PRINCIPLES OF CUTTING-WHEEL TOOTHING

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***Abstract**: the paper discusses the way in which cylindrical gear-wheels are being produced as shown in figures 1,2 and 3;*

- *the principle of cylindrical gear-wheels mortising using the cutting-wheel tool;*
- *the rolling kinematic chain (A,B) of gear-wheel mortising machines;*
- *the kinematic scheme of gear wheel mortising machine;*

Subsequent to the analysis of the application areas of cylindrical gear wheels, the way cutting-wheels are being made is being discussed (see fig. 4 and 5);

- *the cutting-wheel tool and the equivalent variable wheel;*
- *the cutting-wheel fabrication process using the gear-hob;*

The paper introduces new terms into this area of research, terms representing the contribution of the author.

***Keywords**: cutting-wheel; mortising, toothing, apparent profile, bi-conical sharpening.*

1. GENERAL ISSUES

The cutting-wheel is the widest used tool for various types of gear wheel processing. This aspect is easily noticeable from a quick scanning of the application areas: internal, straight and inclined toothing processing, multiple stage wheel toothing, gear wheel blocks and collar wheels, v-shape gear wheel processing with or without longitudinal channel between the branches, precision rack toothing using the generative method, processing of toothed sectors, roughing of toothing for shave cutter processing, hob and thread rolling processing.

Gear wheel mortising eliminates the time used by the technological advance (longitudinal) as well as the time required by the tool to penetrate into the half-finished material – in case of spiral toothing or of gear wheels with elevated number of teeth – having a positive influence upon productivity and cutback.

Due to various usages of cylindrical gear wheels toothing using the cutting-wheel, this tool will continue to be one of the most important tools within a certain category of gear wheels processing.

Therefore the precision of fabricated gear wheels depends not only on the quality of the machine tool, on the precision of the half-made material or of its fixing to the machine but mainly on the precision of the tool itself and of the employed cutting mode.

Upon the processing of wheel-cutter, the evolvent of processed toothing profiles, obtained in a multiangular shape, is the result of the cutting edge's transition over the tool-piece contact area. Unlike the rolling milling process [4] in the case of mortising toothing process, the number of sides of the polygon reeling the profile within the evolvent increases with the number of double strokes acting upon one tooth. The evolvent achieved as a result of this procedure may be considered as correct from a practical perspective.

The mortising of cylindrical gear wheels by use of the cutting-wheel is a procedure of continuous rolling [1], [7] between the half-finished material and the imaginary generative gear wheel materialized by the tool, a way in which a gear is being formed; this gear abides by the well-known relation:

$$i = \frac{\omega_0}{\omega_1} = \frac{Z_1}{Z_0} = \frac{n_0}{n_1} \quad (1.1.)$$

Of which:

i - is the transfer proportion (transmission)

ω_0, ω_1 - the angular speeds of generative gear wheels and of the gear wheel (the piece)

z_0, z_1, – number of generative and processed gear wheels' teeth;

n_0, n_1, – generative gear wheel revolution during processing and half-finished material revolution.

It is to be noticed that: $\omega_0 \equiv \omega_s$; $Z_0 \equiv Z_s$; $n_0 \equiv n_s$;

Of which

ω_s – is the angular speed of the tool;

Z_s– the tool's number of teeth;

n_s– the tool's revolution.

The evolvent toothing has the advantage that it generates a gearing process without disturbing the rolling conditions [2], [3] even though the modification of the width between centres is based on the cutting-wheel's profile variable scrolling; this is underlined by the fact that the generated evolvent is always constant. The basic circle of generated toothing remains the same.

The principle of gear wheels mortising (fig.1 [6]) is based on the rolling of the two gear wheels during the gearing process with no free running; of these two one is the imaginary generative wheel materialized by the tool while the other is the half-finished material.

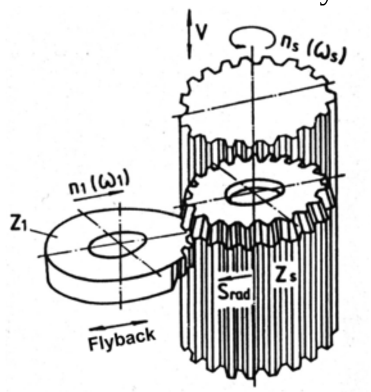

Fig.1. Cylindrical gear wheels' mortising principle using the cutting-wheel

The kinematic rolling chain of toothing machines that use the cutting-wheel tool must conform to the condition set up by the (1.1) relation resulting from the scheme in fig.2 and the kinematic scheme of the machine in fig.3. [2], [5], [7].

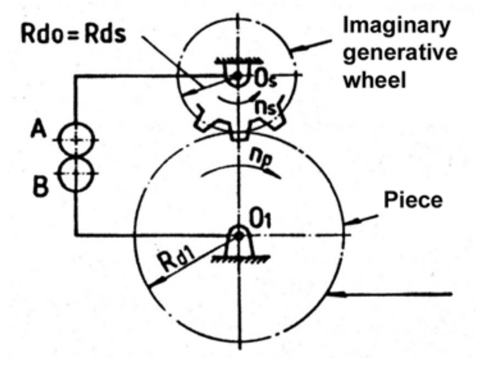

Fig. 2. Kinematic rolling chain of wheel gears mortising machines.

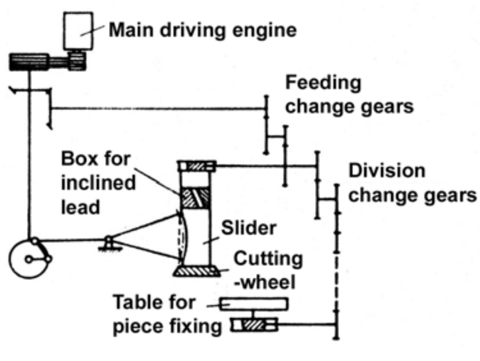

Fig. 3. Kinematic scheme of the gear wheel mortising machine with cutting-wheel.

From the analysis of figure 2, we notice that in order to achieve an elevated precision of processed toothing, besides the general conditions enlisted above, it is necessary to achieve rolling without sliding and to ensure the high precision of the generative imaginary wheel materialized by the tool (by maintaining a certain precision of the cutting tool); the regulation the width between the centres of the half-finished material and the generative imaginary gear wheel according to the momentary parameters of the latter and based on the re-sharpening state of the cutting-wheel considered as consisting of an infinity of cylindrical gear wheels of different debugging; the exact compliance with the tool’s re-sharpening technology; the guarantee of an optimal cutting mode and proper cutting medium (liquid); the recurrent control of the toothing machine, a precursory processing of the half-finished material and its appropriate fixing (positioning and fixing), a strict control of the precision of processed wheels.

Of course, to these special conditions the respect of general cutting laws is to be added. While trying to find the appropriate cutting speed and feed, Taylor has established a number of 12 variables: the quality of processed materials; the material and the thermal treatment of the tool (to which the surface treatment of the tool may be added); the cutting depth; the thickness and the shape of the chip; the cutting liquid, the geometry of the tool; the profile of the tool’s edge; the endurance of tool; the stiffness of both the piece and the tool; the diameter of the half-finished material; the cutting force at various speeds; the feed power [5].

2. CONTRIBUTIONS TO THE PRODUCTION OF THE CUTTING-WHEEL

The cutting-wheel has to be produced in such a way to:

1. guarantee on each part of its cutting edge the geometrical parameters required by the cutting process: the placement angle and the disengagement angle;
2. materialize, while in motion, the generative imaginary gear wheel, with the profile that has been imposed to it, fig.4;
3. after re-sharpening, the processed profile of the half-finished material remains the same.

The first condition is met by adapting a placement angle vis-à-vis the tangent to the current point trajectory; this is considered a disengagement angle (positive) adapted according to the tangent’s perpendicular on the trajectory; consequently, at the intersection of the placement and disengagement surfaces emerges the current point of the cutting edge within the lateral surface of the disengagement facets’ cone.

The second condition is met when the profile made by the cutting edges of the cutting-wheel in a normal section upon its axis (identical with the axis of the generative imaginary wheel), namely the apparent profile (the term was adopted as a generalization of the term “apparent edge” used for lath cutters) of the cutting-wheel, coincides with the evolvent profile prescribed for the generative imaginary wheel, fig.4, [5].

Certainly, introducing the notion of apparent profile requires that the deviations introduced by the geometrical parameters to be considered as in the case of each profiled tool.

The third condition is met if, taking into consideration the fact that by re-sharpening the disengagement facet the diameter of the cutting-wheel decreases, the apparent profile of the successive sections obtained through re-sharpening is made of evolving profiles (other evolvent parts) meaning that the cutting-wheel has to consist of an infinity of gear wheels of different debugging, of course based on the processing of half-finished material’s teeth, the with between centres of the debugged, generative, imaginary and processed gear wheel is calculated as follows:

$$A_{1_s} = A_0 + (\xi_1 + \xi_s) \cdot m \qquad [mm], \qquad (1.2.)$$

Of which:

A_0 – is the width between centres of the generative, imaginary and processed wheel, both un-bugged;

$\xi_{1,s}$ – profile scrolling coefficients (of the processed wheel and in the section where the tool re-sharpening has arrived)

m – the module.

The last condition is actually met by the method used at processing the toothing of the cutting-wheel using a gear hob, figure 5, [7].

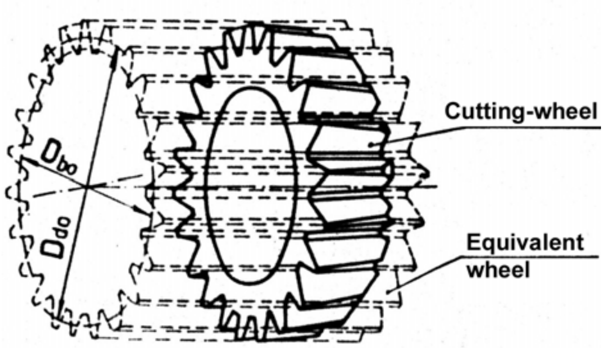

Fig.4. Cutting-wheel tool and the variable equivalent wheel.

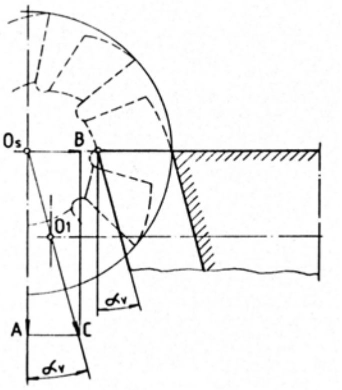

Fig.5. The fabrication procedure of the cutting-wheel using a gear hob – module.

As stated in the second condition upon establishing the apparent profile of the cutting-wheel the (1.2.), [2] relation needs to be respected:

$$\mathrm{tg}\alpha_s = \mathrm{tg}\alpha_{d_1} / 1 - \mathrm{tg}\alpha_v \cdot \mathrm{tg}\gamma_v \qquad (1.2.)$$

Of which :

α_s - is the angle of the tool's profile in apparent section;

α_{d_1} – engagement angle upon the division diameter of processed gear wheel;

The relation 1.2 is set in the specialized literature for the basic rack-type cutter for toothing. Analogically, the relation may be achieved for the cutting-wheel as well if instead of the processed gear wheel its defining gear rack is being considered.

As a consequence of the fact that in each position of the gear wheel's apparent profile generated by re-sharpening an "equivalent gear wheel" of a differently debugged cutting-wheel is achieved, we will introduce the notion of "equivalent variable gear wheel" [2].

Through STAS 6655-67 the following value are being set:

The same values are also adopted in foreign standards, a geometry that was unmodified until nowadays for the production of these tools.

3. CONCLUSIONS

This paper presents the process of cylindrical gear wheel's mortising by means of the cutting-wheel as well as other new elements.

The conical surface of the cutting-wheel is a result of the sharpening of the disengagement facet, here named as "the cone of the disengagement facets", with the angle of the cone generator (90°-γ_v).

In this paper the research was focused on the "Bi-conical sharpening (multi-conical)" as well as on various (γ_v) angles for various tool wear and tear stages.

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