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INFLUENCE OF METALS CUTTING ON PARTS MACHINED BY TURNING OF BRONZE AND ALUMINIUM METALS

UTICAJ REZANJA METALA NA DELOVE BRONZANIH I ALUMINIJUMSKIH METALA OBRAĐENIH STRUGANJEM

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Keywords
- aluminium alloy
- bronze alloy
- metal turning
- roughness
- cutting parameters

Ključne reči
- legure aluminijuma
- bronze
- struganje metala
- hrapavost
- parametri rezanja

Abstract

The roughness is the set of defects and irregularities of a micrographic and/or macrographic machined surface due to the machining of mechanical parts using machining tools. It is more difficult to obtain a low roughness index which necessarily increases the manufacturing cost. The objective of this experimental study is based on the analysis of the states of surfaces on different metals such as aluminium and bronze in order to measure and control the roughness obtained. A parametric choice is made to optimise several cutting parameters, namely the cutting tool, rotation speed, feed rate of the tool, and other parameters during turning machining without lubricants.

Izvod

Hrapavost je skup nedostataka i nepravilnosti mikrografske i/ili makrografski obrađene površine zbog obrade mašinskih delova alatima za obradu. Teže je postići nizak indeks hrapavosti, što nužno povećava cenu proizvodnje. Cilj ovog eksperimentalnog istraživanja temelji se na analizi stanja površina na različitim metalima kao što su aluminijum i bronza u cilju merenja i kontrole dobijene hrapavosti. Napravljen je parametarski izbor za optimizaciju nekoliko parametara rezanja, odnosno, reznog alata, brzine rotacije, brzine pomeranja alata i druge parametre tokom mašinske obrade na strugu bez podmazivanja.

INTRODUCTION

The turning process is a very important operation in the field of machining by chip removal, whatever the mode of machining by chip removal, the final goal is to obtain a product whose workmanship will be characterised by dimensional precision of geometric shapes and a degree of surface cleanliness directly linked to the notion of roughness, /1/. Several studies have been carried out to identify the factors that influence the surface finish and tribological behaviour of parts in a mechanism. It has been shown that there is a close relationship between manufacturing processes of mechanical parts and the quality of surfaces in service. The last few years have seen a great evolution in the techniques of finishing the surfaces of parts, /2/. New materials shaped by steelmakers to meet the specific requirements of a few fields such as aeronautics must be characterised, /3/.

All machined materials have mechanical properties that also influence the surface finish. In order to improve the surface finish of a material, it is necessary to remove all surface defects that exist after a turning operation, and this problem has become a major concern for many scientists and researchers. Bourebia /4/ studied in his thesis the defects of surfaces and tribological systems of surfaces in contact. Azizi et al. /5/ studied the evolution of surface roughness (Rz), cutting forces and tool wear as a function of cutting parameters on hardened steel 100Cr6 during turning by the tool ceramic coated with TiN. Hamadi /6/ shows the importance of surface coating on 42CrMo4 steel in dry turning. Boulahmi /7/ in his work on the machining of several types of aluminium alloys, studied the effects of machining conditions on the quality of parts and their tensile behaviour under different cutting conditions and under various lubrication modes. R. Kamguem /8/ made a mechanical and environmental study on aluminium alloys (6061-T6, 7075-T6 and 2024-T351) in which he showed that the TiCN coating tool offers a better opportunity for a dry machining operation and improves the surface quality. On the other hand Adeel /9/ succeeded in finding a relationship between the optimised cutting parameters, the required surface quality and surface temperature machined by a turning tool. He has proven that it is possible to increase machine utilisation and decrease production costs in an automated manufacturing environment. For this, Crolet /10/ carried out a study on the superfinishing machining of copper alloy CuC2 on numerically controlled lathes model SOMAB T400 and model T450 with various metal carbide tools. He also showed that the vibrations induced during the machining process have a significant influence on the surface finish generated by superfinishing. And so Izelu et al. /11/ show in their research when turning 41Cr4 alloy steel the turning parameters (cutting depth, cutting speed and overhang of workpiece) had an effect significant on the surface roughness of the workpiece and are proportional. Other research study done by Yousefi and Zohoor /12/ on the surface finish in hard turning of MDN250 steel with a nitride tool cubic boron (CNBC) developed an expert system that shows better surface roughness results at both cutting speed and cutting depth, can be achieved compared to ceramic and carbide tools. Some other researchers have reported similar results using carbide and ceramic tools. Das et al. /13/ show that impact of depth of cut on the roughness of the surface is insignificant. Asiltürk and Akkuş /14/ determined the effect of cutting depth, feed rate and cutting speed on the final surface of the AISI 4140, the result shows that the feed speed is the most important factor that affects Ra and Rz, on the same AISI 4140 steel with a hardness of 60 HRC. Elbah et al. /15/ use different ceramic inserts and analyse the modification of the surface roughness. Some researchers like Bartarya and Choudhury /16/ and also Revel et al. /17/, show that the cutting depth between 0.05 and 0.3 mm is suggested by most researchers for the hard finish turning operation. Hussain and Tiwari /18/ show experimental results on a CNC lathe the effect of spindle speed on surface roughness is approximately (48.17 %) and the feed rate is (42.54 %), respectively.

These are the main parameters among four controllable factors (spindle speed, feed rate, depth of cut, and type of material) that influence the roughness of the surface. Natarajan /19/ studied 36 dry-machined C26000 brass specimens in a CNC turning machine. Results were designed by software using Matlab 7® linked by artificial neural network (ANN) model, The results obtained conclude that this programme is reliable and precise to solve the optimisation of cutting parameters. A comparative study between a CNC lathe and a conventional lathe shows Al-Dolaimy /20/ by an analysis of the results that show the quality of roughness also as the turning of samples using carbide tools of grade P-30. The CNC machine gave better results where the surface roughness has decreased than on the conventional machine tool with and without coolant. For the effect of machining parameters on the cutting material removal rate on a lathe, Kumar and Gupta /21/ used 6063 aluminium alloy, as the material removal rate increases with increasing speed the depth of cut. In a similar study and same previous material, on a CNC lathe the work of Pant et al. /22/ prove that the analysis of experimental observations highlights that the process of CNC turning is strongly influenced by cutting speed and cutting depth, and even more influences the surface roughness (Ra).

EXPERIMENTAL PROCEDURE

Materials and specimens

In this paper two materials, namely bronze alloy (CuSn9P) and aluminium alloy (AU4G) are used in order to study the effect of cutting parameters on the surface condition during operation machining by turning. These materials are prepared in round form according to standard NF /23, 24/ (see Fig. 1), whose chemical and mechanical properties are presented in Tables 1 and 2. In this study we are studying the evolution of roughness on these materials, taking into account the influence of various parameters of cuts, namely cutting speed, tool feed rate, cutting depth, and the shape of the cutting tool under the determined machining conditions. Namely the absence of lubrication (dry turning), ambient temperature (24° C), without vibration, after each operation the average roughness (Ra) is measured for each test carried out on the materials (2017A and CuZn9P) using a thickness roughness gauge shown in Fig. 3, according to the cutting parameter.

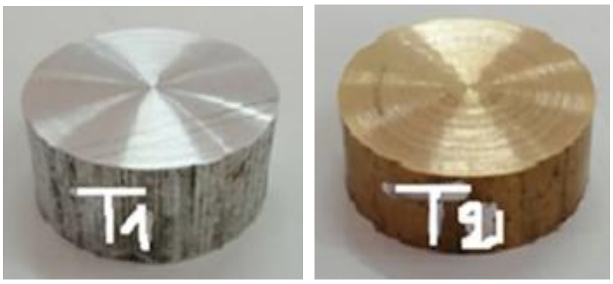


Figure 1. Material used: T1) aluminium; T2) bronze.

Table 1. Chemical composition of materials.

Chemical composition of CuSn9P							
material	Fe	Cu	Si	Mn	Mg	Cr	Zn
%	max 0.7	3.5- 4.5	0.20 -0.80	0.4- 1.0	0.4 - 1.0	0.1	0.25
Chemical composition of AU4G							
material	Fe	P	Sn	Pb	Zn	Others	
%	0- 0.1	0.05-0.35	7.7-10	< 1	< 0.5	0.03	

Table 2. mechanical properties of materials.

Mechanical properties of the aluminium alloy (AU4G)							
Grade	Dimensions (mm)	R_m (MPa)		$R_{p\,0.2}$ (MPa)		A % min	A5 %min
	Diam	min	max	min	max		
O/H111	< 80		240		125	12	10
T 3	< 80	400		250		10	8
T 351	< 80	400		250		8	8
Grade	R_p (N/mm²)	R_m (N/mm²)		A5 %		hardness HB 10/1000	Elastic modulus (GPa)
Mechanical properties of the bronze alloy (CuSn9P)							
	290	>440		>25		120-150	115
Y70Y80	170	>350		25-50		80-90	

Figure 2. a) Parallel turn machine (model D 330/1000).

Figure 2. b) Carbide cutting tools (MC).

Specimens are machined on a parallel lathe (model D 330/1000, Fig. 2a, using carbide cutting tools (MC), the geometry of which is shown in Fig. 2b. Metal cutting is a strongly coupled thermo-mechanical process in which plastic deformation, heat and friction phenomena play a critical role in terms of wear. The tool-chip interface is a place of complex interactions between mechanical, thermal, and physico-chemical phenomena. The surface of the tool in contact with the chip undergoes various forms of wear as a result of mechanisms such as adhesion, abrasion, and diffusion. The quality of the parts produced depends largely on the cutting conditions, and this quality is an important parameter during the production of mechanical parts.

Figure 3. Laboratory roughness gauge Model Surftest SJ-310 /25/.

EXPERIMENTAL RESULTS AND DISCUSSION

Results of roughness, presented in the following tables, are made on each machined surface for each material with three profile measurement tests, and taking the average and one plotting the curves.

Feed rate effect

Turning and dressing operations are carried out with selected cutting parameters presented in the following table for two cases of materials. Results are shown in Table 3.

Table 3. Effect of feed rate on aluminium and bronze surface.

<table>
<tr><td colspan="7">Aluminium alloy (AU4G)</td></tr>
<tr><td>Machining parameters</td><td colspan="2">Feed rate (mm/round)</td><td>0.2</td><td>0.25</td><td>0.3</td><td>0.35</td></tr>
<tr><td rowspan="2">Turning and dressing tool
N = 1255 rpm;
Vc = 63 m/min
Depth = 0.4 mm</td><td rowspan="2">Ra (μm)</td><td>Longitudinal turning</td><td>0.81</td><td>0.87</td><td>1.18</td><td>1.27</td></tr>
<tr><td>Transverse turning</td><td>2.63</td><td>3.02</td><td>3.16</td><td>3.28</td></tr>
<tr><td colspan="7">Bronze alloy CuSn9P</td></tr>
<tr><td>Machining parameters</td><td colspan="2">Feed rate (mm/round)</td><td>0.2</td><td>0.25</td><td>0.3</td><td>0.35</td></tr>
<tr><td rowspan="2">Turning and dressing tool
N = 1255 rpm;
Vc = 63 m/min
Depth = 0.4 mm</td><td rowspan="2">Ra (μm)</td><td>Longitudinal turning</td><td>1.91</td><td>2.56</td><td>2.67</td><td>3.38</td></tr>
<tr><td>Transverse turning</td><td>0.93</td><td>1.00</td><td>1.08</td><td>1.12</td></tr>
</table>

Figure 4 (a and b) shows the change in roughness as a function of feed rate applied to the two materials (aluminium and bronze) by operations (longitudinal turning and dressing). The analysis of these results explains that during machining, the roughness value increases with the increase in feed rate, for both cases of longitudinal material removal and dressing operations. By analysis of these results we notice that roughness values are important in the case of dressing with a difference of about 32 % compared to the contribution of turning aluminium compared to bronze. This means that surface finish is best for training operation for the two materials and aluminium in particular. Perhaps these results of roughness contribute to the surface damage of the facets and cutting edges probably by the effect of the active part of the tool which favours the degradation of the surface condition.

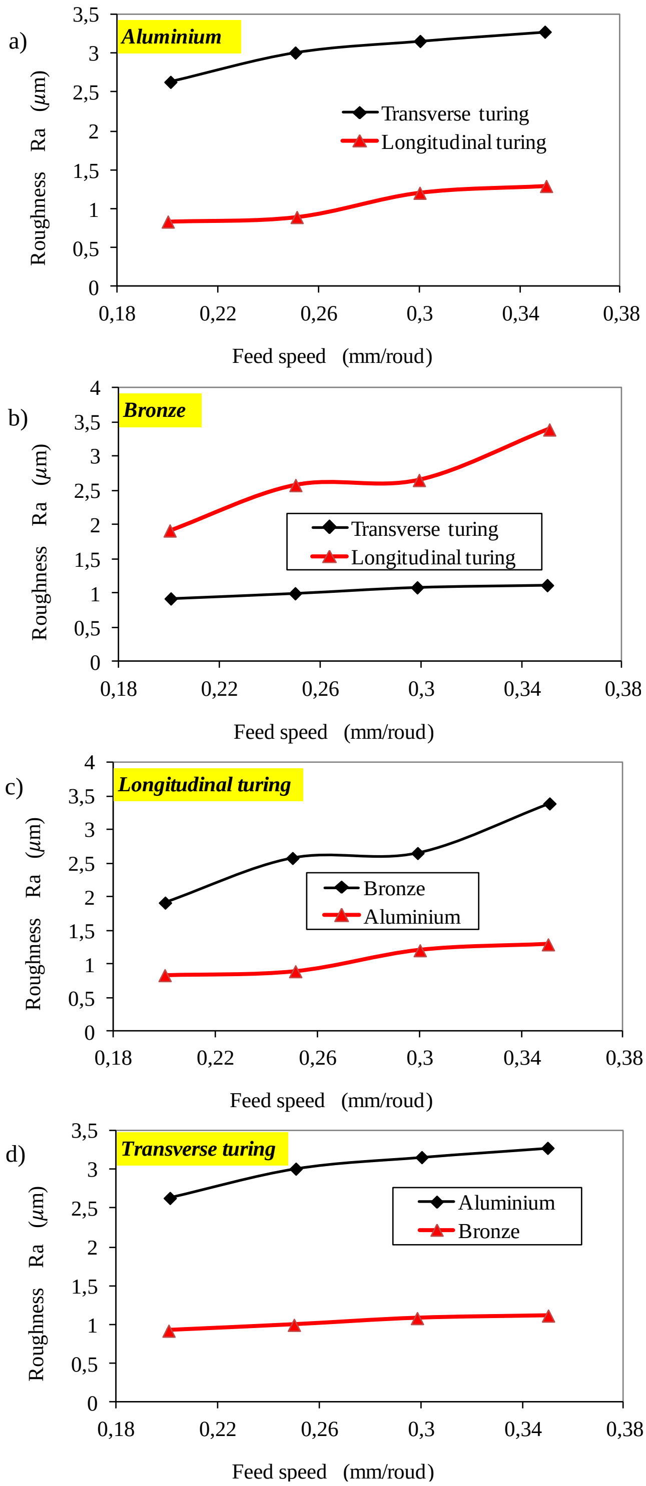


Figure 4. Effect of feed rate on aluminium and bronze.

By comparing the surface finish results obtained by longitudinal and transverse turning presented in Fig. 4 (c and d) on the two materials (bronze, aluminium), we notice that during machining the value of roughness increases with increasing feed, and for aluminium in case of longitudinal turning, and vice-versa for bronze. This is caused by the structure and the quality of the material which means that the surface finish is better in aluminium, a flexible and easy to machine material.

Cutting speed effect

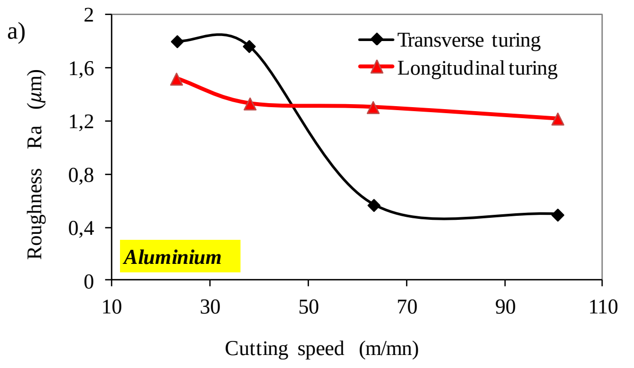
Turning and dressing operations are carried out with selected cutting parameters presented in the following table for two cases of materials to study the cutting speed. The results are shown in Table 4.

Table 4. Effect of cutting speed on surface finish of materials.

aluminium alloy (AU4G)						
Machining parameters		Cutting speed (m/min)	23.11	37.93	63.00	100.48
Turning and dressing tool Vf = 0.2 mm/min Depth = 0.4 mm	Ra (µm)	Longit. turning	1.52	1.34	1.31	1.22
		Transv. turning	1.80	1.77	0.58	0.50
Bronze alloy CuSn9P						
Machining parameters		Cutting speed (m/min)	23.11	37.93	63.	100.48
Turning and dressing tool Vf = 0.2 m/min Depth = 0.4 mm	Ra (µm)	Longit. turning	2.35	1.56	1.51	1.33
		Transv. turning	1.81	1.33	1.19	1.07

Results presented in Fig. 5 (a and b) show the evolution of roughness as a function of cutting speed in the case of aluminium and bronze. These results show that increase in cutting speed influences directly the roughness of aluminium where the surface becomes smooth and polished. When the cutting speed increases, the roughness decreases directly, so it is inversely proportional to the change in cutting speed. The latter is caused by the decrease in cutting force on the tool nose during machining operation. With disappearance of noise, reduction of heat and wear of tool, the machining becomes easy and finally the surface finish becomes smooth and substantial.

The comparison of results of surface finish on the two materials (bronze and aluminium) in the case of turning and dressing is presented in Fig. 5 (c and d). We notice from Figs. 5 c and d that better quality of surface finish is given to material aluminium in case of longitudinal turning and for bronze in case of transverse turning. The behaviour is caused by the reduction in cutting forces on the edges of the part tool active during machining operations.



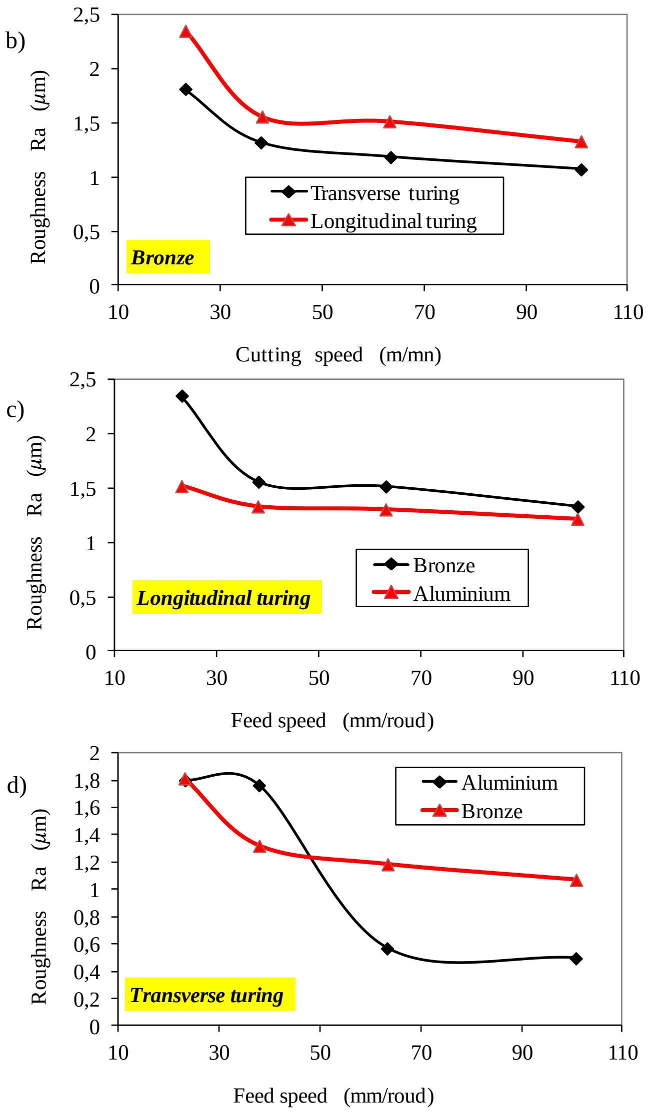


Figure 5. Effect of cutting speed on aluminium and bronze surface.

Cutting depth effect

Turning and dressing operations are carried out with selected cutting parameters presented in the following table for the two cases of materials.

Table 5. Effect of cutting depth on surface finish of materials.

aluminium alloy (AU4G)						
Machining parameters		Cutting depth (mm)	0.2	0.25	0.30	0.35
Turning and dressing tool in HSS N = 755 rpm Vc = 37.93 m/min Vf = 0.2 mm/min	Ra (µm)	Longit. turning	1.18	1.58	2.14	2.37
		Transv. turning	0.6	0.83	1.52	1.64
Bronze alloy CuSn9P						
Machining parameters		Cutting depth (mm)	0.2	0.25	0.30	0.35
Turning and dressing tool in MC N = 755 rpm Vc = 37.93 m/min Vf=0.2 mm/min	Ra (µm)	Longit. turning	1.80	2.05	2.43	2.59
		Transv. turning	1.06	1.10	1.20	1.52

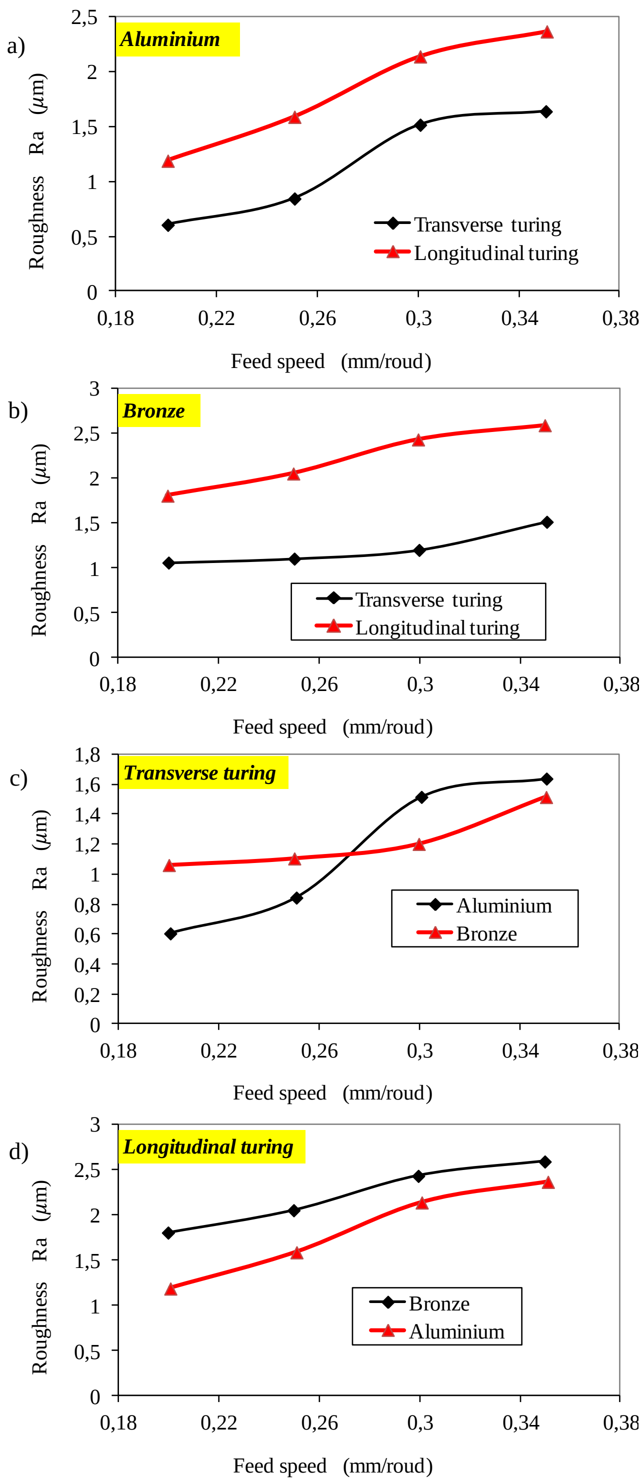


Figure 6. Effect of cutting depth on aluminium and bronze surface.

Figure 6 shows the change in roughness as a function of cutting depth for two materials in the case of two turning operations (longitudinal turning and dressing). The analysis of these results shows that during machining, the roughness value increases with increase of cutting depth, for all machining operations. We notice that roughness values in the case of longitudinal turning of bronze gives the best surface quality compared to surface machined aluminium in the same type of machining. All results by this type of regime, when the depth of cut increases the roughness increases according to this cutting parameter, which means that the surface is better than that for the turning operation. Poor surface quality is probably due to the effect of the active part of the tool which favours the degradation of the surface. The main drawback when machining aluminium is the creation of a resulting false edge and the gluing of the cuts to the edges of the tool.

The comparison between the change in roughness as a function of depth of cut in the case of the two turning and dressing operations is successively applied to the two materials (aluminium and bronze) as shown in Fig. 6 c and d. It can be seen that during machining, the roughness value increases with increase in cutting depth, for both cases of materials. We also notice that the roughness in the case of aluminium is lower than that in the case of bronze. This means that the surface finish is better than that of bronze. The latter is hard compared to aluminium. This is valid up to a cutting depth equal to 0.28 mm. Above this value, the surface finish of bronze is better than that of aluminium.

CONCLUSION

From the experimental analysis of monitoring the change in roughness as a function of cutting conditions, the following conclusions are drawn.

The machining conditions, cutting speed, feed and cutting depth (Vc, Vf, P) have a considerable influence on the quality of the machined surface.

Poor surface finish results are attributed to high feed rates and depths of cut, in which case the roughness increases in proportion to the increase in these parameters.

For cutting speeds, the results show that roughness is inversely proportional to this parameter (Vc), which calls for high cutting speed machining (HSM) for finishing high quality parts.

In fact, there are other parameters that directly influence the surface condition of the machined parts such as the power of the machining machine tool, quality of cutting tool used and its characteristics, cooling during operation machining, the nature of the material being machined, and the machine itself (vibrations) and other several parameters.

Abbreviation list

N : Rotation speed (frequency rpm) ;
Vf : Feed rate (mm/round)
Vc : Cutting speed (m/min)
Ra : Roughness (µm)
MC : Turning and dressing carbide cutting tools
P : Cutting depth (mm)

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