EXPERIMENTAL RESEARCH ON THE INFLUENCE OF CUTTING PARAMETERS ON ROUGHNESS OF TURNED SURFACES

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Abstract: Some results of the investigation of factors influencing the roughness of turned surfaces are presented In the paper**.** The main parameters affecting the surface roughness of machined sourfaces are: cutting speed, feed and axial depth of cut. By choosing different cutting regimes in finishing turning on a CNC lathe, it was investigated the variation of the surfaces roughness.

Keywords: surface roughness, cutting parameters, turning process, CNC lathe

1. INTRODUCTION

The manufacturing processes do not allow achieving the theoretical surface roughness due to the defects appearing on machined surfaces and mainly generated by deficiencies in the process. A good knowledge of these defects and an optimum selection of process conditions are extremely important as these ones determine the surface quality and the dimensional precision of the manufactured parts, in the best economic conditions [1].

Turning, whose principle scheme is shown in figure 1, is the process of mechanical machining used most often for pieces of industrial equipment and installations. Therefore, the purpose of this paper is to optimize the cutting regimes, in order to get the quality of the parts required by technical documentation.

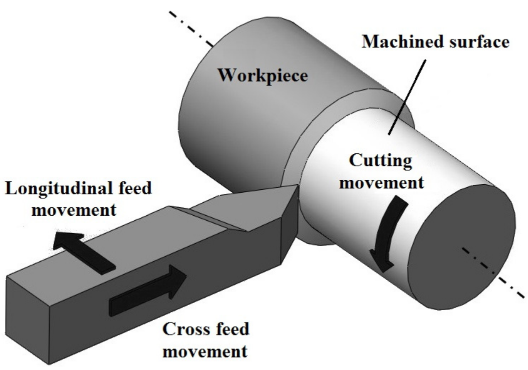


Figure 1. Turning working scheme

Usually, the roughness parameter values will mainly depend on the manufacturing conditions, such as: the cutting parameters, the rigidity of technological system, the dynamic phenomena, the use of cutting fluids, the geometrical conditions of machined surface, the material proessed, the temperature in the cutting area, [2], [3], the microgeometry and wear of the cutting edge and the material of the tool. So, a complete evaluation of roughness should take into consideration all these factors. Nevertheless, Puertas Arbizu and Luis Perez [4] show that the main parameters affecting the surface roughness are: cutting speed v_c in m/min, feed f, in mm/rev and axial depth of cut $a_{p,}$ in mm.

The cutting parameters are the main factors affecting the quality of turning machined surfaces, in terms of roughness. These parameters influence the plastic deformation of the processed material, ultimately affecting the quality of machined surfaces, simultaneously influencing the cost, time, quality and safety of manufacturing processes.

According to literature, small cutting advances are recommended, in order to reduce the surface roughness and the cutting depths which are big enough to keep the productivity into the required limits, without having a surface quality decrease. The choice of the tool nose radius requires a compromise that takes into account the surface roughness and the residual stresses.

The geometrical parameters of the cutting tool that influence the surface roughness are: the tool nose radius, r_ε; rake angle γ; clearance angle, α; the position angle Kr. The edge direction angle Kr is recommended to be chosen around 90 ˚[5].

This paper investigates in particular the influence of turning cutting parameters on surface roughness.

2. MATERIALS AND EXPERIMENTAL PROCEDURE

Processed material was E355 alloy steel (EN 10305 - 1 : 2010 Steel tubes for precision applications), hardened and tempered (60 - 65HRC), having the following chemical composition: max 0,22 % C; max 1,6 % Mn; Max.0,55 % Si; Max 0,045 % S; Max 0,045 % P.

Experimental investigations were conducted on cylindrical surfaces of 20 mm length each, separated by gorges. The workpiece has 50,5 mm in diameter and 252 mm in length; it was obtained from seamless circular steel tubes for general and mechanical and engineering purposes.

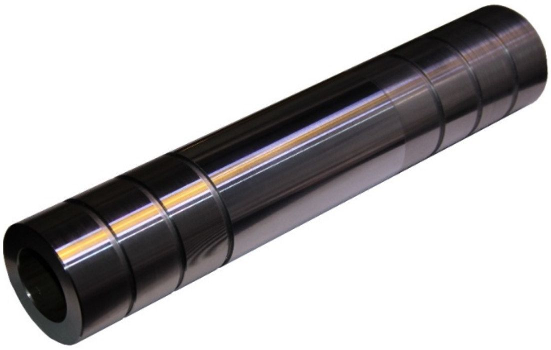


Figure 1. Workpiece shape

The machining was carried out on a CNC lathe, also by making use of a Metsol B cooling liquid. It wasn't quantified the effect of vibration on experimental studies carried out.

Figure 2. CN MAZAK Quik Turn Smart 300

The processing was performed by using changeable tool inserts VNMG160404 CM4225, presented in figure 3, with their support MVVNN 2525 M16, Sandvik Coromant products [6].

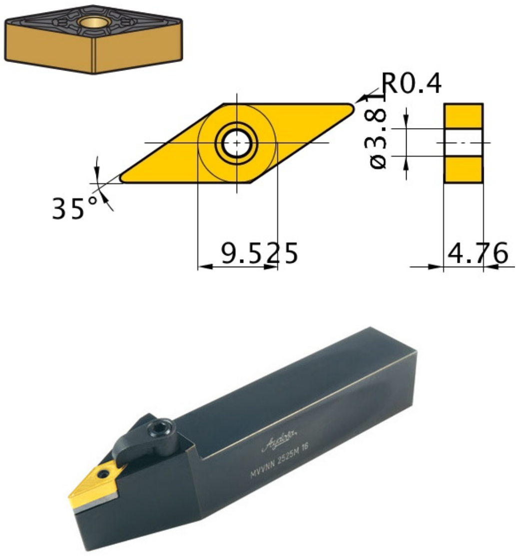


Figure 3. Geometrical properties of insert and insert tool holder

The measurement of the surface roughness parameter Ra was made with 0,8 mm cut off value, using a Mitutoyo SJ-201 rugosimeter, according to ISO 4287.

The surface roughness average Ra was taken as a parameter defined on the basis of the ISO 4287 norm [7] as the arithmetical mean of the deviations of the roughness profile from the central line along the measurement. The average surface roughness (R_a) was investigated in other works, as well, but the surface roughness measurement was done by profilometry [8].

There were measured the surface roughness values for different cutting regimes, presented in tables 1 and 2.

Figure 4. Mitutoyo SJ-201 rugosimeter

3. RESULTS AND DISCUSSION

The design of experiments is a powerful analysis tool for modeling and analyzing the influence of feed rate on the surface roughness, the main parameters affecting the surface roughness.

It also analyses the influences of the other two parameters (cutting speed and cutting depth). For this purpose, there were turned surfaces with different advances, for different values of the cutting speed and for different cutting depths values. By using different steel tubes, seven surfaces have been machined by turning process, corresponding to the advance values contained in the range (0,015 mm/rev – 0,3 mm/rev), keeping unchanged the cutting speed and the depth of cut values. There have been repeated these experiments for three different cutting speeds, corresponding to the following three rotation speed (spindle speed) values: 1000 rev/min, 1500 rev/min, 2000 rev/min and for two cutting depths values (0,5 mm and 1 mm).

The roughness parameter Ra values are presented in table 1, table 2, figure 5 and figure 6.

Table 1.The influence of feed on Ra parameter of surface roughness, in turning with:
a_p= 0,5 mm;
n_1= 1000 rev/min; n_2 =1500 rev/min; n_3 = 2000 rev/min

f [mm/rev]	0,01	0,02	0,05	0,1	0,15	0,2	0,3
Ra1 [μm]	2,16	2,06	0,57	0,93	1,54	2,91	6,49
Ra2 [μm]	0,65	0,36	0,3	0,98	1,69	3,03	6,69
Ra3 [μm]	0,37	0,55	0,49	0,74	1,5	3	6,72

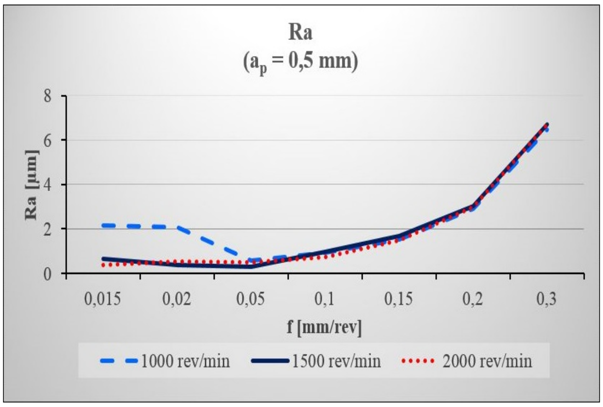


Figure 5. The variation of roughness parameter Ra in turning with different feeds, for different values of spindle speed, when a_p = 0,5 mm

Ra1, Ra2 and Ra3 correspond to the spindle speed values of: 1000 rev/min, 1500 rev/min and 2000 rev/min.

Table 2. Influence of feed on Ra parameter of surface roughness, in turning with:
a_p= 1 mm;
n_1= 1000 rev/min; n_2 =1500 rev/min; n_3 = 2000 rev/min

f [mm/rev]	0,01	0,02	0,05	0,1	0,15	0,2	0,3
Ra1 [μm]	1,16	0,33	0,31	0,71	1,91	2,41	6,07
Ra2 [μm]	0,38	0,59	0,34	0,72	1,57	2,61	5,95
Ra3 [μm]	0,43	0,29	0,3	0,6	1,53	2,85	6,08

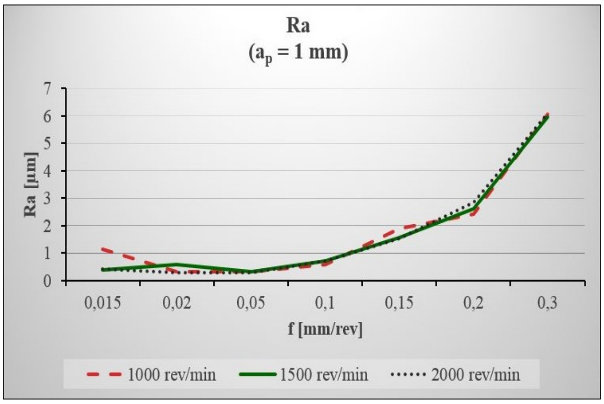


Figure 6. The variation of roughness parameter Ra in turning with different feeds, for different values of spindle speed, when a_p = 1 mm

The microscopic analysis of the machined surfaces obtained by the mean of a MC6 optical microscope, was performed for the confirmation of the experimental research.

The micrographies of the turned surfaces presented in table 3 reveal an increaseing pitch of the roughness profile, in accordance with the feed values: 0,015; 0,05; 0,1; 0,15; 0,2; 0,3 mm/rev, when a_p=1mm and n =1500 rev/min.

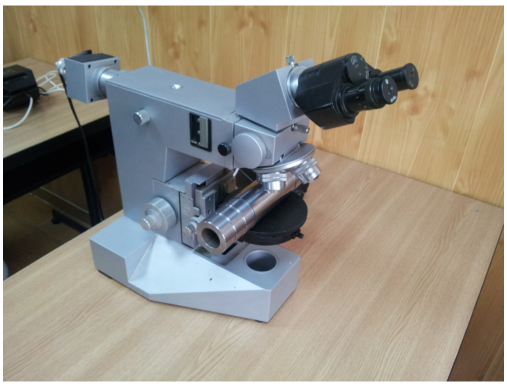
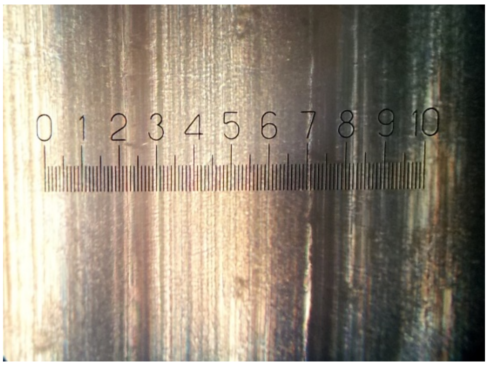
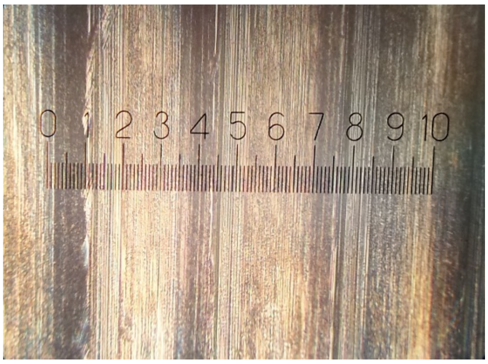


Figure 7. MC6 Optical microscope

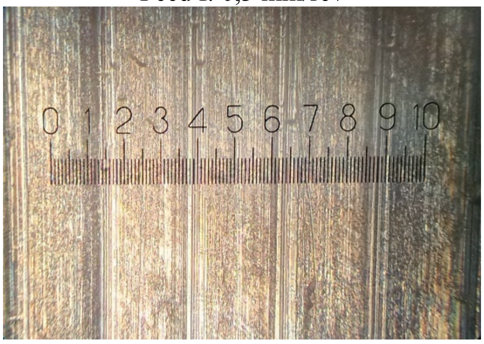
Table 3. Microscopic analysis of the turned surfaces with different cutting feed



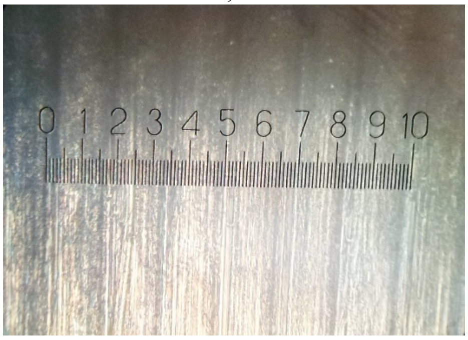
Feed f: 0,3 mm/rev



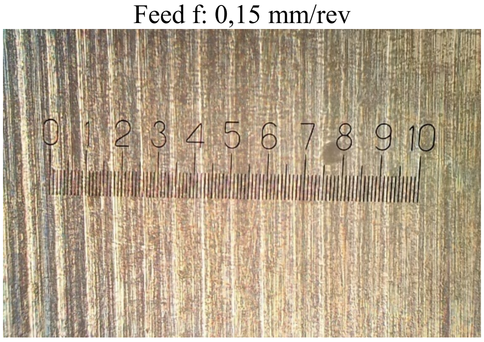
Feed f: 0,2 mm/rev



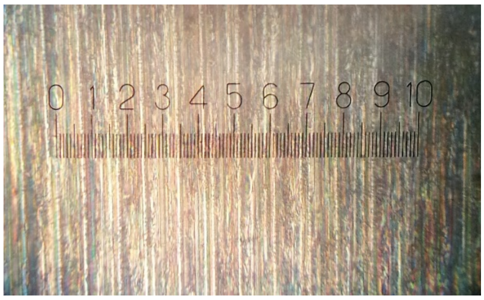
Feed f: 0,15 mm/rev



Feed f: 0,1 mm/rev



Feed f: 0,05 mm/rev



Feed f: 0,015 mm/rev

The roughness of the surfaces machined with cutting advances under the value 0,02 mm/rev is greater than that of the processed surfaces with larger advances, in the range 0,02 mm/rev - 0,1mm/rev. This is explained by the fact that, in turning with very small advances, it appears the phenomenon of strain hardening and can even occur deposits on the cutting edge. For higher advance values, deposits on the cutting edge are reduced or completely removed, as a result of the bigger forces that arise in the clearance face, but the surface roughness increases.

Also, when the tool advance is under 0.1 mm / rev, the roughness doesn't change too much. This proves the theories [9] and [10], which claim that for finishing, is not necessary to decrease the advance, because, in this context, the surface roughness doesn't decrease, only the productivity does ; the improvement of roughness does not cover the decrease in productivity. At finishing, the improvement of roughness can be obtained by increasing the cutting.

Regarding to the cutting depth influence on the surface roughness, notice that, the values of surfaces roughness turned with cutting depth of 1 mm are smaller than those of the turned surfaces with depths of cut of 0,5 mm, as shown in tables 1 and 2 and figures 5 and 6, which suggests that, at a cutting depth of 0,5 mm, is manifesting the phenomenon of hardening.

Spindle speed and, by default, cutting speed does not influence significantly the surface roughness in the range analyzed (1000 rev / min - 2000 rev / min).

The high cutting speeds have favored the occurrence of vibrations during machining, especially at turning with very small advances/feed, sometimes leading to a reduced quality of machined surfaces.

4. CONCLUSIONS

Experimental investigations have shown that, by decreasing the cutting advance, the quality of machined surfaces is improved in terms of roughness, with the exception of turning with advances under the value 0,02 mm/rev, when it appears the phenomenon of strain hardening and the values of roughness parameter Ra increases.

Also, cutting depths below 1 mm, favors the strain hardening phenomenon, and a surface quality improvement is observed for cutting depths of 1 mm.

By increasing the spindle speed and also, the cutting speed, is observed an improvement of surface quality.

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