtained results, it was shown that the feed used during machining has the greatest influence on roughness, while the change of depth or cutting speed does not cause significant differences in roughness.

Keywords: turning, non-ferrous metals, surface roughness

Streszczenie

W artykule przedstawiono analizę parametrów toczenia dwóch materiałów nieżelaznych. Materiałami poddanymi badaniom były: mosiądz CuZn39 Pb3 i stop aluminium AW 6060. Do wykonania próbek użyto noża tokarskiego firmy Kyocera i płytki WNMG080404AH tej firmy. Badaniom poddano trzy parametry: prędkość obrotową, posuw i głębokość skrawania na trzech poziomach zmienności. Do analizy wybrano parametr chropowatości Ra i Rz. Na podstawie uzyskanych wyników wykazano, że największy wpływ na chropowatość ma posuw stosowany podczas obróbki, natomiast zmiana głębokości czy tez prędkości skrawania nie powoduje znaczących różnić w chropowatości.

Słowa kluczowe: toczenie, metale nieżelazne, chropowatość powierzchni

1. Introduction

Machining processes include shaping machine and device elements by removing the stock in the form of chips. For this purpose, it is necessary to properly select the right tool and processing parameters of a given material. The materials used for processing are divided into six treatment groups according to ISO [11]. One of these groups is the group of materials marked as N - non-ferrous metals, softer metals such as aluminum, copper, brass, etc.

After the machining process, an important element is to determine the surface roughness. It is an important factor apart from the shape and dimensional accuracy [5]. Nowadays, roughness parameters are determined by contact technique using profilometers or by optical technique [1].

The surface geometry of machine parts is shaped as a result of the machining process. There are geometric errors on the machined surface. Due to the geometric features and dimensions, the following surface errors are distinguished: macroscopic (shape, position and waviness), microscopic (roughness) and submicroscopic (submicron inequalities). As a result of machining, the surface geometry is characterized by errors in shape, position, waviness and roughness. The surface geometry represents the surface layer, which is the layer of material that delimits the actual surface. The elements that make up the surface layer are, among others, surface roughness. The roughness of the surface represents the actual state with unevenness such as raised or depressions [8]. In order to achieve the assumed quality of the treated surfaces, it is

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necessary to determine the relationship between the controlled technological parameters.

2. Research methodology

From the group of non-ferrous materials, two materials were selected for testing: brass CuZn39Pb3 and aluminum alloy AW 6060. Brass with the designation CuZn39Pb3 is a soft and very easy-to-process material. Brass does not produce long chips during machining, unlike many copper alloy materials [3]. The chemical composition of this material is shown in Table 1.

Table 1. Chemical composition of CuZn39Pb3 [6]

Material	%Cu	%Fe	%Pb	%Zn	%Ni	%Sn	%Al
CuZn39Pb3	57,7	0,2	3,3	38,49	0,1	0,2	0,01

This material is widely used in water supply installations and plumbing because it transfers heat very easily and is resistant to corrosion [2].

The second material is AW 6060 aluminum alloy. These alloys are widely used in the aviation industry. AW 6060 alloy is characterized by medium tensile strength and fatigue strength. It is susceptible to welding and anodizing [9]. The chemical composition of this material is shown in Table 2.

The mechanical properties of both tested materials are shown in Table 3.

All the tools used to perform the tests are presented in Table 4.

Table 2. Chemical composition of AW 6060 [5]

Material	%Al	%Mg	%Si	%Fe	%Zn	%Mn	%Cu	%Cr	%Ti
AW 6060	rest	0,4	0,5	02	0,15	0,1	0,1	0,05	01

Table 3. Mechanical properties of tested materials [2,8]

Indication	$R_{0,2}$ [MPa]	R_m[MPa]	A_5 [%]	HB	ρ [g/cm^3]	E [GPa]
CuZN39Pb3	365	502	18	120	8,47	97
AW 6060	160	215	16	60	2,7	72,5

Table 4. Input data for the experiment

Machine tool	HAAS ST20
Turning tool	DWLNL2525M-08 Kyocera
Plate	WNMG080404 AH Kyocera
Workpiece material	CuZn39 Pb3
	AW 6060
Profilometer	Surtronic S128 TalyProfile Silver

Variable parameters in the tested samples were rotation, feed and depth of cut. These parameters were selected as the maximum, average and minimum parameters according to the recommendations of the cutting plate manufacturer [10]. The selected parameters are presented in Table 5.

Table 5. Technological parameters

Rotation [rpm]	Feed f [mm/rev]	Depth of cut a_p [mm]
3200	0,2	1,5
2400	0,1	0,5
1600	0,03	0,2

For three variable parameters on three levels, 27 samples were made for each of the materials on a 20 [mm] diameter shaft. In the next step, roughness measurements were carried out using the Surtronic S128 profilometer – It is a universal device for roughness measurement both in laboratory and workshop conditions [12]. The TalyProfile Silver software was used for the measurement. A Gaussian filter was used to calculate the roughness parameters. Two roughness parameters were analyzed: Ra [µm] and Rz [µm]. According to Leach R. [7] the Rz parameter have a significant influence on friction, wear, lubrication and mechanical tightness.

3. Results and discussion

Standard methodology for surface roughness analysis was used for each sample measured. All measurements were repeated three times and mean values were determined. Surface leveling was used in each measurement. The surface roughness was filtered (Gauss-Sow filter), and then the roughness parameters were determined according to ISO 4287. The selection of the surface roughness parameters depends on the operational purpose of the treated surface [8].

The parameters used and the results of the obtained measurements are presented in Table 6.

Table 6. Measurement results

				CuZn39 Pb3		AW 6060	
Lp.	**n [rpm]**	**a_p [mm]**	**f[mm/rev]**	**Ra [µm]**	**Rz [µm]**	**Ra [µm]**	**Rz [µm]**
1	3200	1,5	0,2	1,81	9,52	1,76	7,84
2	3200	1,5	0,1	0,92	4,92	0,82	4,11
3	3200	1,5	0,03	0,41	2,80	0,62	3,79
4	3200	0,5	0,2	1,84	9,84	1,81	8,48
5	3200	0,5	0,1	0,90	5,14	0,72	3,55
6	3200	0,5	0,03	0,42	2,64	0,34	2,05
7	3200	0,2	0,2	1,78	9,72	1,79	7,78
8	3200	0,2	0,1	0,92	5,19	0,66	3,04
9	3200	0,2	0,03	0,34	2,61	0,27	1,88
10	2400	1,5	0,2	1,91	9,66	1,66	7,49
11	2400	1,5	0,1	0,92	5,29	0,74	3,69
12	2400	1,5	0,03	0,44	2,73	0,42	2,75
13	2400	0,5	0,2	1,90	**10,24**	1,70	7,73
14	2400	0,5	0,1	0,93	5,50	0,69	3,48
15	2400	0,5	0,03	0,44	2,78	0,33	2,14
16	2400	0,2	0,2	1,90	9,99	1,77	7,62
17	2400	0,2	0,1	0,97	5,26	0,68	3,10
18	2400	0,2	0,03	0,31	2,14	0,31	2,06
19	1600	1,5	0,2	1,72	9,29	1,80	8,22
20	1600	1,5	0,1	0,96	5,57	0,72	3,64
21	1600	1,5	0,03	0,36	2,43	0,49	3,72
22	1600	0,5	0,2	**1,93**	9,82	**1,94**	**13,13**
23	1600	0,5	0,1	0,91	5,20	0,95	7,15
24	1600	0,5	0,03	0,34	2,34	0,35	2,55
25	1600	0,2	0,2	1,84	8,94	1,80	8,58
26	1600	0,2	0,1	0,83	4,65	0,86	6,23
27	1600	0,2	0,03	**0,24**	**1,71**	**0,23**	**1,36**

On the basis of the obtained results, a large variation in the roughness parameter Ra for individual tests can be noticed.

Fig. 1 shows an example of the roughness profile and the measurement results obtained for sample 1 for the AW 6060 material, while Fig. 2 shows the same for the CuZn39Pb3 material.

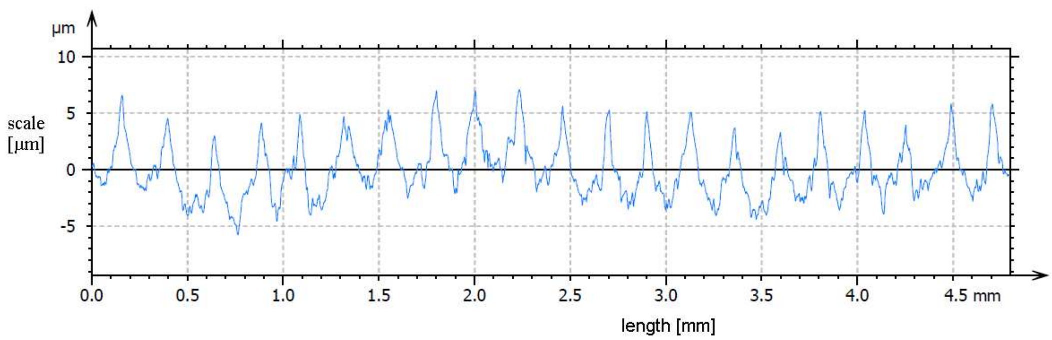


Fig. 1. Roughness profile of the AW 6060 material for sample 1

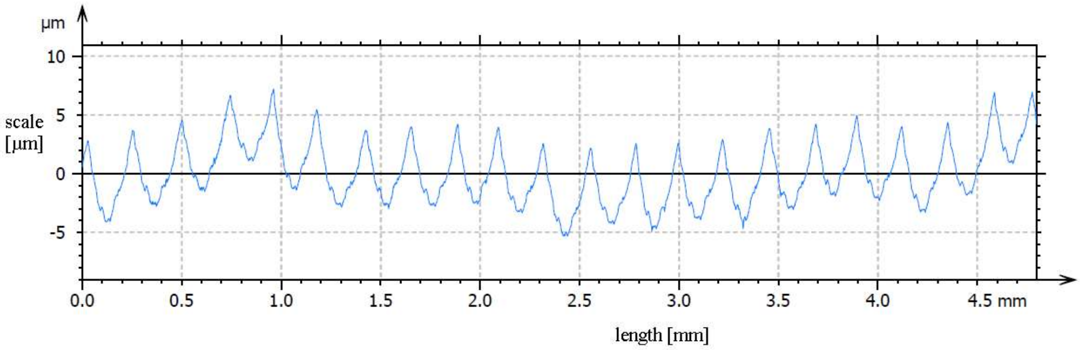


Fig. 2. Roughness profile of CuZn39Pb3 material for sample 1

On the basis of the obtained results (Table 6), it can be seen that the smallest values of the roughness parameter Ra and Rz were obtained for the measurement of sample No. 27. Both for CuZn39 Pb3 and AW 6060 materials, they were 0.24 µm and 0.23 µm, and Rz 1.71 µm and 1.36 µm, respectively. In the case of the Rz parameter for the material AW 6060, its highest value was recorded for sample No. 22 and the value was 13.13 µm. For the material CuZn39 Pb3 the highest Rz was 10.24 µm for the sample No. 13. In order to analyze the obtained results in more detail, graphs of the dependence of the feed and the depth of cut on the roughness parameter Ra and Rz were prepared for specific rotational speeds. There is a different dependence for the tested materials than in the case of steel turning. For steels, the surface roughness decreases when the depth of cut and feed decrease, while the rotational speed increases [4].

Fig. 3 shows the effect of feed and depth of cut on the surface roughness Ra at n = 3200 rpm. From the obtained results, it can be seen a significant influence of the decrease in the roughness parameter value with the decrease of the machining feedrate. On the other hand, the change of the cutting depth does not significantly affect the Ra parameter.

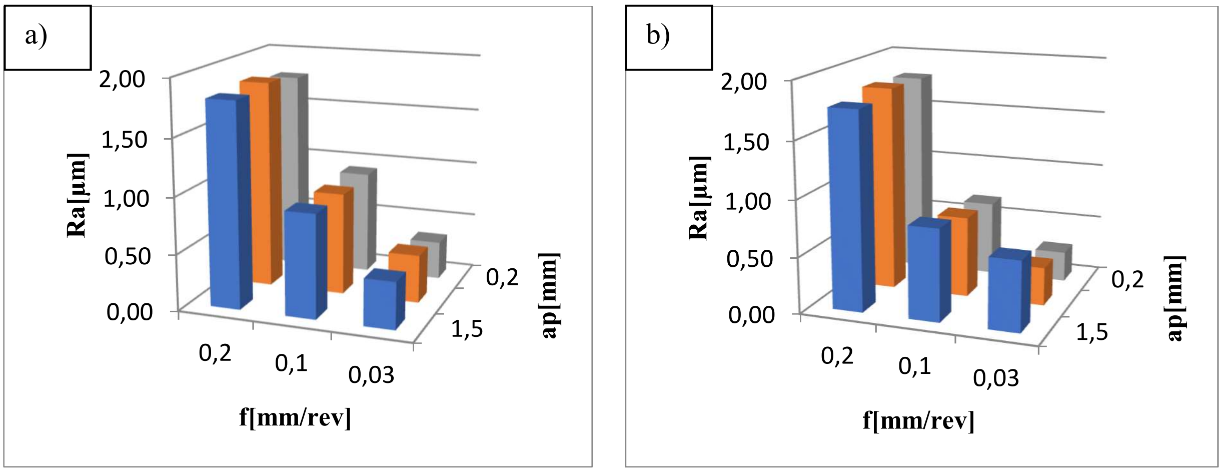
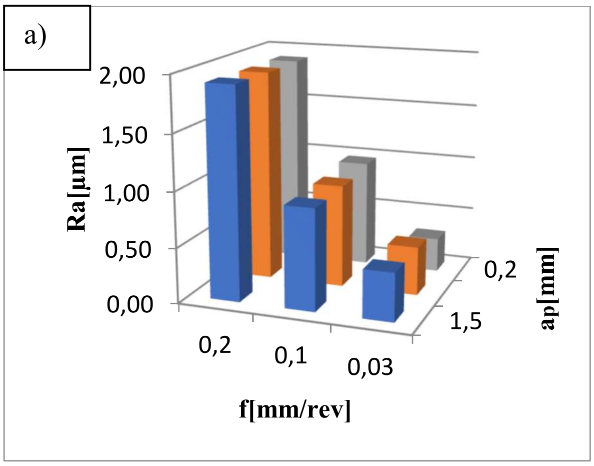


Fig. 3. Influence of feed and depth of cut on the Ra parameter at n = 3200 [rpm]: a) CuZn39Pb3, b) AW 6060

Identical charts were prepared for the remaining rotational speeds. For the rotational speed of 2400 rpm, the results are shown in Fig. 4, and for n = 1600 rpm in Fig. 5 for each rotational speed, there is an identical relationship for both analyzed materials.



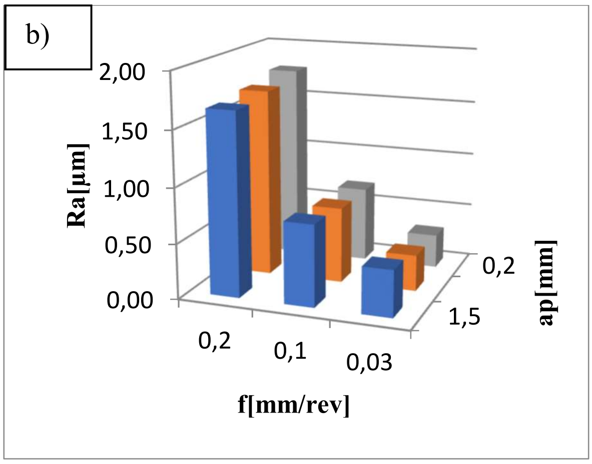
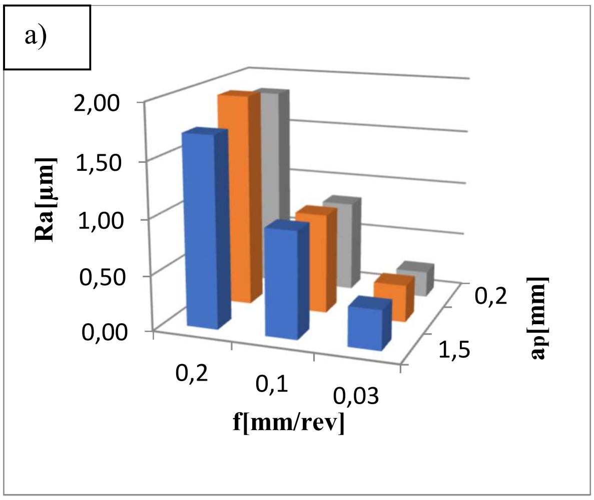


Fig. 4. Influence of feed and depth of cut on the Ra parameter at n = 2600 [rpm]: a) CuZn39Pb3, b) AW 6060



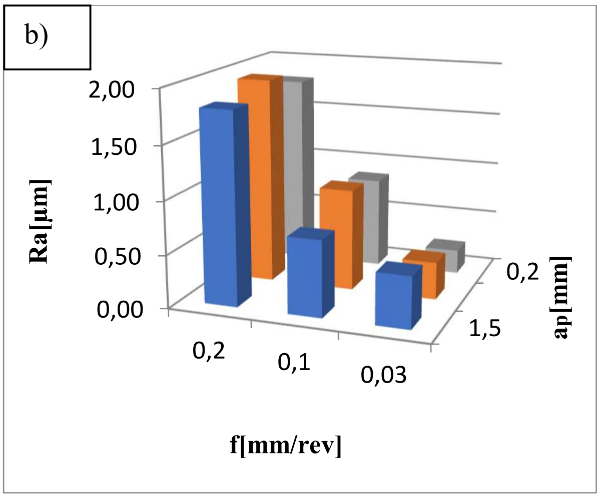


Fig. 5. Influence of feed and depth of cut on the Ra parameter at n = 1600 [rpm]: a)CuZn39 Pb3, b) AW 6060

The lowest values of the roughness parameter Ra were obtained at the lowest feeds and depths of cut in all tested rotational speeds. For a more precise analysis, a graph of the relationship between the rotational speeds and the Ra parameter was drawn up at the lowest feed and the smallest depth of cut. The result is shown in Fig. 6

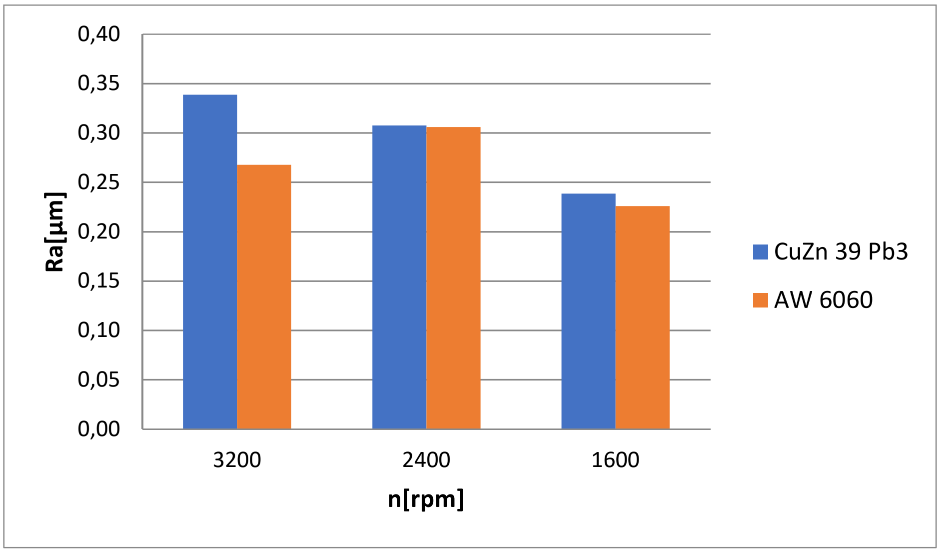


Fig. 6. Dependence of the Ra parameter on the rotational speed

As can be seen (Fig. 6), the lowest Ra parameter value can be obtained during turning with the lowest recommended technological parameters for both analyzed materials. The largest difference in Ra parameter was obtained between the tested materials for the highest rotational speed.

A similar analysis was performed for the Rz parameter. Fig. 7 shows the influence of feed and depth of cut on the roughness parameter Rz at n = 3200 [rpm]. From the obtained results, it can be seen the influence of the decrease in the roughness parameter value along with the decrease of the machining feed rate, for aluminum this decrease at lower feed rates is not so rapid. On the other hand, changing the depth of cut does not significantly affect the Rz parameter, as it did in the case of the previous Ra parameter.

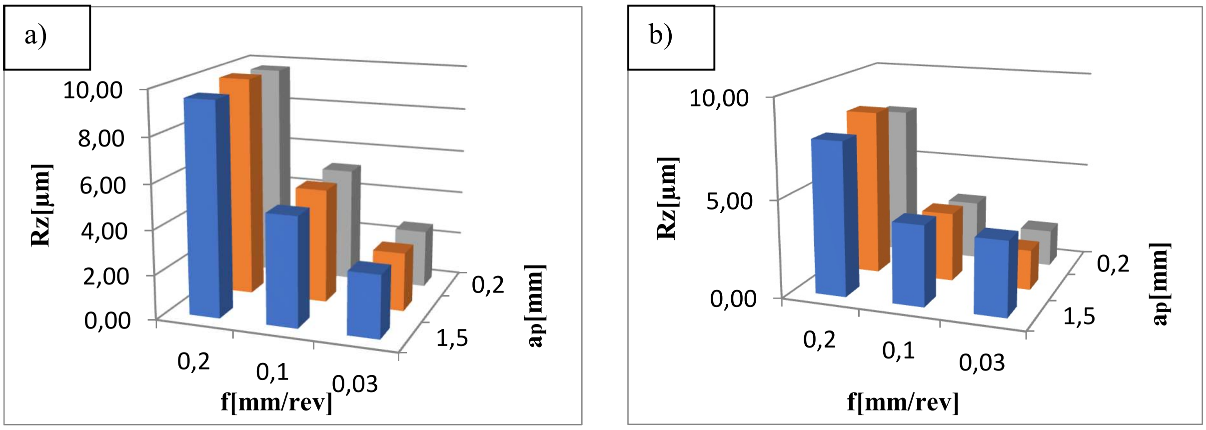


Fig. 7. Influence of feed and depth of cut on the Rz parameter at n = 3200 [rpm]: a) CuZn39 Pb3, b) AW 6060

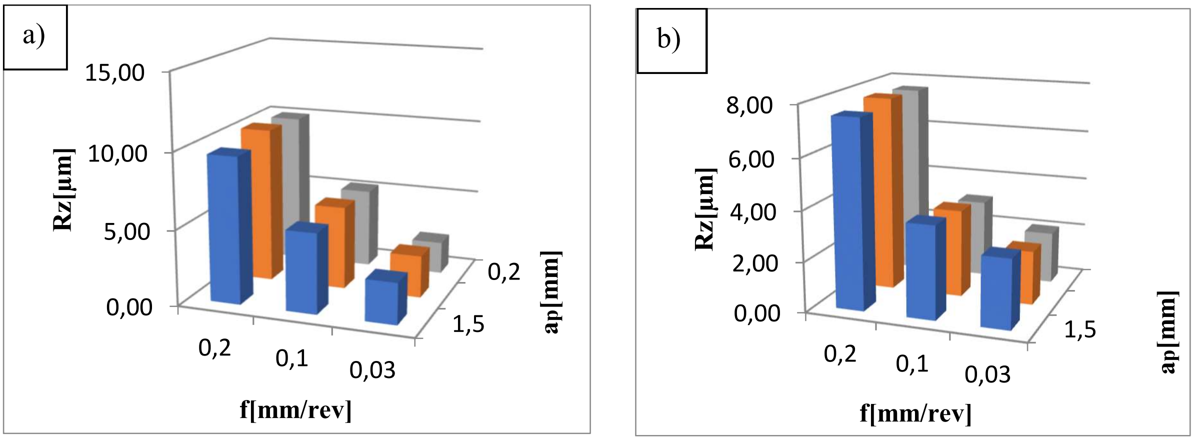


Fig. 8. Influence of feed and depth of cut on the Rz parameter at n = 2600 [rpm]: a) CuZn39 Pb3, b) AW 6060

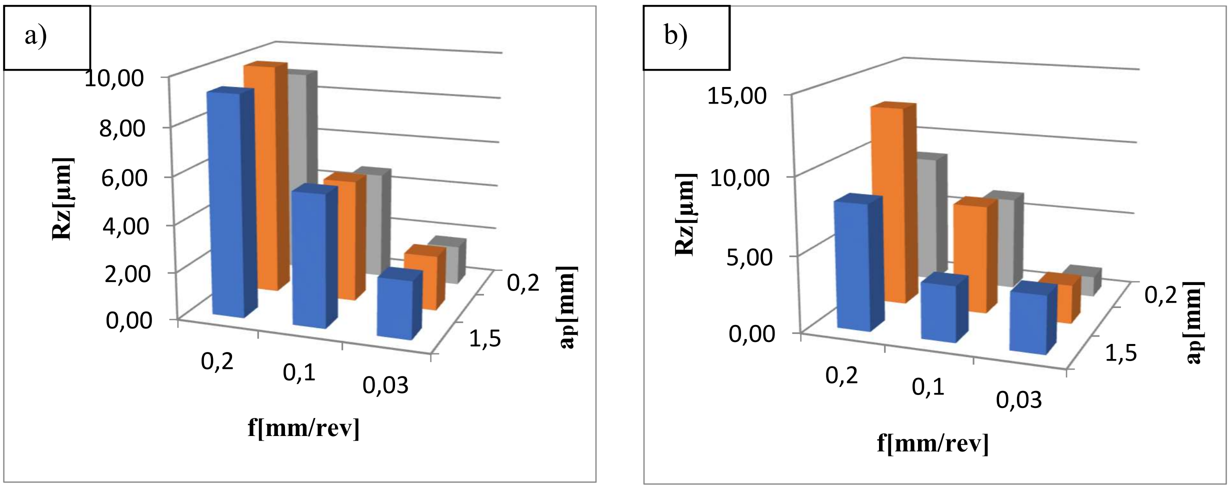


Fig. 9. Influence of feed and depth of cut on the Rz parameter at n = 1600 [rpm]: a) CuZn39 Pb3, b) AW 6060

Identical charts were prepared for the remaining rotational speeds. For the rotational speed of 2400 rpm, the results are shown in Fig. 8. Also in this case, the relationships are the same as for the speed of 3200 rpm. On the other hand, for n = 1600 rpm (Fig. 9), a significant decrease in the value of the Rz parameter can be seen for a depth of cut of 1.5 mm and 0.2 mm at the highest feed.

4. Conclusions

In this work, experimental studies of the influence of cutting parameters on the roughness of the obtained surfaces were carried out for the CuZN39Pb3 brass alloy and the AW 6060 aluminum alloy. Based on the obtained results, the following conclusions can be drawn:

- Turning various materials from the N group, non-ferrous materials and aluminum, with the selected tool, does not cause significant differences in the roughness Ra parameter, these differences can only be observed for the Rz parameter for the lowest speed and the highest feed.
- The highest values of the Ra and Rz roughness parameters were obtained for the lowest rotational speed n = 1600 rpm, the highest feed 0.2 mm/rev, and the average depth of cut for the AW 6060 material, while for CuZN39Pb3 the highest value of the Rz parameter was obtained for a higher rotational speed n = 2400 rpm.
- The smallest values of the roughness parameter Ra and Rz were obtained for the smallest parameters of the rotational speed n = 1600 rpm, feed 0.03 mm / rev, and cutting depth 0.2 mm.
- The greatest difference in measurements for the same parameters was obtained for Ra for sample No. 17 and the difference was 0.29 µm, while for Rz for sample No. 22 it was 3.32 µm.

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