

## COMPARATIVE RESULTS CONCERNING THE ROUGHNESS OBTAINED ON SURFACES CUT BY WHIRLING METHOD

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### 1. GENERAL CONSIDERATIONS

For controlling a complex manufacturing process as whirling thread-cutting, the influence of the cutting regime, respectively of the cutting speed  $v$  and of the feed rate per cutting tooth  $f_z$  upon the roughness obtained on the flank of the processed helical surface it is very important to be established and to be known, for different kind of mechanical parts with helical surfaces, as threaded shafts, cylindrical worms etc.

The two above-mentioned parameters of the cutting regime,  $v$  and  $f_z$ , are not independents, so that the study of their individual influence upon the surface roughness is not possible.

The bi-dimensional equations describing the dependence of the roughness parameter  $R_a$  by the cutting regime parameters imposed to be determined.

For determining such dependence equations, it was necessary to fix the other process parameters at certain values, which established the limits of the validity domain of the respective models.

### 2. EXPERIMENTAL CONDITIONS

The experimental samples reffered bellow have been realized on a whirling thread-cutting device installed on a normal lathe SNA 560x1000, in the Department of Machine Manufacturing Technologies from TU "Gh. Asachi" of Iasi.

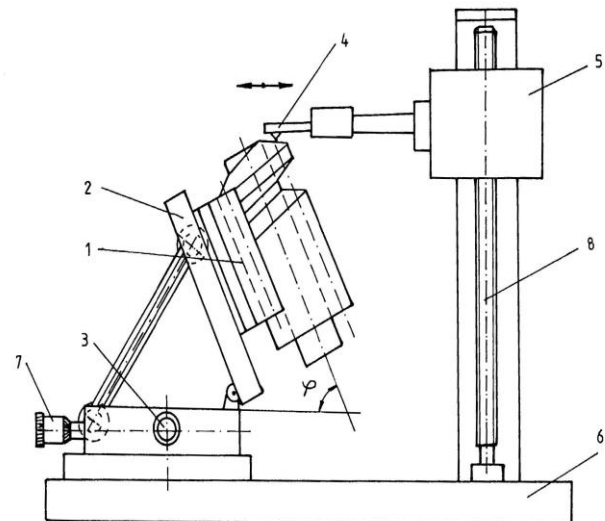
Gh. Crețu, Ph.D, [1], have developed experimental researches concerning the influence of the cutting regime's parameters upon the surface roughness on the flank of the cylindrical worms processed by whirling method.

The technological conditions of the experiments mentioned above were, as following:

- the number of rotations per minute for the whirling head,  $n_s$ : 614 rot/min; 878 rot/min; 1070 rot/min;
- the number of rotations per minute for the processed part,  $n_m$ : 2,4 rot/min; 3 rot/min; 3,76 rot/min; 4,74 rot/min; 6 rot/min; 7,52 rot/min;

- the diametrical coefficient of the processed worm,  $q$ : 11; 12;
- the module of the worm,  $m_x$ : 2; 3; 4,

For all the experimental samples, realized of OL60 and OLC45 steel, the roughness parameter  $R_a$  was measured with a SURTRONIC instrument produced by TAYLOR-HOBSON Co., following a measuring principle as it is shown in figure 1.



**Figure 1.** The schema for measuring the roughness parameter  $R_a$  on the flank of cylindrical worms [1]

V. Merticaru jr., Ph.D, [4], have developed similar experimental researches, but concerning the influence of the cutting regime's parameters upon the surface roughness on the flank of some external trapezoidal threads processed by whirling method.

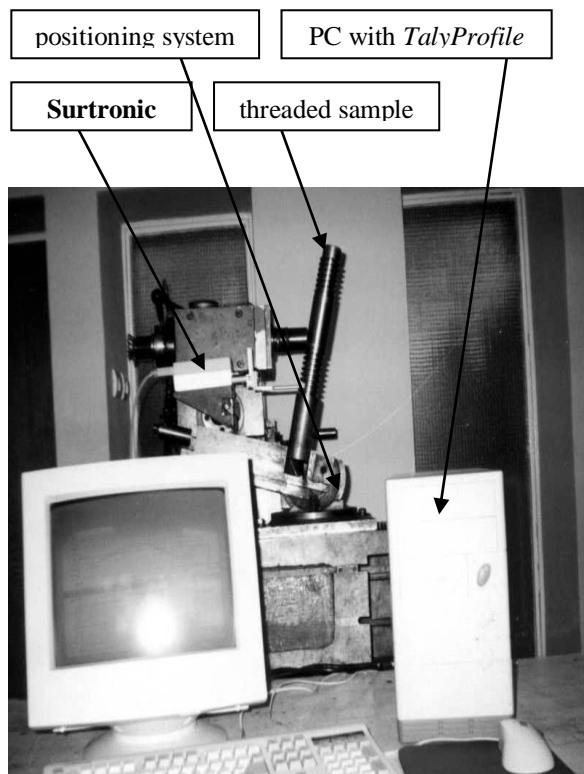
For these experiments, some of the process parameters were fixed at certain values, as following:

- the pitch of the processed trapezoidal external threads  $p=10$  mm;
- the major diameter of the processed threads  $d=48$  mm;
- the diametrical coefficient, respectively the ratio between the diameter of disposing the cutting teeth and the major diameter  $k_d=1.1$ .

In these stipulated conditions, the value of the cutting speed  $v$  was modified through the value of the number of rotations per minute for the whirling head  $n_c$  and the value of the feed rate per cutting tooth  $f_z$  was modified both through  $n_c$  and through the number of rotations per minute for the processed part,  $n_p$ .

These researches were developed following an experimental plan as it is presented in table 1, for each of the steel materials submitted to study, respectively: OL60, OLC45.

The applied measuring methodology is illustrated in figure 2. In this sense, the threaded sample was fixed into a positioning system consisting from an  $\alpha$ -vice, set on the plate of a milling machine FUS-22, existing in the Department of Machine Manufacturing Technology from the "Gh. Asachi" Technical University of Iasi.



**Figure 2.** Roughness measuring methodology, for trapezoidal threads – image from laboratory, [4]

For measuring, a *Surtronic 3+* instrument, produced by *Taylor-Hobson Co.*, was used and this apparatus was integrated with *TalyProfile* software, installed on a computer linked to the measuring instrument.

For allowing the access of the measuring pick-up, a groove was executed by milling on the threaded surface.

**Table 1.** Experimental plan for studying roughness on trapezoidal threads cut by whirling, [4]

Exp. no.	$n_c$ [rot/min]	$n_p$ [rot/min]	$v$ [m/min]	$f_z$ [mm/tooth]
1	614	2.4	111.5	0.15
2	878	2.4	159.4	0.10
3	1070	2.4	197.6	0.09
4	1241	2.4	229.2	0.07
5	614	3.76	111.5	0.23
6	878	3.76	159.4	0.16
7	1070	3.76	197.6	0.13
8	1241	3.76	229.2	0.11

### 3. EXPERIMENTAL RESULTS. CONCLUSIONS

*Gh. Crețu*, Ph.D, [1], have determined the mathematical dependencies of the roughness parameter  $R_a$  through the parameters  $m_x$ ,  $v_s$  and  $f_z$ , for the cylindrical worms processed by whirling, as it is shown in table 2.

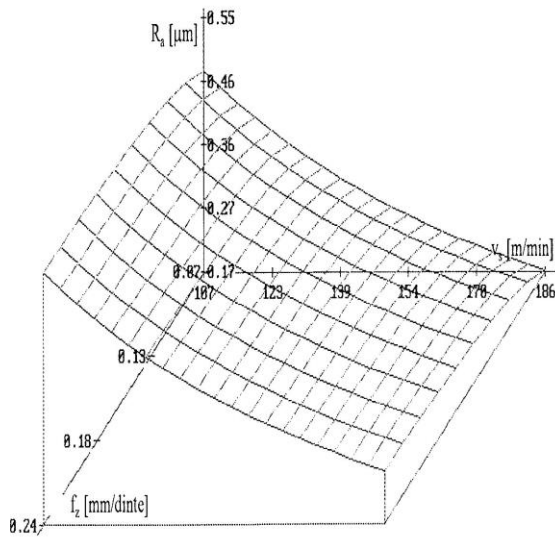
On the base of the measured and registered results, *Gh. Crețu*, Ph.D, [1], also have graphically represented the bi-dimensional dependencies of the roughness parameter  $R_a$  through the cutting regime's parameters  $v_s$  and  $f_z$ , as it is shown bellow in figure 3 for OL 60 steel and in figure 4 for OLC45 steel.

**Table 2.** Mathematical dependencies of the roughness parameter  $R_a$  through the parameters  $m_x$ ,  $v_s$  and  $f_z$ , for the cylindrical worms processed by whirling [1]

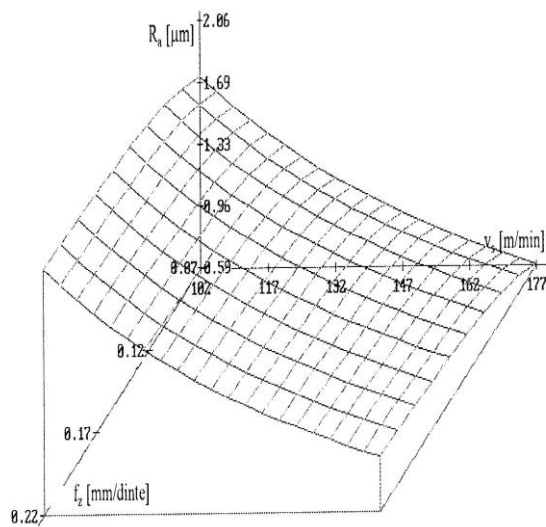
Sample's material	Mathematical dependencies of the roughness parameter $R_a$ through the parameters $m_x$ , $v_s$ and $f_z$
OL60	$R_a = -0,4323 + \frac{0,9276}{m_x} + \frac{75,6863}{v_s} - \frac{0,0079}{f_z} \quad [\mu m]$
OLC45	$R_a = 1,3029 - \frac{5,29}{m_x} + \frac{272,056}{v_s} - \frac{0,03366}{f_z} \quad [\mu m]$

**Table 3.** Mathematical dependencies  $R_a=R_a(f_z,v)$  [ $\mu\text{m}$ ], for trapezoidal external threads, [4]

Material	Regression function	$R^2$
OL60	$R_a = -0,5098 + 6,4714 \cdot f_z + 26,6636 \cdot f_z^2 - 2,4718 \cdot 10^{-3} \cdot v$	0,9984
OLC45	$R_a = 0,2080 + 13,1491 \cdot f_z - 0,0114 \cdot v - 3,7861 \cdot 10^{-5} \cdot v^2$	0,9960



**Figure 3.** Graphical representation of the dependency  $R_a=R_a(f_z,v)$ , for cylindrical worms, for OL60 steel, [1]



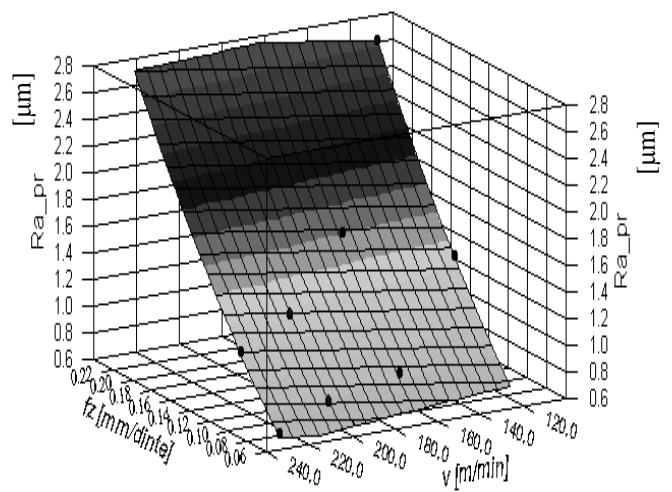
**Figure 4.** Graphical representation of the dependency  $R_a=R_a(f_z,v)$ , for cylindrical worms, for OLC45 steel, [1]

The obtained experimental results and their processing allowed to *Gh. Creţu*, Ph.D, [1], to formulate adequate conclusions and to establish that:

- the surface roughness decrease when the cutting speed increases;
- the feed rate per tooth and the module of the worm have a smaller influence upon the roughness values;
- the mathematical models  $R_a=R_a(f_z,v)$  are described by complex functions having polynomial expressions.

*V. Merticaru jr.*, Ph.D, [4], have processed the data obtained from experimental measurements, in computerized regime, using in this sense the informatic product DataFit 6.1.

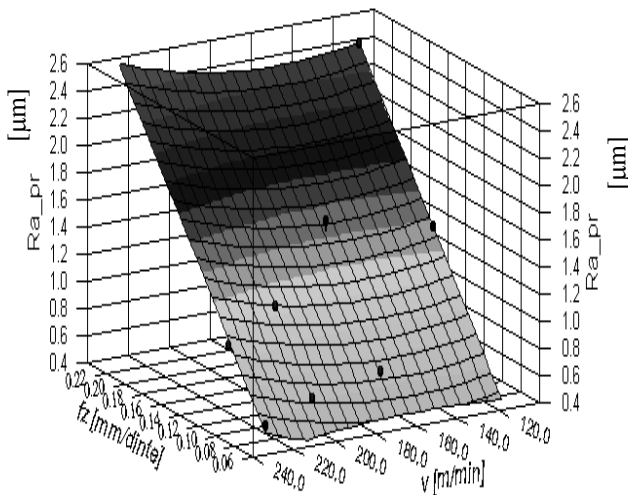
The regression functions found to approximate in the best way the dependence of the roughness parameter  $R_a$  on the cutting regime's parameters  $f_z$  and  $v$ , together with the corresponding values for the coefficient of multiple determination  $R^2$ , are presented in table 3.



**Figure 5.** Graphical representation of the dependency  $R_a=R_a(f_z,v)$ , for external trapezoidal threads, for OL60 steel, [4]

In figure 5 and figure 6, the graphical representations of the response surfaces for the models from table 3 are illustrated.

In these two figures, also the experimental points are represented on the diagrams, together with the distances from them to the response surfaces, for to visualize the models' errors in the considered points.



**Figure 6.** Graphical representation of the dependency  $R_a=R_a(f_z,v)$ , for external trapezoidal threads, for OLC45 steel, [4]

The results presented above allowed to formulate the following conclusions for the trapezoidal threads cut by whirling:

- when the cutting speed's value  $v$  increases, the value of the roughness parameter  $R_a$  slowly decreases;
- when the value  $f_z$  of the the feed rate per tooth increases, also the value of the roughness parameter  $R_a$  increases, the influence being bigger in this situation, comparative to the influence of the cutting speed;
- the mathematical models  $R_a=R_a(f_z,v)$  are described by complex functions having polynomial expresions.

#### 4. FINAL CONSIDERATIONS

As final conclusion, it can be remarked that the obtained values for the roughness parameter  $R_a$ , both for the cylindrical worms and for the external trapezoidal threads, are similar to the values of this parameter corresponding to grinding operations.

So, there result that whirling thread-cutting can be succesfully applied as final operation for processing such kind of helical surfaces.

The methodology of measuring the roughness parameter  $R_a$  presented in the paper can be used also for other types of helical surfaces generated by whirling thread-cutting.

The results of the paper are useful for the activities of repairing and machining the spare parts for the cam type pieces, which require to know the follower motion law.

#### References

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