The influence of the geometry of the lathe tool on the surface condition at the processing of the polyamide PA 66 – GF 30

As. eng. Marin MOȚOI - CRISTESCU
University of Pitești

ABSTRACT

As it is known, the surface condition has two constituents: dimensional accuracy and roughness of the machined surface. In this study it is presented only the condition of the machined surface from the roughness point of view. As regards the geometry of the lathe tool, this study presents only the influence of two tool parameters: radius of the tool point and the end cutting edge angle.

Keywords: *polyamide, lathe tools, radius of the tool point, end cutting edge angle.*

1. Introduction

As it is known, the surface condition is set off by the dimensional accuracy and by the roughness of the machined surface. Between the two constituents of the surface condition, in this study it is presented only the roughness of the machined surface.

As it results from the title, the processing operation is the turning, and particularly it is talked about the straight turning (of rough cutting and of finishing).

As regards the geometry of the lathe tool, this study presents only the influence of two parameters of the tool, which is the radius of the tool point r_ε and the end cutting edge angle χ_1.

2. The radius of the tool point's influence

Starting from the data presented in table no 1, which is the process input parameters, I laid down an experimental fractional factorial plan of the type 2^{4-1}.

In table 1.a is presented the parameters of cutting, for condition the rough turning; in table 1.b is presented the parameters for finish turning.

In table 2 is presented the plan experimental, the parameters of cutting, for condition the rough turning and finish turning.

Table 1.a
Values of the process input parameters

Rough turning			
Parameter		**Actual value**	**Normative value**
Cutting speed, v [m/min]	v_{min}	20,724	-1
	v_{med}	41,605	0
	v_{max}	83,21	1
Work advance, s_l [rot/min]	s_{min}	0,4	-1
	s_{med}	0,6	0
	s_{max}	0,9	1
Cutting depth, t [mm]	t_{min}	0,5	-1
	t_{med}	1	0
	t_{max}	2	1
Radius of the tool point, r_ε [mm]	$r_{\varepsilon min}$	0,25	-1
	$r_{\varepsilon med}$	0,5	0
	$r_{\varepsilon max}$	1	1

Table 1.b

Finish turning			
Parameter		**Actual value**	**Normative value**
Cutting speed, v [m/min]	v_{min}	83,21	-1
	v_{med}	117,75	0
	v_{max}	166,42	1
Work advance, s_l [rot/min]	s_{min}	0,1	-1
	s_{med}	0,15	0
	s_{max}	0,225	1
Cutting depth, t [mm]	t_{min}	0,1	-1
	t_{med}	0,2	0
	t_{max}	0,4	1
Radius of the tool point, r_ε [mm]	$r_{\varepsilon min}$	0,25	-1
	$r_{\varepsilon med}$	0,5	0
	$r_{\varepsilon max}$	1	1

Table 2

Experimental plan

Exp.	Normative values of the independent variables			
	v	s	t	r_ε
1	-1	-1	-1	-1
2	1	-1	-1	1
3	-1	1	-1	1
4	1	1	-1	-1
5	-1	-1	1	1
6	1	-1	1	-1
7	-1	1	1	-1
8	1	1	1	1
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0

The conditions in which the researches have been performed are:

- the machine tool utilized: center lathe MSZ 5022;
- the lathe tool having its geometry presented in table 3;
- without cooling;
- the measurement of the roughness Ra was effectuated with a Surtronic 4 apparatus.

Table 3

Geometrical elements of the utilized lathe tool, [3], [4]

Angle of clearance α, [°]	Rake angle γ, [°]	Entering angle χ, [°]	End cutting edge angle χ_1, [°]
8	30	45	45

In the wake of the experimental data processing, table 4, obtained on base of the research plan presented in table 2.

With the help of the technical literature regarding the experimental data processing, [1], [2] and [6], on an obtained a series of empirical relations as regards the influence of the radius of the tool point upon the roughness of the machined surface.

Table 4

Values of the independent variables and those obtained for the independent variable

Rough turning					
Exp	Values of the independent variables and the dependence				
	v, [m/min]	s, [rot/min]	t, [mm]	r_ε, [mm]	*Ra*, [μm]
1	20,724	0,4	0,5	0,25	*26,26*
2	83,21	0,4	0,5	1	*21,26*
3	20,724	0,9	0,5	1	*41,95*
4	83,21	0,9	0,5	0,25	*42,57*
5	20,724	0,4	2	1	*24,46*
6	83,21	0,4	2	0,25	*24,26*
7	20,724	0,9	2	0,25	*47,25*
8	83,21	0,9	2	1	*42,92*
9	41,605	0,6	1	0,5	*31,91*
10	41,605	0,6	1	0,5	*31,91*
11	41,605	0,6	1	0,5	*31,91*
12	41,605	0,6	1	0,5	*31,91*

Finish turning					
Exp	Values of the independent variables and the dependence				
	v, [m/min]	s, [rot/min]	t, [mm]	r_ε, [mm]	*Ra*, [μm]
1	83,21	0,1	0,1	0,25	*8,84*
2	166,42	0,1	0,1	1	*6,43*
3	83,21	0,225	0,1	1	*12,35*
4	166,42	0,225	0,1	0,25	*15,00*
5	83,21	0,1	0,4	1	*7,20*
6	166,42	0,1	0,4	0,25	*8,55*
7	83,21	0,225	0,4	0,25	*15,90*
8	166,42	0,225	0,4	1	*13,10*
9	117,75	0,15	0,2	0,5	*10,02*
10	117,75	0,15	0,2	0,5	*10,02*
11	117,75	0,15	0,2	0,5	*10,01*
12	117,75	0,15	0,2	0,5	*10,04*

The relations obtained in the wake of the data processing from table 4 are:

- for the longitudinal rough turning:

$$R_a = 55,21 \cdot v^{-0,054} \cdot s^{0,737} \cdot t^{0,034} \cdot r_\varepsilon^{-0,057} \quad [\mu m] \qquad (1)$$

- for the longitudinal finish turning:

$$R_a = 50,93 \cdot v^{-0,053} \cdot s^{0,740} \cdot t^{0,036} \cdot r_\varepsilon^{-0,158} \quad [\mu m] \qquad (2)$$

If one gives up the cutting depth influence, because one observes that this is small enough, one obtains the relations:

- for the longitudinal rough turning:

$$R_a = 56,75 \cdot v^{-0,058} \cdot s^{0,737} \cdot r_\varepsilon^{-0,033} \quad [\mu m] \tag{3}$$

- for the longitudinal finish turning:

$$R_a = 49,15 \cdot v^{-0,058} \cdot s^{0,740} \cdot r_\varepsilon^{-0,121} \quad [\mu m] \tag{4}$$

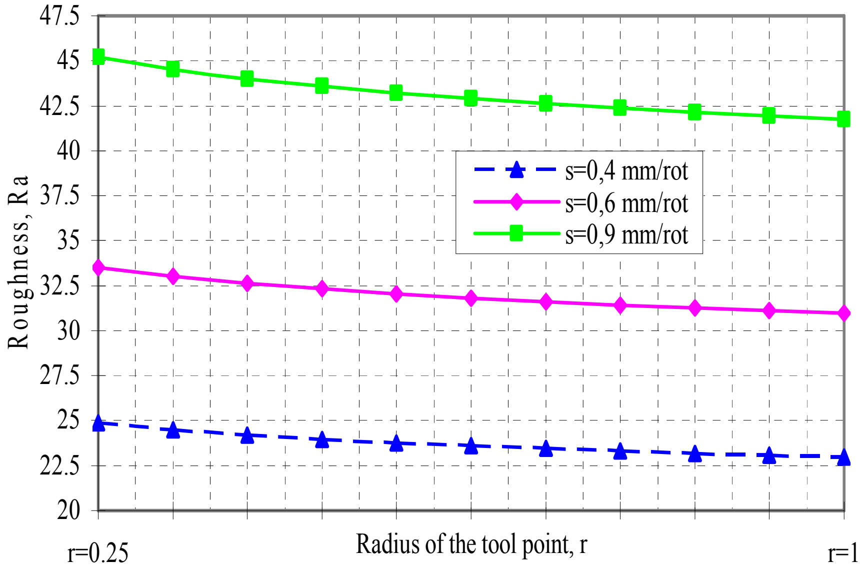

Figure 1 The influence of the radius of the tool point at the rough turning

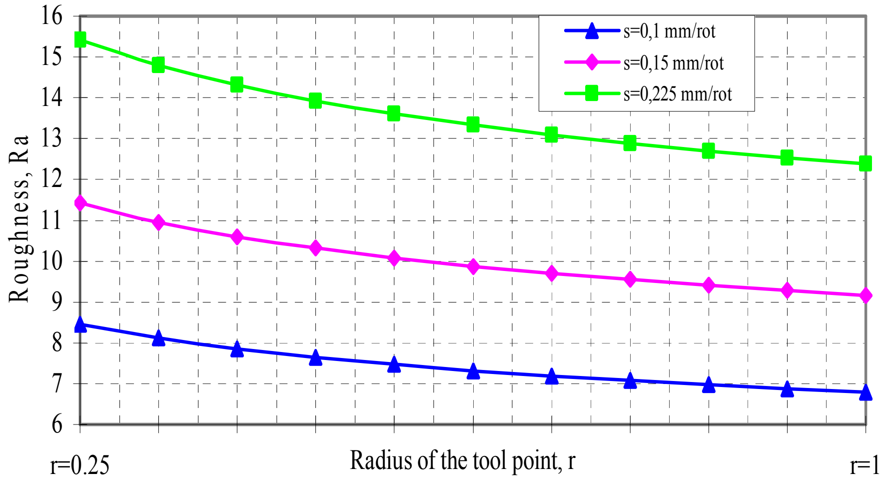

Figure 2 The influence of the radius of the tool point at the finish turning

It can be observed, from the figures 1 and 2, which the radius of the tool point has a positive influence on the roughness of the machined surface, which means that when the radius of the tool point increases the roughness subtracts.

Though, the roughness obtained values are not optimum, because it is known from technical literature, that besides the radius of the tool point, the end cutting edge angle also has a large influence on roughness.

3. The lathe tool's end cutting edge angle influence

To emphasize this influence i have started from a fractional factorial research plan of the type 2^{4-1}, in which the independent variables are: the cutting speed, v [m/min], the work advance, s_1 [mm/rot], the

cutting depth, t [mm] and the end cutting edge angle of the lathe tool, χ_1 [^{o}].
The values of these input variables are those from the table 4, with the observation that the radius of the tool point was kept constant, that is 1 mm, and the values of the end cutting edge angle are presented in table 5.

Table 5
Values of the end cutting edge angle

End cutting edge angle of the lathe tool, χ_1, [^{o}]		
$\chi_{1\min}$	χ_{1med}	$\chi_{1\max}$
5	15	45

The other geometrical elements of the lathe tool were kept constant, that is: the angle of clearance, $\alpha = 8^o$ and the rake angle, $\gamma = 30^o$.

The work conditions have been the same as those from point 2.

In the wake of the experiments performed, there have been obtained the results presented in table 6.

Table 6
Values of the independent variables and those obtained for the independent variable

Rough turning					
Exp	**Values of the independent variables and the dependence**				
	v, [m/min]	**s, [rot/min]**	**t, [mm]**	**χ_1, [rad]**	***Ra*, [µm]**
1	20,724	0,4	0,5	0,1744	2,51
2	83,21	0,4	0,5	1,57	21,26
3	20,724	0,9	0,5	1,57	41,95
4	83,21	0,9	0,5	0,1744	4,44
5	20,724	0,4	2	1,57	24,46
6	83,21	0,4	2	0,1744	5,77
7	20,724	0,9	2	0,1744	7,22
8	83,21	0,9	2	1,57	42,92
9	41,605	0,6	1	0,5233	7,92
10	41,605	0,6	1	0,5233	8,02
11	41,605	0,6	1	0,5233	8,26
12	41,605	0,6	1	0,5233	7,74

Finish turning					
Exp	**Values of the independent variables and the dependence**				
	v, [m/min]	**s, [rot/min]**	**t, [mm]**	**χ_1, [rad]**	***Ra*, [µm]**
1	83,21	0,1	0,1	0,1744	0,85
2	166,42	0,1	0,1	1,57	6,43
3	83,21	0,225	0,1	1,57	12,35
4	166,42	0,225	0,1	0,1744	1,25
5	83,21	0,1	0,4	1,57	7,2
6	166,42	0,1	0,4	0,1744	1,38
7	83,21	0,225	0,4	0,1744	1,24
8	166,42	0,225	0,4	1,57	13,1
9	117,75	0,15	0,2	0,5233	2,63
10	117,75	0,15	0,2	0,5233	2,28
11	117,75	0,15	0,2	0,5233	2,4
12	117,75	0,15	0,2	0,5233	2,31

The data obtained in the wake of the experimental researches, in the above mentioned conditions, led, in base of technical literature [1], [2] and [6], to the determination of some empirical relations between the roughness of the machined surface and the input parameters of the processing process.

These relations are:
- for the longitudinal rough turning:

$$R_a = 21,73 \cdot v^{0,041} \cdot s_l^{0,628} \cdot t^{0,267} \cdot \chi_1^{0,866} \quad [\mu m] \qquad (5)$$

- for the longitudinal finish turning:

$$R_a = 7,6 \cdot v^{0,158} \cdot s_l^{0,472} \cdot t^{0,117} \cdot \chi_1^{0,947} \quad [\mu m] \qquad (6)$$

From the relations (5) and (6) it is observed that in the case of the rough turning, and the finish turning, the end cutting edge angle of the utilized lathe tool has the most important influence on the roughness of the machined surface.

On base of the relations (5) and (6) there have been raised graphics (figures 3 and 4) to emphasize the dependence between the end cutting edge angle and the roughness of the machined surface.

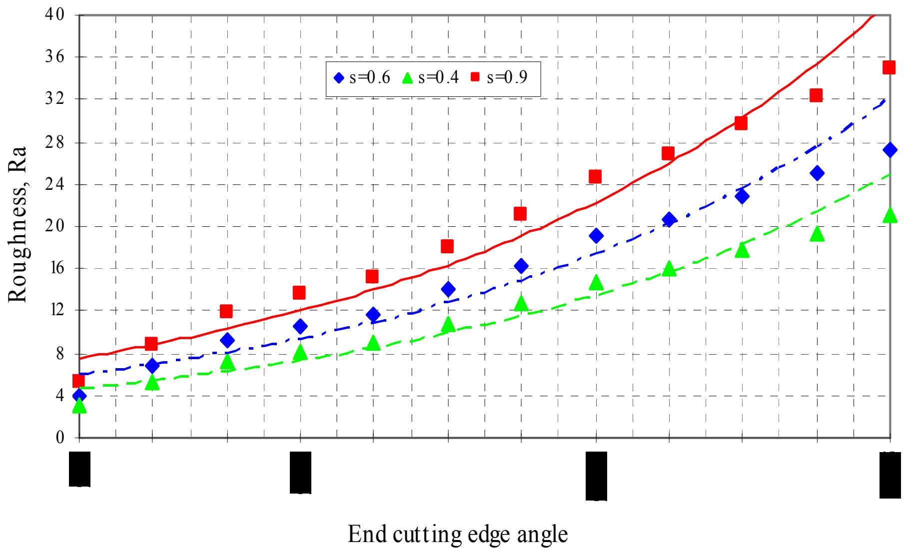

Figure 3 The dependence between the roughness of the surface and the end cutting edge angle, in the case of the longitudinal rough turning

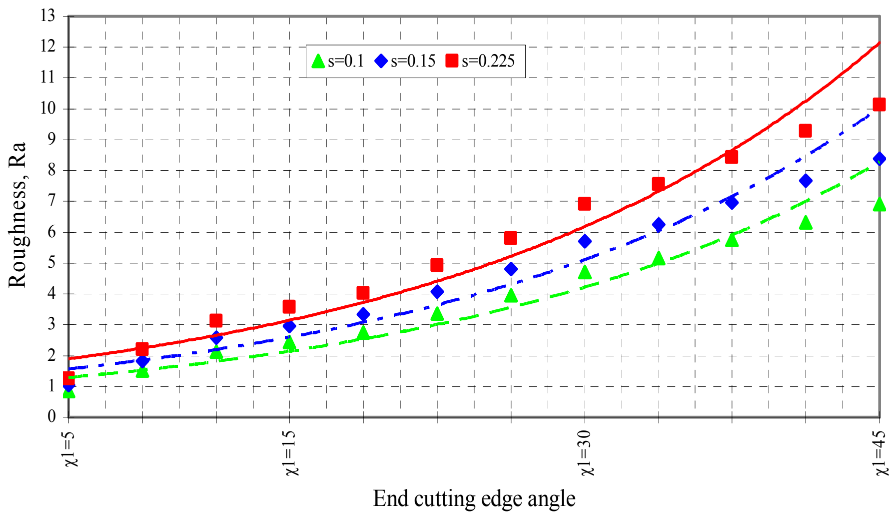

Figure 4 The dependence between the roughness of the surface and the end cutting edge angle, in the case of the longitudinal finish turning

4. Conclusions

As it is remarked in the figures 1 and 2, it results that the radius of the tool point $r_\varepsilon \geq 1$ *mm*, in order to obtain roughness' values Ra close to the normal ones for the applied processing process.

According to (5):

$$R_a = 21,73 \cdot v^{0,041} \cdot s_l^{0,628} \cdot t^{0,267} \cdot \chi_1^{0,866} \quad [\mu m],$$

for the OLC 45:

$$R_a = 43,85 \cdot V^{-0,159} \cdot s^{1,457} \cdot r_\varepsilon^{-0,428} \quad [\mu\text{m}] \quad (7),$$

figure 5.

If relation (7) is compared with the relation (3) it is remarked that the difference between them is in the value of the coefficient and of the exponents, because the properties of the processed material have an influence on the dependent variable, Ra.

From the figures 3 and 4 we observe that normal values for the applied process are obtained, in the case of the longitudinal finish turning, at the values of the end cutting edge angle: $5^o \leq \chi_1 \leq 30^o$; in the case of the longitudinal rough turning, at the values of the end cutting edge angle: $15^o \leq \chi_1 \leq 30^o$;

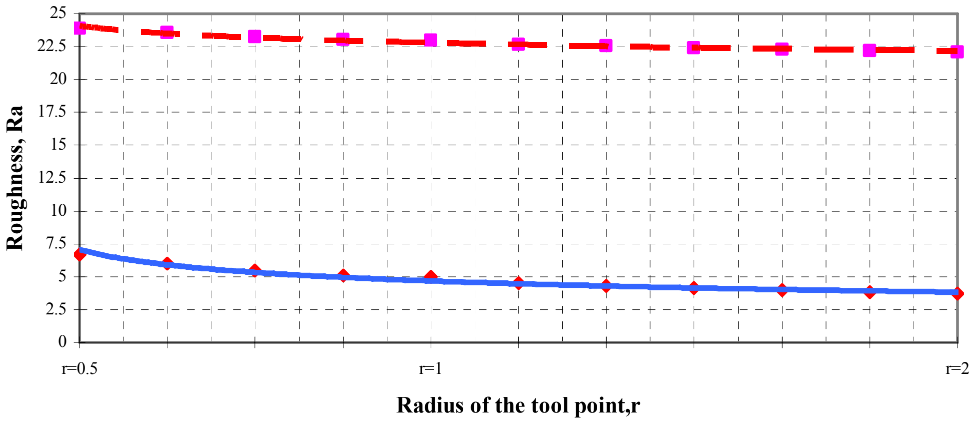

Figura 5 Comparation OLC 45 with PA 66 – GF 30

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Influenţa geometriei cuţitului de strung asupra stării suprafeţei la prelucrarea poliamidei PA 66 – GF 30

Rezumat

După cum se ştie, starea suprafeţei are două componente: precizia dimensională şi rugozitatea suprafeţei prelucrate. În această lucrare se prezintă doar starea suprafeţei prelucrate din punct de vedere al rugozităţii.

In ceea ce priveşte geometria cuţitului de strung, lucrarea prezintă doar influenţa a doi parametrii ai cuţitului: raza la vârf şi unghiul de atac secundar.

L'influence de la géométrie de l'outil de tour sur la condition de surface au traitement du polyamide PA 66 – GF 30

Résumé

Comme il est su, la condition de surface a deux constituants : la précision et la rugosité à dimensions de l'a usiné la surface. Dans cette étude qu'il est seulement présenté la condition de l'a usiné la surface du point de vue de rugosité.

Comme considère la géométrie de l'outil de tour, cette étude présente seulement l'influence de deux paramètres d'outil : le rayon du point d'outil et l'angle d'avant-garde de fin.