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A SOFTWARE PROGRAMME FOR TOOTH PROFILING OF WORM HOBS FOR CUTTING GEAR PUMP COGWHEELS

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Abstract: *The tooth profiling in normal section of teeth for cutting cogwheels for gear pumps with involute profile is described. Due to the small number of cogwheel teeth, their profile could be realized with a change of the shape of the worm hob's tooth head. A new original decision of dimensioning of the hob's tooth is offered. It helps to control the cogwheel's tooth profile and the right mesh of the tooth pair. The main problems, connected with profiling and control of solutions obtained, are represented in a software program. With some transformations, this program could be used for profiling of worm hobs for other cogwheels as well.*

Key words*: thread milling tool, profiling, cogwheel, software system.*

1. INTRODUCTION

Cylindrical involute cogwheels are some of the most popular details in industry. They have been used in different types of constructions, machines, tools and equipment.

The problem of cylindrical cogwheels used in hydraulic gear pumps is especially pressing. They differ from "classical" cogwheels considerably. The correct profile of the involute cogwheel depends on the tool used for machining (usually it is a worm hob).

2. PRECONDITIONS AND RESOURCES FOR SOLVING THIS PROBLEM

The geometric parameters of cylindrical evolving involute cogwheels of a gear pump are determined on the basis of the initial cog crest parameters [1]. The special feature, which differentiates those cogwheels, is that they have a small number of teeth, i.e. for a gear pump they will be 12.

The main parameters of the worm hob tooth profile are determined in a similar way using the parameters of the initial tool crest.

The parameters for initial cog and tool crests are the same and are recommended for uncorrected cogwheels and the gear-cutting tools appropriate for them.

The geometric parameters of hydraulic gear pump cogwheels assume a different shape for the profile of the initial tool crest.

The small number of teeth is the reason for the large cut in the base of the tooth by the worm hob. That calls for a check up for the right meshing of the two cogwheels of the pump.

In order to observe the requirements for cogwheels, connected with their shape and measurements, it is necessary that the geometric presentation of the initial tool contour of the crest be modified (Fig. 1).

Marked out in such a way, the initial crest allows to:

a) Measure the worm hob tooth profile in a normal section.

b) Use the parameters, given in Fig.1 for making the exploitation control.

In addition, the following parameters have been added – vertical axis line, which divides the width of the tooth into halves, horizontal shift of the center of rounding of the tooth apex – Δ, vertical shift of the center of rounding of the tooth apex – h_ρ. Those parameters, together with the standard ones, make it possible to develop a software system for their rational determination, depending on the form and parameters of the cogwheel.

In the present paper is offered an original software system for geometric profiling of the worm hob teeth in normal section for cutting hydraulic gear pump cogwheels based on the authors' research [1, 2, 3].

2.1. Preconditions for the development of a software system

The line diagram of the main software systems is developed, using the following moments:

a) Entering parameters necessary for the cut cogwheel and the gear transmission.

b) Determining the involute profile of the cogwheel.

c) Determining the parameters for the worm hob teeth in normal section.

d) Calculating the parameters of the transition curve obtained from the worm hob, in the base of the cogwheel tooth.

e) Comparing the trajectory of the tip of the associated wheel with the transition curve in the base of the wheel.

f) Changing parameters of the worm hob tooth on the understanding that there is no optimal mesh of the two wheels from the gear transmission.

2.1.1. Entering the parameters for the cut cogwheel and the gear transmission

In order to create software programs with the appropriate accuracy and thoroughness, it is necessary to enter the main parameters of the cut cogwheel, and the cogwheel associated with it, as well as their gear transmis-

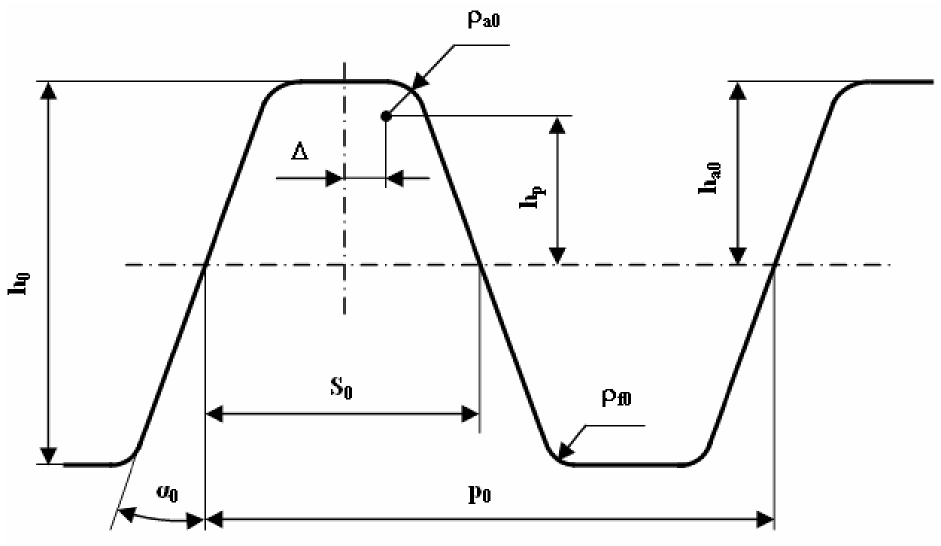

Fig.1. Profile of the hob's teeth for cogwheels III.

Table 1

Main parameters of the cut cogwheel, the cogwheel associated with it and their gear transmission

Name of parameter	Symbol	Value		
		I	II	III
Gear module	m	2.54	3.5	0.75
Profile angle of the teeth	α^0	20	20	20
Center-line distance	a_w	31.43	42.3	14.65
Shifting coefficient of the initial contour	x_1	0.161	0.015	0.300
Number of teeth	z_1	12	12	19
External diameter	d_{a1}	37.359	50.552	16.05
Internal diameter	d_{f1}	24.62	32.798	12.75
Initial diameter	d_{w1}	31.43	42.3	14.65
Dividing diameter	d_1	30.48	42.00	14.25
Diameter of the initial involute mesh	d_{P1}	28.705	–	13.73
Diameter of the border involute point	d_{L1}	–	–	13.51
Length of the common normal	W_1	11.904	16.062	5.889
Number of teeth included	z_{w1}	2	2	3
Note: Both cogwheels have the same number of teeth and parameters.				

sion (Table 1). Using those parameters, additional computations will be made in the programs that follow.

Often the operational gear wheel drawing does not show in the tables the diameters of the initial involute mesh (d_{P1}) with the border point of the involute curve (d_{L1}). They have to be calculated and entered into the entry page of the software program. It must be noted that they may not have values for certain gear wheel parameters because it is cut at the base of the tooth.

2.1.2. Determining the involute profile of the cogwheel

The involute profile of the cogwheel is determined by well known methods. described in the specialized literature. To realize all other programs it is advisable to use the outcomes of the paper [4]. They could be used further without extra transformations. which is convenient. Usually for starting point of the involute line of the hydraulic pump cogwheel is selected the diameter of the initial involute mesh. The reason is that the number of teeth is smaller than 17.

2.1.3. Determining the worm hob tooth parameters in normal section

The main worm hob tooth parameters in normal section and their measurements have been determined by well known methods from specialized technical literature [8]. In addition. the horizontal shift of the rounding center of the tooth point Δ and the vertical shift of the center of rounding of the tooth apex – h_ρ have been determined as follows (Fig.1):

$$\Delta = \frac{S_0}{2} - \left(h_{a0} - \rho_{a0}\right)\cdot \tan\alpha_0 - \frac{\rho_{a0}}{\cos\alpha_0}; \qquad (1)$$
$$h_P = h_{a0} - \rho_{a0}\,.$$

These parameters are necessary to calculate the path of the transmission curve. formed by the head of the worm hob tooth.

2.1.4. Calculating the paths' parameters. formed by the hob and opposite wheel in the base of the cut wheel tooth

Using calculated parameters of the worm hob in normal section. a transition curve is defined. which is made by the cutting edges of the worm hob teeth in the base of the cut cogwheel tooth [2].

The rounding radius ρ_{a0} and its characterizing parameters – Δ and h_P have crucial influence. The encircling line of the lines from the rounding points is an elongated involute.

On cutting cogwheels using worm hobs. the transition curves in the base of their teeth are obtained from points of rounding through the top and side cutting edges of the teeth (Fig.2).

Each of the rounding points is drawing an elongated involute. which parametric equations are (2):

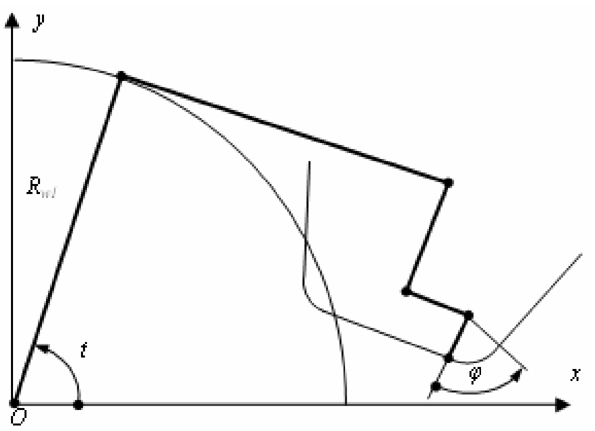

Fig. 2. Calculating scheme for determination of the transition curve in the base of cogwheels teeth.

$$x_i = R_{w1}.\cos t + R_{w1}.t.\sin t - h_\rho.\cos t + \Delta.\sin t - \rho_{a0}.\cos(\varphi_i + t) \quad (2)$$
$$y_i = R_{w1}.\sin t - R_{w1}.t.\cos t - h_\rho.\sin t - \Delta.\cos t - \rho_{a0}.\sin(\varphi_i + t).$$

where h_ρ is the distance from the centroidal line to the center of the rounding;

Δ – distance from the middle of the tooth to the center of the rounding;

ρ_{a0} – rounding radius;

t – angle of going round;

φ_i – angle. characterizing the i-th point from the rounding.

The encircling line of family elongated involutes. described from the rounding points of the cutting edge. will be an elongated involute too. In order to determine encircling line equations. the following system (3) have to be solved:

$$\begin{cases} x = f_1(t,\varphi) \\ y = f_2(t,\varphi) \\ \begin{vmatrix} \dfrac{\partial f_1}{\partial t} & \dfrac{\partial f_2}{\partial t} \\ \dfrac{\partial f_1}{\partial \varphi} & \dfrac{\partial f_2}{\partial \varphi} \end{vmatrix} = 0 \end{cases} . \quad (3)$$

In the same coordinating system. where the transition curve made by the worm hob is built. the trajectory of the top of the other wheel from the gearing pair. which is a lengthened cycloid. is also built [2].

Using graphic-analytic profiling. part of the results obtained is shown on Fig. 4. The drawing illustrates the involute profile of the cogwheel; the transition curve EIC (elongated involute curve). which is drawn by the edges of the cogwheel teeth; the trajectory of the top EEC (elongated epicycloids) of the associated cogwheel; the location of the two lines in relation to each to other.

3. RESULTS

On the basis of the theoretical development. described in 2. a software program for tooth profiling of a worm hob for cutting cylindrical involute cogwheels for gear pumps has been designed. The parameters of the teeth in normal section have been checked as well. Using graphic-analytic profiling the possibility for the right mesh of the gearing pair has been established – “cut cogwheel – associated wheel”.

The operation of the program has been tested by cogwheels of gear pumps of Caproni JSC. whose parameters are given in Table 1.

The dimensions of the hob tooth profile in normal section are given in Table2, Figs. 1 and 3.

Table 2

Dimensions of the hob tooth profile in normal section

Parameters name	Symbol	Value		
		I	II	III
Module	m_0	2.54	3.5	0.75
Profile Angle	α^0	20		20
Tooth height	h_0	6.35	8.75	2.10
Height of the tooth head to the initial line	h_{a0}	2.89	4.60	0.75
Step on the initial line	p_0	7.979	10.995	2.356
Thickness on the initial line	S_0	3.656	5.438	1.062
Rounding radius at the top	ρ_{a0}	1.10	1.50	0.2
Shift of the axes of the radius	Δ	0	0	0.118
Vertical shift of the radius	h_P	1.79	3.10	0.95
Rounding radius at the base	ρ_{f0}	0.75	1.00	0.25

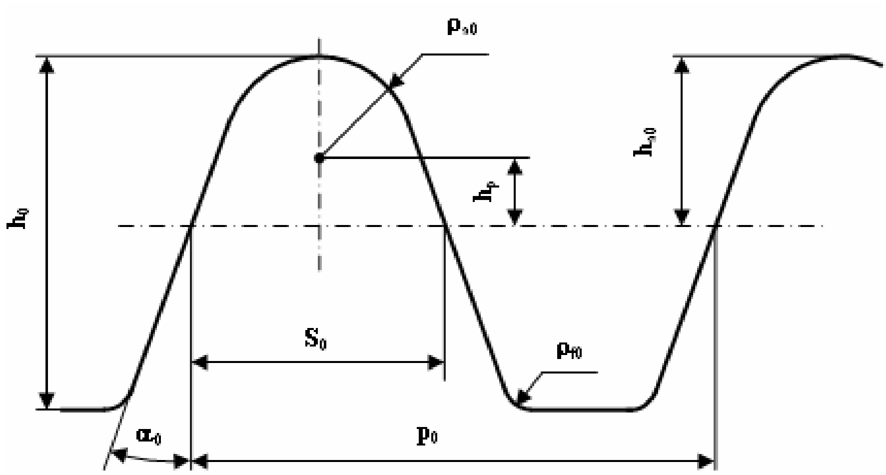

Fig. 3. Profile of the hob teeth for cogwheels I and II.

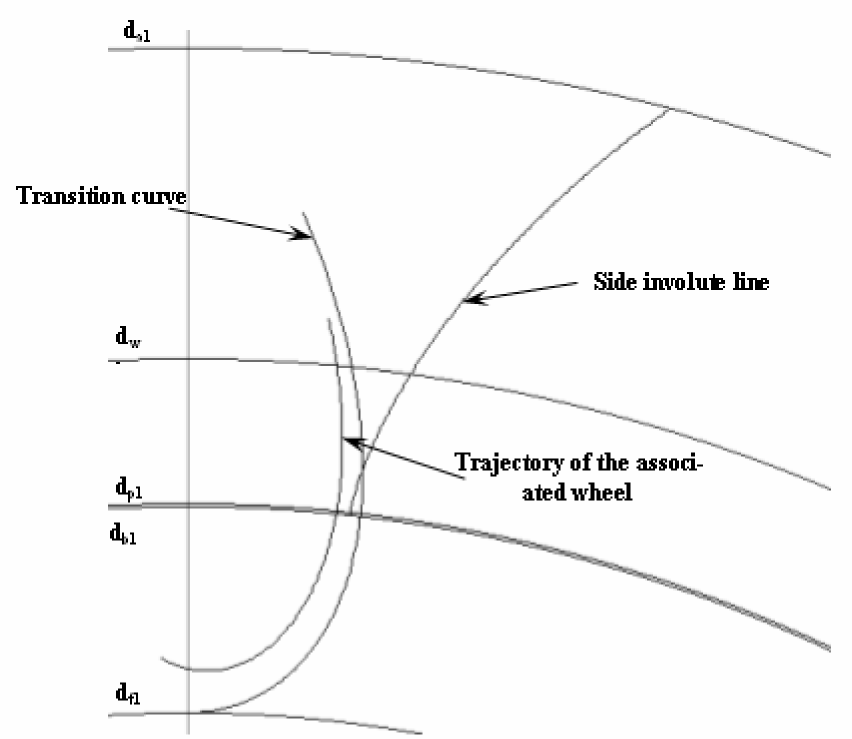

Fig. 4. Cut wheel profile.

4. CONCLUSIONS

The software program developed by the authors and the results received lead to the following recommendations and conclusions:

1. The system developed gives parameters of the worm hob teeth in normal section for cutting cogwheels for gear pumps.
2. The software program could be successfully used for tooth profiling of worm hobs which will process cylindrical cogwheels with various profiles.
3. Different parts of the software program could be used for solving other similar problems. such as exploitation control of worm hobs.

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