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STUDY CONCERNING THE CUTTING PROCESS USING A WORM-HOB WITH INCREASED MESHING ANGLE

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Abstract: *The paper presents a comparison between the cutting process using a worm-hob with increased meshing angle and a conventional worm-hob. The paper describes some aspects related to the wearing of the worm-hob with increased meshing angle as compared to the conventional worm-hob, on the basis of the experimental research.*
Keywords*: worm-hob, increased meshing angle, gear-cutting, wearing*

1. THEORETICAL ASPECTS

It is known the fact that in case of radial backed-off worm-hobs, between the side relief angle α_1 and the top relief angle α_v after backing-off, there is the relation [2]:

$$tg\ \alpha_1 = tg\ \alpha_v \sin \alpha \qquad (1)$$

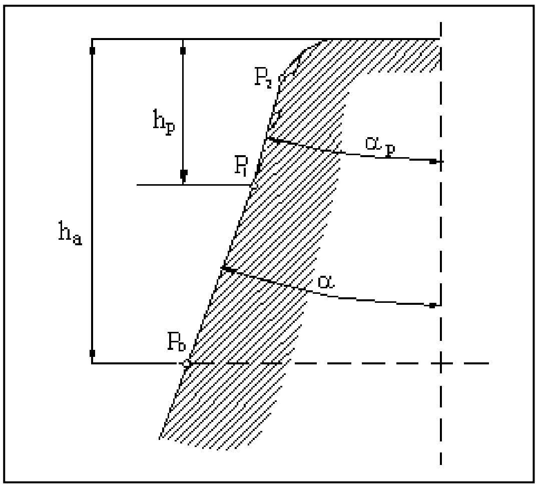

Fig.1. Profile of the basic rack for worm-hob with protuberance

Therefore, at the minimum values of the clearance angle α, the side relief angle may decrease under allowable limits that contribute to the wearing of the side flank of the teeth.

A particular case of this phenomenon is encountered on the addendum portion of the worm-hob with lipped backed-off teeth (fig.1). To be noticed that portion P_1P_2 of the profile angle of the tooth is much smaller than α. Therefore, on this portion also the side relief angle will be small.

2. ABOUT SOME ASPECTS REGARDING MILLING WITH INCREASED MESHING ANGLE WORM-HOB

Making a numerical analysis based on relation (1), it can be obtained the diagram of variation for the side relief angle α_l function with clearance angle α and clearance tip angle α_v, (fig.2), [1].

With the view to avoid the disturbing phenomenon of wearing on the addendum tooth portion of the tool, we propose gear-cutting with worm-hob with increased meshing angle.

This solution is based on the principle of generating involute-tooth gear with infinity of gear racks.

Considering the technological gearing

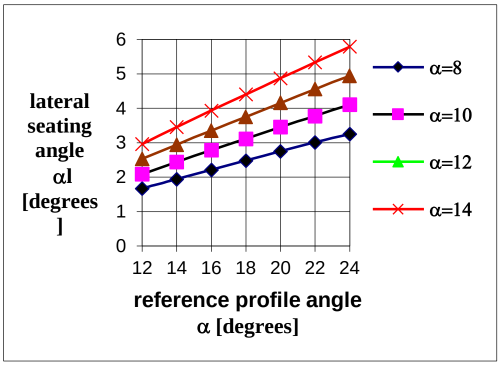

Fig.2 Diagram of variation for the side relief angle α_l

[1], made between generating gear rack materialized by the tool in its relative motion and the blank gear, (fig. 3) we can write:

$$R_b = R\cos\alpha = R_{ws}\cos\alpha_s \quad (2)$$

Where:

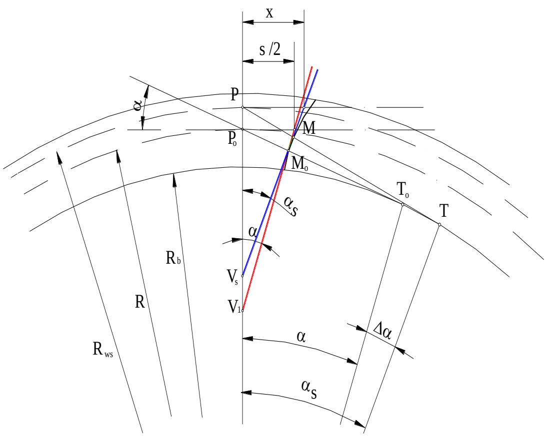

Fig.3 Gear-cutting with increased meshing angle worm-hob scheme

- R is pitch circle radius
- R_{ws} rolling circle radius
- α pressure pitch circle angle (meshing angle)
- α_s pressure tool angle

Basing on the annotation made in figure 3, we can write:

$$x = \frac{1}{\cos\alpha_s}\left(R_{ws}\sin\alpha_s - R\sin\alpha + \frac{s}{2}\cos\alpha - R_b\Delta\alpha\right) \quad (3)$$

where:

- R_b is base circle radius
- s is gear tooth thickness on pitch circle radius
- $\Delta\alpha = \alpha_s - \alpha$

In table 1 are synthetic presented semi thicknesses of gear tooth on rolling circle, in case that: $\alpha_s = 25^\circ$ and $\alpha_s = 30^\circ$. Basic circle with R_b radius is the same as for manufacturing with worm-hob with meshing angle at the value 20˚ as for manufacturing with increased meshing angle α_s.

Table 1. **Values for semi thicknesses of the tooth in case α_s= 25˚ and α_s = 30˚**

z (no. of teeth)	m	α	α_s	Δα	s	R_b	R	R_{ws}	x
30	4	20	25	0.087	π	56.38	60	62.20	4.21
30	4	20	30	0.174	π	56.38	60	65.10	5.971

3. RESEARCHES ABOUT WEARING OF THE WORM-HOB WITH INCREASED MESHING ANGLE

The experimental researches made, put in the light the advantage that it has the worm-hob with the increased meshing angle as compared with the conventional worm-hob (with meshing angle at 20˚) concerning wearing of the tool.

These experimental researches consisted of processing 12 spur gears, with the next characteristics:

Normal modulus: m = 4 mm;
Tooth width: b = 40 mm;
Meshing angle: α = 25˚;
Number of teeth: z = 30;
Material: OLC45.

The spur gears were manufactured on a FD-630 gear-cutting machine. It has been considered two worm-hobs: first with increased meshing angle and protuberance, and second a conventional worm-hob with same modulus, same meshing angle at 20˚.

The gear-cutting was made in climb milling. The cutting conditions parameters were set on:

- t equal with depth of the processing gear
- feed per revolution, s_a = 2mm/rot
- cutting speed v = 40/min

After that every spur gear is finish processed, it is measured, with the help of a microscope, the wearing parameters of the worm-hob. Parameters values that characterize the wearing of worm-hob teeth on lateral side flanks are described on table 2.

Table 2 **The values that characterize wearing of worm-hob tooth on lateral side flanks**

Type of worm-hob used	**Wearing on lateral side flank, B_f [μm]**				**Wearing on back tip tooth, B_s [μm]**			
Worm-hob with increased meshing angle at 25˚	6	9	13	19	17	19	23	28
Conventional worm-hob	10	14	17	22	20	24	29	32

In figures 4 and 5 are presented the evolution of wearing of the worm-hob with increased meshing angle as compared with conventional worm-hob. The strategy above presented was repeated for all the spur gears cut-off with the two worm-hobs.

Measurement of the parameters that characterized the surface and length wearing of the spur-gear tooth on the lateral clearance areas was done on BK70x50 microscope from CARL ZEISS JENA Company.

The measurements were referred at worm hob tooth that machines the central gap of spur gear.

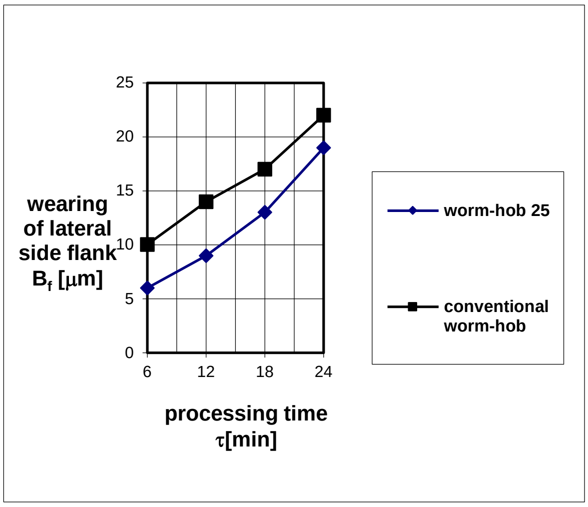

Fig.4. Evolution of worm-hobs wearing on lateral side flank

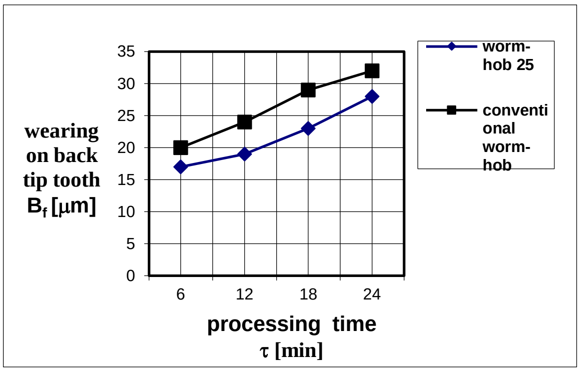

Fig.5. Evolution of wearing on back tip tooth at worm-hobs

4. CONCLUSIONS

It can be remarked a pronounced tendency of wearing for a worm-hob with α_0 = 20˚ as compared with a worm-hob that has increased meshing angle. When was processing first spur gear was determined the value of its wearing B_s, recorded on the back of the tooth, at 17 μm in case of worm-hob with meshing angle at 25˚, and 20 μm for conventional worm-hob. On lateral side flanks were determined B_f values at 6μm for worm hob with increased meshing angle and 10 μm for conventional worm-hob.

That is explained by the enlargement of lateral clearance angles same time with the increase of meshing angle and therefore the decrease of friction with processing gear in case of conventional worm-hob, relatively to worm-hob with increased meshing angle.

The worm-hob with increased meshing angle wear both on the side face and on the tip of the tooth, can have a longer durability than the conventional worm-hob.

The presence of the protuberance in the case of worm-hob with increased meshing angle, are intended to increase the strength of the tool tip to the applicant during machining, and on the other hand the size of the geometry, when the addition of material to the base at finishing processing (grinding, hardening) there is no need to patronize the tools with care is compared to finishing for removal by the addition of processing.

5. FURTHER RESEARCH

Future research will focus on:

- determination of cutting forces in case of worm-hob with increased meshing angle and conventional worm-hob;
- determination of the variation of cutting forces during machining and their influence on vibrations for worm-hob with increased meshing angle;
- determining the optimal variant of worm-hob with increased meshing angle for different materials.

6. REFERENCES

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Studiu privind aşchierea cu freză - melc cu unghi de angrenare majorat

Rezumat: Lucrarea prezintă o comparaţie între aşchierea cu freză-melc cu unghi de angrenare majorat şi aşchierea cu freză-melc convenţională. Se prezintă aspectele legate de uzura frezei-melc cu unghi de angrenare majorat în comparaţie cu uzura frezei-melc convenţionale pe baza unor cercetări experimentale.

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