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STUDIES REGARDING THE INFLUENCE OF THE IMPROVING ELEMENTS UPON THE ROUGHNESS OF THE SURFACE PROCESSED OF POLYAMIDE

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Abstract: The current work contains a study about the influence of the improving elements upon the roughness of a surface processed through longitudinal turning of a part of polyamide**.** The types of polyamide under discussion are: PA 66, PA 66 – GF 30 (PA 66 with 30% of glass fibred) and PA 66 MoS2 (PA with MoS2), composite material proceeding from ERTA Company.

1. Introduction

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

The processing operation had in view is the turning, and particularly it is about the cylindrical turning (rough turning and finish turning).

This work presents a series of dependence relationships between the roughness of the machined surface by the above-mentioned process and the elements of the cutting conditions, as well as the influence of the improving elements on this roughness.

The Taguchi method is statistical tool, adopted experimentally to investigate influence of surface roughness by cutting parameters such as cutting speed, feed and depth of cut [1]. The Taguchi process helps to select or to determine the optimum cutting conditions for turning process. Many researchers developed many mathematical models to optimize the cutting parameters to get lowest surface roughness by turning process.

2. Taguchi method

Taguchi method is powerful tool for the design of high quality systems. It provides simple, efficient and systematic approach to optimize designs for performance, quality and cost [2]. Taguchi method is efficient method for designing process that operates consistently and optimally over a variety of conditions. To determine the best design it requires the use strategically designed experiment [3]. Taguchi approach to design of experiments in easy to adopt and apply for users with limited knowledge in the engineering and scientific community [4-5]. The desired cutting parameters are determined based on experience or by hand book. Cutting parameters are reflected on surface roughness [5]. Taguchi method is especially suitable for industrial use, but can also be used for scientific research [6].

3. Experimental

The materials on which experimental researches have been made are: polyamide PA 66, polyamide PA 66 – GF 30 and nylatron GSM (PA 66 MoS_2), and those properties are presented in table no.1.

Polyamide PA 66– GF 30 is a material based on a polyamide PA 66 to whom it was added, for the improvement of certain properties, 30% glass fiber, and the polyamide Nylatron GSM is composed by PA 66 to whom it was added 1% molybden disulphide (MoS_2).

Table no.1: Mechanical properties of the materials used [1]

Properties	Unit	PA 66	PA 66–GF 30	PA 66 MoS_2
Density	g/cm^3	1,14	1,29	1,16
Breaking strength	MPa	90	100	78
Breaking elongation	%	>40	5	25
Resistance to shock	KJ/m^2	4,5	6	3,5
Ball test hardness	N/mm^2	160	165	160

Table no.2: Parameters of the cutting conditions

Parameters \ Processing		Roughing	Finishing
Cutting depth, t [mm]	Minimum	0,4	0,1
	Medium	0,7	0,18
	Maximum	1,2	0,3
Advance, s_l [mm/rot]	Minimum	0,4	0,1
	Medium	0,6	0,15
	Maximum	0,9	0,225
Cutting speed, v [m/min]	Minimum	29,83	117,75
	Medium	41,605	166,42
	Maximum	58,875	235,5

The experimental assays established in basis of a research plan having as input variables the parameters of the cutting conditions (table no.2), were performed in the following conditions:

- turning tool (lathe tool) for each processing method (roughing/finishing), with the geometry presented in table no.3;
- the machine – tool: normal parallel lathe MSZ 5022;
- the measuring instrument: Surtronic 4;
- the processing were made without cooling;
- the ambient temperature: 20^0C;
- the semi-products utilized had a diameter of 50 mm.

Table no.3: The cutting tool used

Parameters \ Processing		Roughing	Finishing
Material	mm	Rp3	
Clearance angle	^{0}	8 [2,3]	
Rake angle	^{0}	30 [2,3]	
Nose radius	mm	1	
Entering angle	^{0}	45	75
End cutting edge angle	^{0}	45	5

The mathematical pattern from which we started is of the type:

$$R_a = A_0 \cdot v^{A_1} \cdot s^{A_2} \cdot t^{A_3} \quad [\mu m] \qquad (1)$$

where: $A_{0 \ldots 3}$ – coefficients.

It was chosen this mathematic model because it is very easy to linear.

4. Results and Discussions

Starting from the established mathematical model and utilizing an orthogonal centered experimental plan of the type 2^3, after the processing of the obtained data, using specialty methods regarding the data processing, it results two equations for each material analyzed.

These equations are:

a. For roughing:

- PA 66 :

$$R_a = 37,15 \cdot v^{-0,132} \cdot s^{0,231} \cdot t^{0,039} \text{ [µm]}; \quad (2)$$

- PA 66 – GF30:

$$R_a = 101,41 \cdot v^{-0,227} \cdot s^{0,903} \cdot t^{0,059} \text{ [µm]}; \quad (3)$$

- PA 66 MoS_2:

$$R_a = 44,67 \cdot v^{-0,106} \cdot s^{0,524} \cdot t^{0,051} \text{ [µm]}; \quad (4)$$

b. For finishing:

- PA 66 :

$$R_a = 31,62 \cdot v^{-0,475} \cdot s^{0,219} \cdot t^{0,102} \text{ [µm]}; \quad (5)$$

- PA 66 – GF30:

$$R_a = 1,98 \cdot v^{-0,071} \cdot s^{0,13} \cdot t^{0,058} \text{ [µm]}; \quad (6)$$

- PA 66 MoS_2:

$$R_a = 3,01 \cdot v^{-0,177} \cdot s^{0,089} \cdot t^{0,076} \text{ [µm]}; \quad (7)$$

In basis of these dependence relationships were traced a series of graphics to mark both the influence of the cutting conditions on quality of the machined surface, and the influence of the improving elements from the materials analyzed on this quality.

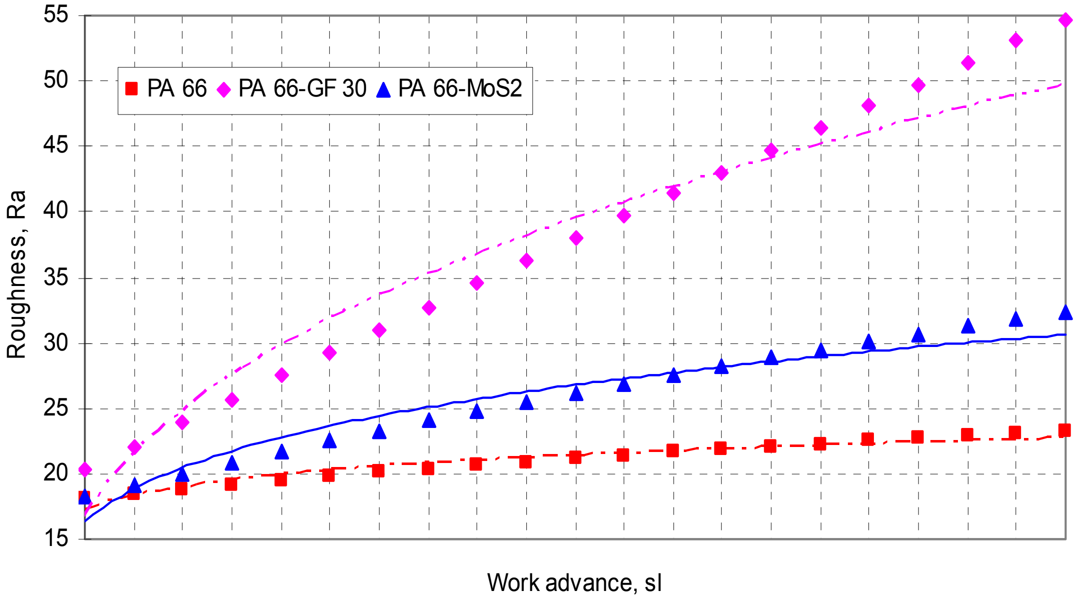

Fig. 1: **Dependence between Ra and s, (v, t = const.), for roughing**

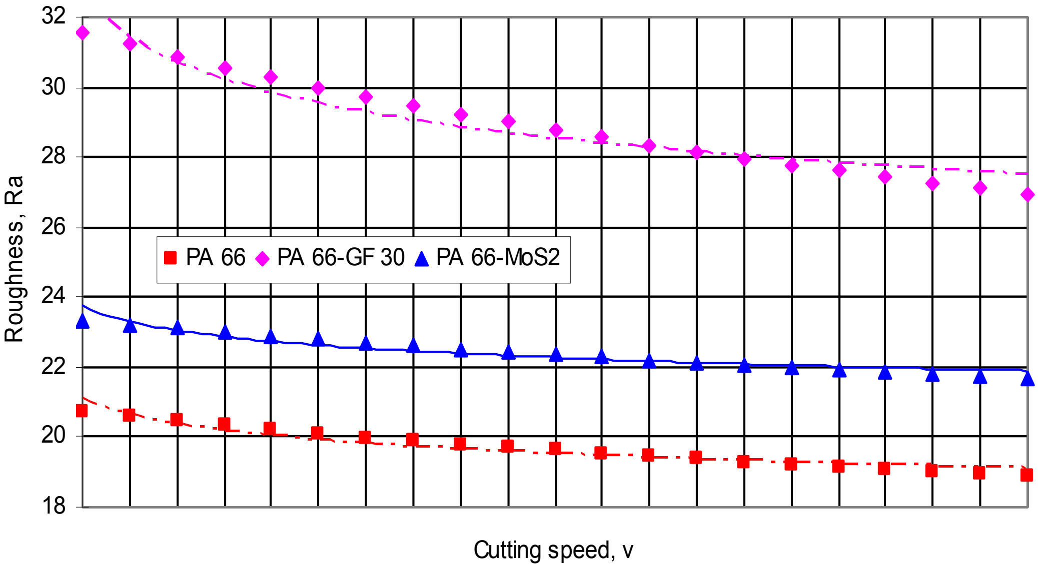

Fig. 2: **Dependence between Ra and v,(s, t = const.), for roughing**

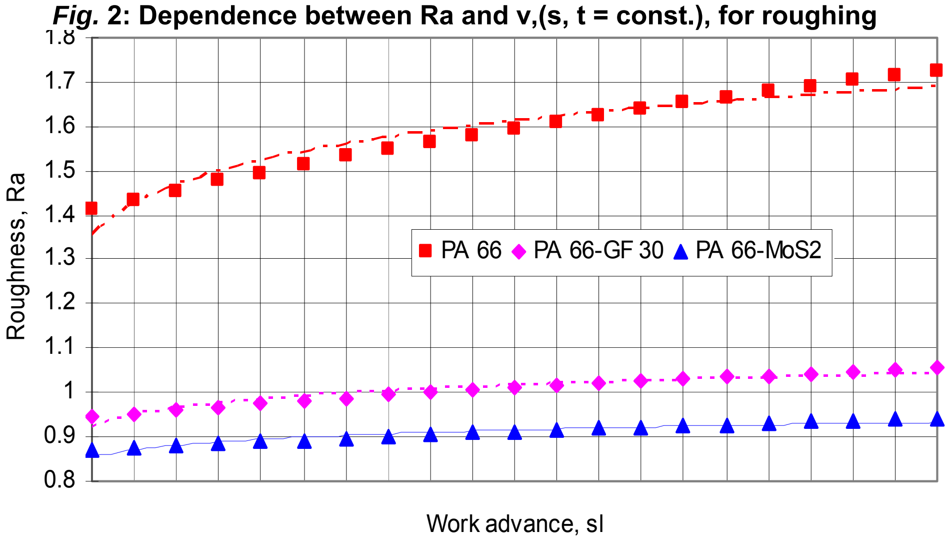

Fig. 3: **Dependence between Ra and s, (v, t = const.), for finishing**

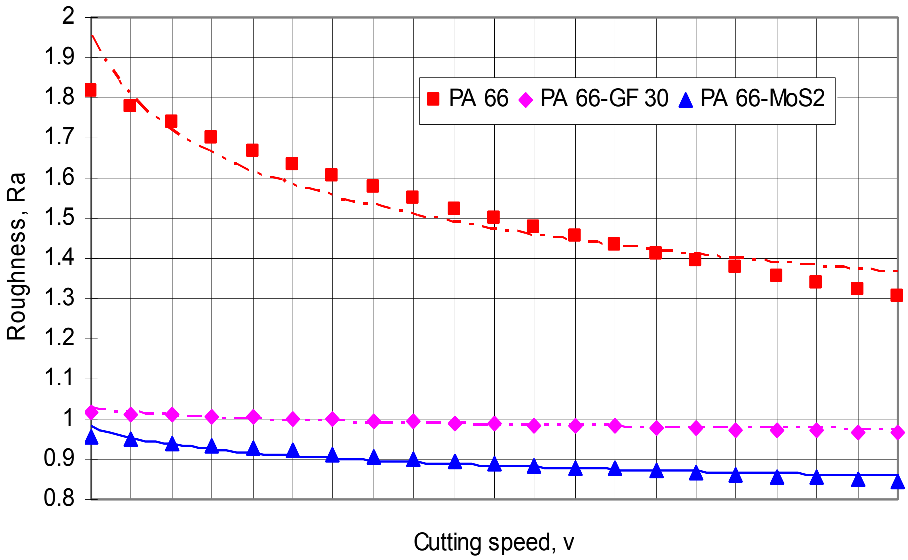

***Fig.* 4: Dependence between Ra and v,(s, t = const.), for finishing**

It can be observed, from these graphics, that the biggest influence on the surface roughness, between the parameters of the cutting conditions, has the work advance, s_l, followed by the cutting speed, v, and, with a very small influence, the cutting depth, t.

Analyzing the results obtained, both from the relations and from the graphics, it can be considered that an influence on the machined surface quality also has the improving element utilized for the modification of certain mechanical and/or chemical properties of the basis polyamide PA 66.

So it is observed that in the case of the longitudinal rough turning process a good processing is assured in the case of polyamide PA 66, so the improving elements added to this polyamide influence negatively the surface quality for this type of processing. The difference between the medium values obtained in the processing of the polyamide PA 66 and the other two polyamides, for example in the case of the constant cutting speed and depth machining and variable advance (Fig.1), it is approximately 42% vis a vis the PA 66 – GF 30, respectively of 18% vis a vis the PA 66 MoS_2.

In the case of the finish turning it can be observed that the added elements are good for the machined surface quality, because the best quality (roughness) was obtained in the processing of the polyamides PA 66 MoS_2 and PA 66 – GF 30, that is the additive ones. The difference between the medium values obtained in the processing of the polyamides PA 66 MoS_2 and PA 66 – GF 30 vis a vis the polyamide PA 66, for example in the case of the constant cutting speed and depth machining and variable advance (Fig.3), it is of approximately 36% in the case of PA 66 GF30, respectively of 42% in the case of PA 66 MoS_2.

5. Conclusion

In the wake of the results obtained, the following conclusions can be drawn:

- in the case when one wants to obtain a superior quality of the machined surface, it is indicated to be utilized one of the additive polyamides, PA 66 GF 30 or PA 66 MoS_2,

this in the case when there are not imposed certain conditions from a mechanical point of view (situation in which the material cannot be changed);
- in the case when the quality of the obtained surface after the processing is not important, it is preferable to utilize the polyamide PA 66 – GF 30.

6. References

[1] Xuc Ping, ş.a., *Experimental study and evaluation methodology on hard surface integrity*. International Journal Advanced Manufacturing Technology, ODI 10.1007/s00170-006-0576-6;
[2] W.H Yang, ş.a., Design optimization of cutting parameters for turning operations based on Taguchi method. Journal of Materials Processing Technology, 84 (1998) 122-129;
[3] Ersan Aslan, Design of optimization of cutting parameters when turning hardened AISI 4140 steel (63HRC) with Al2O3+TiCN mixed ceramic tool. Materials and Design, date received 21.07.2005 and date accepted 06.01.2006;
[4] D.C. Montgometry, *Design and analysis of experiment*. 4th edition, New York: Wiley:1997;
[5] N. Nalbant, H. Gokkaya, G. Sur, *Application of Taguchi method in the optimization of cutting parameters for surface roughness in turning*. Materials and Design, date received 21.07.2005 and date accepted 06.01.2006;
[6] B Erginc, Z. Kampuŝ, B. Sustarsic, The use of Taguchi approach so determine the influence of injection – molding parameters on the properties of green parts. Journal of achievement in Materials and Manufacturing Engineering, 15, 2006;
[7] Catalog de produse, SC Ceproinv SA, Focşani
[8] C. Fetecău, ş.a.: *Prelucrarea mecanică a maselor plastice*. Editura Didactică şi Pedagogică, Bucureşti, 1999
[9] E. Jaksch: Materiale plastice poliamidice – Seria Polimeri. Editura Tehnică, Bucureşti, 1988.
[10] Ciocârdia, C., ş.a. – *Bazele cercetării experimentale în tehnologia construcţiilor de maşini.* Editura Didactică şi Pedagogică, Bucureşti, 1979.
[11] Craiu, V., ş.a. – *Elemente de statistică matematică cu aplicaţii*. Editura Mondo-Ec, Craiova, 1998.
[12] Ungureanu, I. – *Bazele cercetării experimentale*, Editura Universităţii din Piteşti, Piteşti, 2002.