

## DESIGNING OF SMOOTHER HOB

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It is important to know the main characteristics of production geometry of the hob for the precise and appropriate quality production, since the various cog wheels, worm gears are produced with this tool. The hobs have complicated geometry and are expensive tools so the production is very expensive.

**Keywords:** module, hob, production geometry

### Introduction

If we give expanded one direction, turning motion for the indented bar shape tool without alternation, plane or chisel motion such we imagine the suitable lengthly indented bar of spreading out of the diameter along wide sloping thread line to spring to a cylinder surface (in production) and the threads defined, equal distance breaking, we create hob edges then the hob creates.

In this article the property, geometry of the hobs and production with this tools is introduced. We work with planning of the hob for which we prepared a program.

### Characteristics of hobs

For the smoother production of the worm gear a tool is only used, the tiller surface of which is equal to the worm (*Fig. 1*). With suitable kinematical motion this is called direct motion mapping.



Figure 1: Geometrical shaping of hob

The advantage of the solution: there is no division from cog to cog, so work is without interruption [1]. The kinematical track of the tool creates the cog profile. During relative motion the side edges of the hobs cover the cog profile.

In production with hob the tool and the workpiece turn such the pitch circle of the workpiece has to turn with cog pitch arch, which multiplied by thread number of the hob, while the hob does one turning.

The correct production technology has three preconditions:

1. The geometry and dimensions of the hob without head leak and cog leak have to be equal to the geometry and dimensions of the worm gear connection with worm considering the possibility of the resharpening.
2. The production centre distance has to be equal strictly with the centre distance of the worm gear box in tangential method. The cogs of the worm has to be thinned for the assurance of necessary cog leak which compensates the forming capacity changing because of working temperature. The cog thickness of the worm in the reference cylinder is:

$$s_0 = \frac{m \cdot \pi}{2} - j_{ax} \quad (1)$$

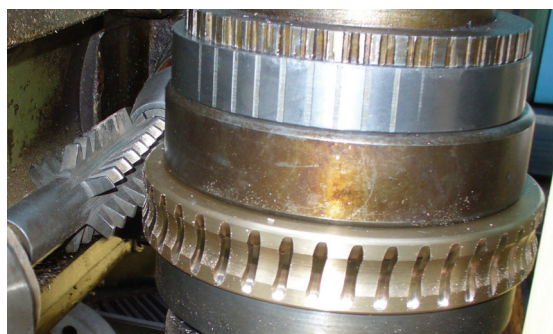


Figure 2: Cogging with hob

- The symmetry plane of the hob has to equal with the symmetry plane of the worm gear.

The strict observation of the lately two requirement is indispensably important in assembly. There are five characteristics of the hobs:

- $d_{os}$  – the reference cylinder diameter of the tool;
- $m_{ax}$  – axial module;
- $\alpha_{on}$  – normal basic profile angle;
- $z_{cs}$  – number of teeth;
- the geometry of the surface.

During the repeated application the tip circle diameter of the hob reduces (we can increase with 5%) because of the after grinding, but the face width of the hob reduces with this because of the backward turning, that is why the face width of the worm gear increases and the reduction of the backlash [3]. Because of the resharping the hob has to be produced with greater diameter and two backward turning. During production the resharpened hob is configured with correction.

*Radial milling*

It is very productive method, but employed till only 8° sloping angle and the quality surface is not sufficient. During production the centre distance is continuously changing (Fig. 3).

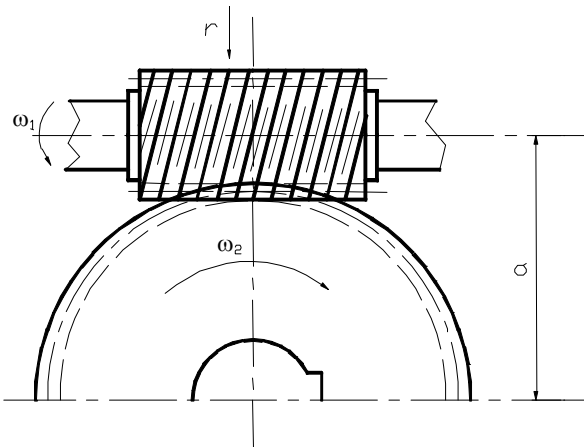


Figure 3: Radial milling

*Tangential milling*

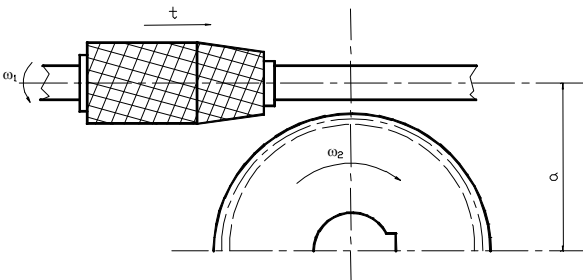


Figure 4: Tangential milling

It is employed with only machine with slide head or universal milling head, if it has differential tool. The hob has the part of 10° starting cone. If we just only smooth with tangential milling then the conical hob is suitable. This method is less productive but results geometrical correct cog surface (with under cutting avoidance) and much better quality surface (Fig. 4).

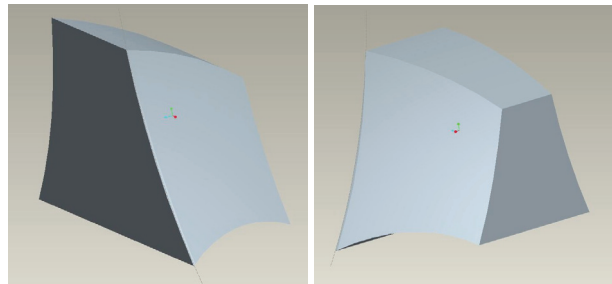
*Combine milling*

We dress with radial method and smooth with tangential method. We give only several tenth mm for smoothing. It is the best worm gear milling methods.

**Surfaces, edges of the hob**

In production geometry the beater knife is knowing for one cog of the hob so the production surfaces can be written down in equal function.

Fig. 5 shows a cog of the hob, prepared by pro engineer software.



a) Head surface view      b) Back surface view

Figure 5: One cog of the hob

In the practical realization of production of the hob and the beater knife, the deviation is only in the motion area.

The most important limiter surfaces of the cog on Fig. 6:

- $H$  – face surface;
- $R_B, R_J$  – back surfaces (left and right)
- $F_h$  – back surface of head ribbon
- $H'$  – face surface (after sharpening)
- $F$  – head ribbon

The most important limiter cog edges on Fig. 6:  $V_B$  – left side edge as intersection of B tooth and H face surfaces;  
 $V_J$  – right side edge as intersection of J tooth and H face surfaces;  
 $V_F$  – addendum edge as intersection of F head ribbon and H face surfaces.

When forming the  $R_B$  and  $R_J$  back surfaces, besides the effect of the chipping process we have to consider mainly the effect of the resharping of the tool (the ensurance of profile accuracy) [1]. Since the hobs have complicated geometry and are expensive tools, it is

important to ensure that the tool could be resharpened several times when we elaborate the geometry of the tool.

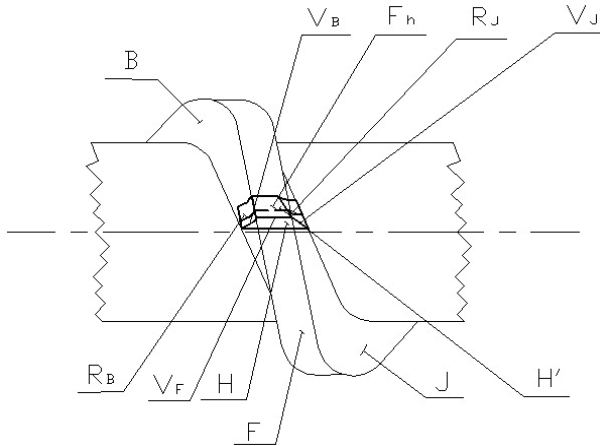


Figure 6: The surface elements of the hob

### Classification of cylindrical hobs

We can divide the cylindrical hobs for two groups:

- Dressing hobs: the number of teeth is equal to the number of the teeth of the worm.
- Smoother hobs: we can use the final production period of the worm gear, when we produce the cogs of the gear by the prescribed dimensions and tolerances.

### The geometry of the hobs

Fig. 7 shows the worm slopping on the reference cylinder.

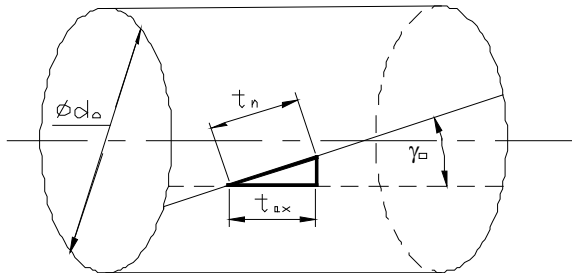


Figure 7: The worm slopping on the reference cylinder

Based on this figure we can write these correlations:

$$t_{ax} = \frac{t_n}{\cos \gamma_0} \quad (2)$$

$$\sin \gamma_0 = \frac{m_n}{d_0} \quad (3)$$

$$m_{ax} = \frac{m_n}{\cos \gamma_0} \quad (4)$$

$$t_n = m_n \cdot \pi \quad (5)$$

$$H_s = z_s \cdot t_{ax} = z_s \cdot m_{ax} \cdot \pi \quad (6)$$

where:

- $t_{ax}$  – axial section pitch;
- $t_n$  – normal section pitch;
- $\alpha_0$  – reference cylindrical slopping angle;
- $d_0$  – reference cylindrical diameter;
- $m_n$  – normal section module;
- $m_{ax}$  – axial section module;
- $z_s$  – number of teeth.

Diameter quotient:

$$q = \frac{d_0}{m_{ax}} \quad (7)$$

We regard the diameter quotient to the axial module. Its reason is the  $m_n$  normal module is normed for cylindrical gear hobs, while the  $m_{ax}$  axial module is normed for worm gear hobs.

Following on Fig. 8 the reference cylindrical slopping angle of the hob is:

$$\operatorname{tg} \gamma_0 = \frac{H_s}{d_0} = \frac{z_s \cdot m_{ax} \cdot \pi}{q \cdot m_{ax} \cdot \pi} = \frac{z_s}{q} \quad (8)$$

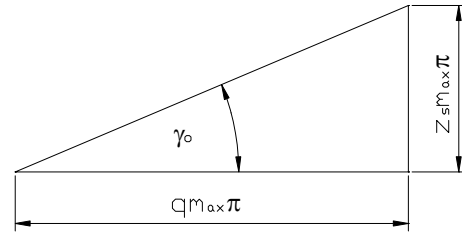


Figure 8: Reference cylindrical slopping angle of the hob

The reference cylindrical slopping angle is an angle which is closed by tangent of the covered worm of the worm and the perpendicular plane to the worm axis. We choose the slopping angle little in technological view. The axial profile angle of the hob is:

$$\operatorname{tg} \alpha_{ax} = \frac{\operatorname{tg} \alpha_0}{\cos \gamma_0} \quad (9)$$

The axial profile angle of the covered worm in case of evolvent worm is an angle, which is closed by the normal line of the profile and the framer of reference cylinder in axial section of the covered worm in section point of the thread surfaces and the framer of reference cylinder. The basic cylinder is coaxial imagined cylinder with hob, for which detach the evolvents of the head section of the hob. Its diameter is not measurable on the hob, only countable:

$$d_a = d_0 \cdot \cos \alpha_{0h} \quad (10)$$

where:

$$d_0 = \frac{z_s \cdot m_n}{\sin \gamma_0} \quad (11)$$

$$\operatorname{tg} \alpha_{oh} = \frac{\operatorname{tg} \alpha_0}{\sin \gamma_0} \quad (12)$$

The  $\gamma_a$  slopping angle on the basic worm is:

$$\cos \gamma_a = \cos \gamma_0 \cdot \cos \alpha_0 \quad (13)$$

But it is neither measurable on the hob.

The  $H_s$  slopping of the hob is countable from this formula:

$$H_s = z_s \cdot t_{ax} \tag{14}$$

After backward working the slopping of the two cog sides will not be same. The right side edge has  $H_{sj}$ , the left side edge has  $H_{sb}$ . On right thread hob:

$$H_{sj} > H_s > H_{sb} \tag{15}$$

On left thread hob:

$$H_{sb} > H_s > H_{sj} \tag{16}$$

The  $t_a$  basic pitch is perpendicular distance between the two neighbouring, similar falled (left or right) thread surface of the covered worm (Fig. 9).

$$t_a = t_n \cdot \cos\alpha_0 \tag{17}$$

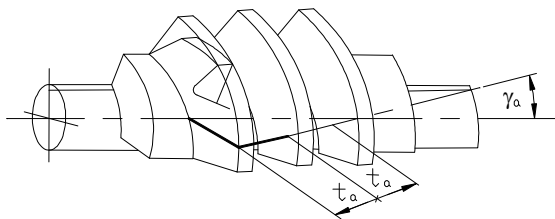


Figure 9: Definition of the basic pitch

**Designing directions of hobs**

Using hobs for worm gears cogging are individual, complicated geometrical, expensive tools. Every worm needs other tools.

The first step of production of hob is defining of construction data, based on that we can create the hob and prescribe the technology.

The basic profile angle of the covered worm is equal with the prescribed basic profile angle of the worm gear and the cogging tool.

The addendum of the hob cog equals with the dedendum of the worm gear [3].

Since the correct rolling down need head leak and the head part of the hob cog will cut that, that is why we added this value to the addendum.

We can define the dedendum of the hob cog dimension between outside diameter of the workpiece and the bottom ribbon cog ditch of the hob with consideration of the necessary leak.

The value of the whole depth of thread will be defined by the sum of the addendum and the dedendum (Fig. 10).

The tooth thickness of the hob has to be given on the reference cylinder (Fig. 10). The thread pitch of the hob has to equal with the thread pitch of the worm gear and worm.

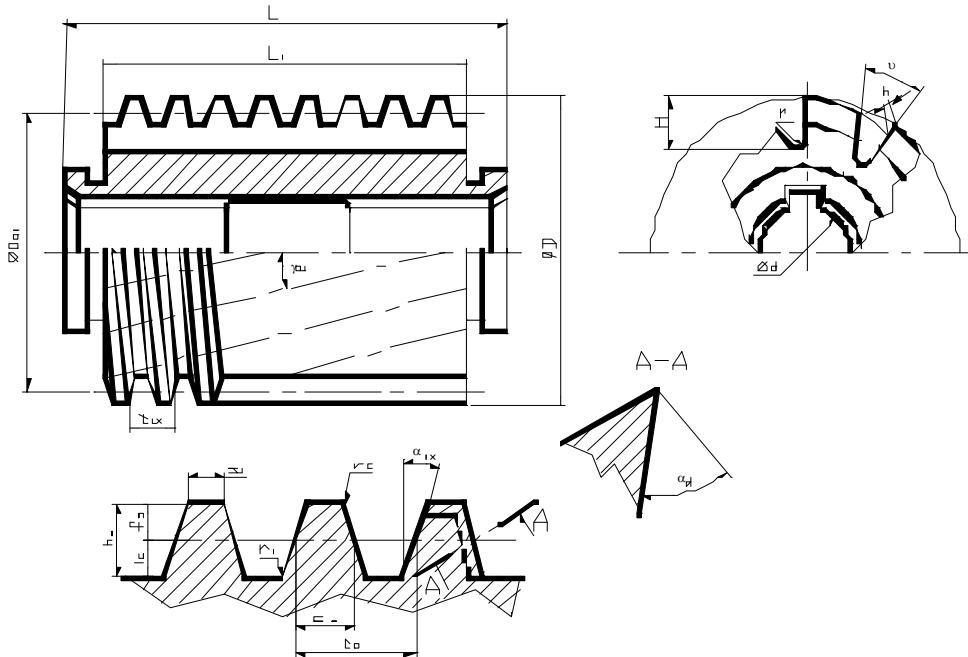


Figure 10: Main dimensions of the hob

The outside diameter of the hob extremely influences the punctual production of the worm gear.

We can define the hobs diameter based on the quality requirement of the production worm gear and worm.

The hob length has to be defined from starting length of working part. The length of working part has to be defined by length of contact.

The numbers of the sliver flute is defined by function of module and surface quality.

Thick cogging hob is often produced for reducing of surface roughness.

The specific sliver force increases with cog number increasing that is why the dressing hobs is prepared with rare cogs and the smoother hobs is prepared with thick cogs.

The back angle value is function of the backward turning and material quality.

The back angle of the hob is different on the head ribbon and the side surfaces.

The diameter of the reference cylinder always changes at resharping of the hob. During counting this change has to be considered with defining of a middle diameter.

The slopping angle of the thread line has to be measured in the reference cylinder.

The middle slopping angle could be defined by the perimeter of the middle reference cylinder and the thread slopping of the worm [2].

In practice the flute angle is  $22^\circ \dots 30^\circ$ .

### The program representation

We work out a program for designing of smoother hob and counting reduction in C programming language.

The program asks 5 input data and defines the other geometrical dimensions of the hob from these.

Fig. 11 shows the theoretical processes of program working.

We could save the received calculation results in txt file format because of the later utilization.

Based on table the program gives the flute number ( $z_h$ ) [3].

Table 1: The data of the designed hob

$m$	5 mm
$\alpha_0$	$20^\circ$
$D$	90 mm
$d_f$	27 mm
$z_h$	9
$t_n$	15,708 mm
$s_{ns}$	7,854 mm
$f_s$	6,25 mm
$l_s$	6,25 mm
$h_s$	12,50 mm
$r_f$	1,25 mm
$r_l$	1,5 mm
$s_f$	3,304 mm
$h$	5,5 mm
$D_{ok}$	76,125
$\alpha_d$	$3^\circ 24'$
$H$	20,5 mm
$L_1$	65 mm
$V_{mp}$	5 mm
$L$	75 mm
$\gamma_{ok}$	$3^\circ 45' 6''$
$H_{cs}$	3698,5 mm
$t_{ax}$	15,708
$\alpha_1$	$10^\circ$
$\nu$	$25^\circ$
$z$	1

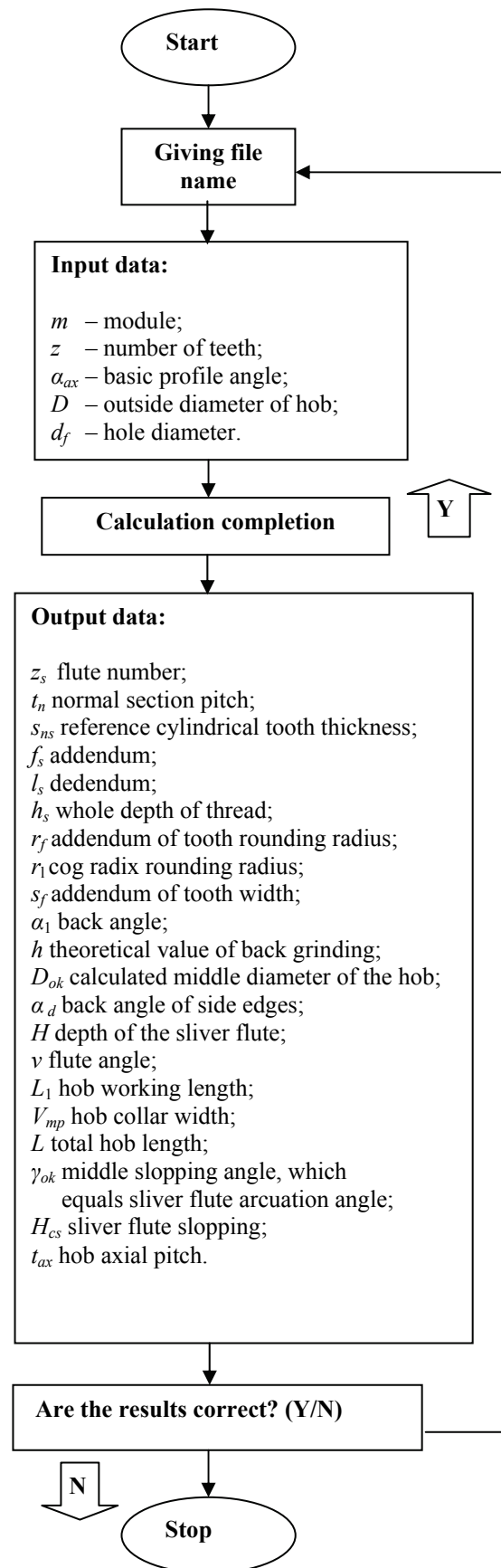


Figure 11: The process of program working

### Summary

We introduced the characteristics, surfaces, edges of the hob. We could see the hobs have complicated geometry, expensive tools that is why the punctual designing and production of hob is very important. Repeated resharping of the hob has to be ensured. We wrote a program for designing of smoother hob and we designed a hob and this geometrical characteristics were introduced by us.

### ACKNOWLEDGEMENTS

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