VSB TECHNICAL UNIVERSITY OF OSTRAVA | FACULTY OF MECHANICAL ENGINEERING

MM Science Journal | www.mmscience.eu
ISSN 1803-1269 (Print) | ISSN 1805-0476 (On-line)
Special Issue | VRBA100
International Conference on Modern Manufacturing Technologies
4. 10. 2023, Ostrava, Czech Republic
DOI: 10.17973/MMSJ.2024_03_2023139

MM SCIENCE JOURNAL

VRBA2024-00009

COMPUTER SUPPORT FOR THE DESIGN OF THE HOB CUTTER

TIBOR JURGA[1], IVAN MRKVICA[1], ANETA SLANINKOVA[1]

[1]Technical University of Ostrava, Faculty of Mechanical Engineering, Ostrava, Czech Republic

e-mail: tibor.jurga.st@vsb.cz

Abstract

The aim of the work is to create a computer program in the 3D CAD system T Flex CAD allowing the creation of parametric models for the design and construction of a modular hob cutter for the selected gearing. The thesis includes the analysis of the problem of hob cutters for the production of spur gearing with an involute profile, the analysis of the initial surface and the shape of the tool cutting edge for the involute surface, the determination of the basic profile of the cutting edge of the hob cutter (geometry of the basic worm, geometry of the cutting edge) and the calculation of the design parameters of the tool. The individual calculations will be programmed in the 3D CAD system T Flex CAD, which will allow to generate a specific 3D model of the hob cutter based on the change of input requirements for the production of a given spur gear (module, engagement angle, tooth inclination angle), with the possibility of displaying the required tool in a 2D view in its base, normal and side planes, which will be in the form of a standard technical drawing. This paper presents the preparation (unification calculations, introduction) before the final version of the computer program for the creation of the parametric tool models.

Keywords:

Hob Cutter, Design, Edge Geometry, Helix, Involute Profile, T Flex CAD, Module, Parametric Model, Pressure Angle, Spur Gearing

1 INTRODUCTION

The hob cutter is designed only according to the gearing module *m*, without depending on the number of teeth of the produced gearing. The DIN 3968 standard specifies 5 quality classes of the hob cutters (A, B, C, D and AA), which are divided into 9 groups according to the size of the cutter module. The instrument generally evaluates 17 measured variables – tool hole diameter, tool hole shape tolerance (cylindricity and circularity), tolerances for longitudinal groove and transverse groove (feather/groove), radial run-out on both flanges of the tool in relation to the tool axis (circumferential throwing on the collars in relation to the hole), axial run-out at the hub face relative to the bore axis (front throwing on the collar), radial run-out on the knife tooth head relative to the tool axis (circumferential throwing of the knife tooth head), changing the shape and position of the cutting surface, pitch – individually on any tooth (measured at half the height of the knife tooth), pitch between teeth (from tooth to tooth), cumulative pitch (deviation between teeth with the largest and smallest value), measurement of the cutting groove at a distance of more than 100mm of tool length, measurement of the knife tooth profile, nominal tooth thickness on the pitch circle, guide cutter from one cutting edge of the tooth to the other cutting edge of the tooth, guiding cutter from the cutting edge of the first tooth of the knife to the last, the basic pitch measured from one cutting edge of the tooth to the next cutting edge of the tooth (again from tooth to tooth) perpendicular to the angle of inclination in the normal (bite) plane, basic pitch in the contact area.

It is a design and manufacturing complex instrument, from a theoretical point of view it is an evolutionary snail. The screw surface of the involute worm is formed by the screw movement of the involute *e* over a base cylinder of radius r_o. A monolithic hob cutter is formed from a cylindrical blank (high-speed steel) by forming two separate formations. One is the helical surface of the production surface and the other is a straight, angled or helical cutting groove (the intersection of the surfaces creates the cutting edge). It has the shape of a screw with a profile of uniform trapezoidal thread, which does not correspond to the profile of the tooth gap.

The thread is interrupted by longitudinal grooves, thus creating cutting wedges that form a toothed ridge – the basic profile. [Svec 1965]

The geometry of the tool has a significant influence on the magnitude of the cutting forces and its distribution in the individual components, chip formation and removal, roughness, accuracy and quality of the resulting machined surface, durability of the cutting edge, wear. [Panda 2014]

The are great development possibilities for increasing the feed rate of the hob cutters – *design* (increasing the angle of the back or the angle of the forehead, positive-angle face hob cutters, longitudinal adjustment of the comb for even chip removal by all teeth – under grinding treatment, modifications – creating input/output clearance, modification has to be solved individually for each gear ratio, thus making the die-casting cutter a special tool), *technological* – (cutters with predetermined chip distribution, use of multi-pass and stacked hob cutters. The use of stacked cutters offers many advantages compared to the use of solid cutters. Saves expensive tool material – the body is made of structural steel, fast rust-resistant combs are easier to heat-treat. We have the possibility to choose larger d_{hn} cutter diameters, which leads to higher tool accuracy. Labour-intensive under grinding is eliminated because the profile is ground with a large grinding wheel like an Archimedes worm. Sintered carbide cutter teeth can provide great advances, where the biggest limitation of these hob cutter is the grinding of the comb teeth during the actual manufacture of the cutter (especially multi-cutters). [Benes 1990]

The maximum chip thickness to be cut and the chip length (the length of the tooth path along which the headstock blade is in direct contact with the wheel to be machined) are important criteria in the design of a deburring cutter. By increasing the modulus, axial feed, depth of cut or the number of strokes of the deburring cutter, the thickness of the layer to be cut increases. [Svec 1968]

When the number of the teeth of the machined wheel, the tooth inclination, the unit offset, the cutter diameter and the number of combs are increased, the chip thickness is reduced (the machined volume is divided into a larger number of teeth).

The first step in the design of any tool is to establish the starting surface associated with the workpiece surface. Associated surfaces can be defined as mutually enveloping surfaces that are created by the relative movement of tool and workpiece during machining. The transformation of the starting surface of the hob cutter is carried out by equipping this surface with razor blades and endowing it with cutting properties. In practice, this means milling the surface of the hob cutter with grooves for chip evacuation and thus creating a tool face at the same time. Next, undercut the comb tooth profile to create back angles on the heads and sides of the teeth and increase the head diameter by the radial clearance of the gear and an allowance for tool reshapening. The back surface are created by giving the axis motion along some curve (Archimedean, logarithmic spiral, circle, line, general curve). Next, we create clamping inspection, stopping or other surfaces on the tool. Diameter of clamping holes, cones, retainers and grooves are standardized (DIN 138).

2 CALCULATION OF THE DESIGN DIMENSIONS OF THE HOB CUTTER

For the production of spur gearing, we propose mostly cylindrical hob cutters, special shapes e.g. nose cones for milling wheels with helical teeth with an inclination of more than 20°. The hob cutter can be used to machine the wheel from the smallest to the largest modules (about m = 0,2 to 40mm). We are only limited by the appropriate tool. The values of the gearing make it possible to determine the basic profile of the hob cutter. The reference profiles of hob cutters are standardized (CSN 222501, DIN 3972). The profile of the cutting edge of the cutter, which strongly influences the shape of the tooth of the wheel, must be producible at a relatively low cost on the necessary equipment and in particular on equipment for undercutting the back surface of the tooth of the comb or equipment for reshaping the cutting edge.

Hob cutter belongs to the tool with very complex geometry. The geometry of the cutting edge of the hob cutter has a primary influence on the formation of the workpiece profile. Incorrect design of the hob cutter can result in undercutting of the root of the tooth on the gearing. The basic requirements placed on the tool during design, construction and production include – to determine the geometry of the sides of the teeth of the gear being machined, to know how the working gear and the cutting tool move in relation to each other. Emphasis on – high performance, quality of machined surfaces, long service life, grinding, machining, clamping (the different clamping method is a socket milling cutter with a hole or with a shank), technological requirement of production, last but not least the price. The basic profile of the produced gearing is the basic for the calculation of the hob cutter. This profile is only partially identical to the normal profile of the hob cutter (same pitch, thickness and tooth height) in the case of straight profiling in the axial plane. For the calculation it is necessary to know the dimensions of the basic profile of the manufactured gearing, because from this profile we derive the dimensions of the front profile of the proposed hob cutter. Its dimensions coincide with the shape of the tooth of the cutter comb in the normal plane. So, m – module, α – profile angle of the base comb, h_h – height of the tooth head, h_p – height of the tooth base, t – pitch, S_r – tooth thickness on the pitch line. The tooth head of the cutter rack machines the tooth heel of the wheel, therefore:

$$\gamma_0 = \frac{\pi.m.i_n}{cos\gamma_n} \quad (1)$$

i_n – number of cutter strokes [-],

γ_n – pitch angle of the cutter helix on the pitch circle [°],

h_{hn} – height of the tool tooth head [mm], for radial clearance c = 0,25m is 5/4m. [Kvapil 1968]

The heel of the tooth of the hob cutter forms the tooth head of the wheel. By limiting the machining of the outer diameter of the workpiece and increasing the tool feed in the production of corrected gearing, the height of the heel of the hob cutter h is greater by the clearance c, which has to be at least 0,4√m and therefore:

$$h_{pn} = h_h + min0.4\sqrt{m} = m + 0,4\sqrt{m} \quad (2)$$

We calculate the tooth height of the hob cutter comb:

$$h_n = h_{hn} + h_{pn} \quad (3)$$

And the cutter pitch in the frontal plane:

$$t_n = t = \pi.m \quad (4)$$

Radius of curvature at the head and heel of the tooth r_f for α = 15° r_f = 0,22m, for α = 20° r_f = 0,25.m. [Mrkvica 2011]

The main design dimensions of the hob cutter include – the outer diameter of the cutter, the diameter of the clamping hole and the number of ridges (grooves). As far as the parameters allow it is advantageous to select these parameters as large as possible. The difference between the design and calculation of the roughing and finishing hob cutters is in the dimension of the basic profile, where the profile of the roughing differs from that of the finishing hob cutter by the allowance for finishing operations on the side of the tooth of the wheel S_{hr}, by which the thickness of the tooth of the casting cutter has to by smaller. The design of rolling hob cutter for the production of helical gearing is the same as for the production of rolling hob cutters for straight gearing. When milling gears with tooth inclination $\beta_r \geq 20°$, we grind a ramp cone on the tool at an angle of 16 - 18° to relieve the first teeth of the tool, which take the largest cross-section of the chip.

2.1 Outer diameter of the hob cutter

The outer diameter of the hob cutter d_{hn} should by chosen as large as possible to increase the accuracy and surface quality of the machined wheel and the durability of the hob cutter edge. Particularly suitable for precision and finishing cutters or stacked cutters.

The larger cutter diameter allows the clamping hole and therefore the clamping arbour to be enlarged, thereby increasing clamping rigidity and reducing chatter. By increasing the diameter it is possible to increase the number of tooth ridges, thus decreasing the feed per tooth and increasing the durability of the hob cutter edge. The disadvantage is the higher price, the problem of the treatment. [Hipke 2011]

As the cutter diameter increases, the accuracy of the gearing increases as the pitch of the helix on the pitch roller decreases (cutter is theoretically closer to the basic screw). Smaller diameter cutters are more suitable for increasing cutting parameters (using higher speeds while maintaining the same cutting speed). As the speed of the cutter increases, the rotational speed of the workpiece and the axial feed of the hob cutter increase. The diameter d_{hn} is either selected from the standard or calculated according to the formula:

$$d_{hn} = d_{dn} + 2.(h_n + r_{dn} + k) \quad (5)$$

d_{dn} – is *(1,4 to 2,0).d_n* – diameter of the tooth groove heel [mm],

d_n – clamping hole diameter [mm],

r_{rdn} – radius of curvature of the heel of the teeth of the longitudinal [mm], in the range 1,5 – 3,5mm,

k – endfloat size [mm]. [CSN 222551 1982]

Relief of the groove for the feather is specified in standard CSN 220450. The groove is placed against the tooth gap. The thickness of the cutter body must not be less than 0,30d_n (if it is less, it is necessary to use cutters with a shank or with face clamping.

2.2 Clamping hole diameter and clamping groove dimensions

The hole serves to clamp the cutter to the arbour. An approximate value for sizing is:

$$d_{hn} = d_{dn} + 2.(h_n + r_{dn} + k) \quad (6)$$

For a better flush fit with the arbour, the seating surface of the hole is interrupted by recessing the length of one third of the total length of the cutter by 1 to 2mm with a radius of curvature of 0,5 to 1,5mm. The minimum thickness of the cutter body between the hole and the bottom of the groove can be 0,30d_n. If it is smaller, it is necessary to design the hob cutter with a shank or with face clamping. The holes on both faces chamfered by 0,5 to 2/45°. Face-mounted hob cutter have the following advantages – the drilling surface is not interrupted and the precision of the shape is guaranteed when grinding the hole, greater guarantee that the hob cutter will clamp onto the arbour without deforming. The standardized range of the diameters of the clamping holes d_n for the socket hob cutters can be found in the standard CSN 222524, DIN 138.

2.3 Number of tooth combs and strokes of the hob cutter

The cutting grooves, which form the face of the individual teeth, divide the surface of the hob cutter into combs. The grooves have two functions. In the manufacture of hob cutters, they are used for the run-out of undercutting tools and in the manufacture of components for chip evacuation. The intersection of the combs with the involute screw produces the cutting edges of the cutter teeth, which form the shape of the sides of the teeth of the manufactured gearing by means of enveloping cuts. The density of the envelope cuts is significantly related to the quality of the sides of the gear teeth (surface roughness), the size of the chip and the magnitude of the deviation from the involute. Determining the number of combs is a decision to optimize for performance or tool life. By keeping the same maximum chip thickness and increasing the number of combs, the feed per revolution is increased non-linearly, leading to a reduction in the number of cuts of each tooth per unit of travel. As the number of cutter combs increases or the number of teeth of the machined wheel increases, the deviation from the envelope mesh decreases as the density of the envelope mesh increases. Tentatively calculate the number of combs:

$$z_n = \frac{360^\circ}{\varphi} \quad (7)$$

$$\varphi = (1\ to\ 4{,}5).\frac{d_{dn}}{d_{hn}} \quad (8)$$

φ – angle per tooth with a gap [°]. [Svec 1968]

The create an acceptable tooth flank profile, number of combs between 8 and 10 is sufficient. By increasing the number of combs, we increase the cutting capacity of the deburring cutter and the density of the envelope cuts. On the other hand, increasing the number of combs reduces the usable part of the cutter teeth, so the number of resharpenings drops to one to three for fine-toothed hob cutters (30 ridges or more). The comb tooth width check at the heel replaces the strength check and is recommended to be between 0,50 and 1,00 h_{dn} (depth of the tooth groove):

$$h_{dn} = \frac{d_{hn} - d_{dn}}{2} \quad (9)$$

The maximum thickness of the cut-off layer increases less by increasing the axial feed than by increasing the number of milling cutter strokes, therefore it is advisable to select the axial feed as high as possible and the number of strokes as low as possible for the selected maximum chip thickness, taking into account the permissible depth of the feed track.

2.4 Cutter length

The length of the hob cutter is composed of the length of the two collars designed for throwing control and the threaded part:

$$L_n = l_{zn} + 2l_{kn} \quad (10)$$

l_{zn} – lenght of threaded part [mm], l_{zn} = *(4 to 5)π.m + 10 to 15mm*,

l_{kn} – length of collar [mm], l_{kn} – 2,5 to 5mm on average d_{kn} = *(1,5 to 1,7).d_n*. [Kvapil 1968]

The length of the threaded part l_{zn} should theoretically correspond to the diameter of the engagement line of the tool with the workpiece on the pitch line of the basic ridge of the hob cutter. The minimum length of the cutting threaded part of the cutter is formed by the section that forms the profile of the teeth of the gearing being produced and the roughing section. The tooth profile forming section corresponds to the projection of the take-off curve of the hob cutter with workpiece in the hob cutter. By taking advantage of the axial offset of the cutter to increase tool life (by distributing the maximum wear over several teeth of the comb), a threaded part length of 1,5 to 2 threads longer is proposed.

2.5 Pitch diameter of the hob cutter

The pitch diameter of the hob cutter is the basic calculation diameter of the cutter, to which other parameters are related – thread and groove pitch angles:

$$d_{rn} = d_{rn}^{'} - 2\frac{k}{4} \tag{11}$$

Pitch diameter of the new tool d'_{rn} which can be considered as the nominal dimension of the cutter. This cut produces a nominal profile with theoretical dimensions and the cutter ground in this way produces the correct gearing:

$$d_{rn}^{'} = d_{hn} - 2(mf + c_a) \tag{12}$$

As the diameter of the pitch circle changes, the pitch angle of the hob helix β_{zn} also changes, because $sin\beta_{zn} = m/d'_{rn}$ and the tooth groove ceases to be perpendicular to the helix of the comb tooth (this change will cause an error in the profile of the hob cutter). The face angle on the tooth head γ_H is usually 0° and the back angle on the tooth head α_H, which is created by undercutting by the cam lift value k, is chosen to be 10 to 12°. Then the normal dorsolateral angle of the tooth α_{Bn} = 2 to 3°.

$$tg\alpha_H = \frac{tg\alpha_{Bn}}{sin\beta_{zn}} \tag{13}$$

β_{zn} – angle of inclination of the helix of the teeth of the cutter comb [°],

$$\beta_{zn} = \frac{m.i_n}{d_{rn}} \tag{14}$$

i_n – number of courses [-], and:

$$k = \frac{\pi.d_{hn}}{z_n}.tg\alpha_H \tag{15}$$

3 PROCEDURE FOR CREATING A COMPUTER PROGRAM IN 3D T-FLEX CAD

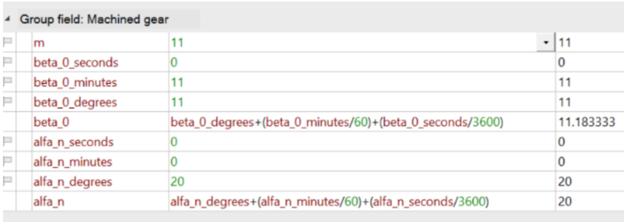
The process of creating a given computer program in T Flex CAD had the following steps.

3.1 Creation of the database

Input parameters for gearing (module, profile angle of the base ridge, height of the tooth head, tooth heel height, pitch, tooth thickness at the pitch line, angle of view in the normal plane, angle of inclination of the teeth of the machined wheel) and tool (cutter outer diameter, clamping hole diameter, number of cutter combs, number of cutter strokes, cuter length, pitch angle of the base screw helix, helix pitch angle of the tooth grooves, slope of grooves for chip evacuation, right or left-hand tool). Taken from standard or (can also be selected based on the requirement).

3.2 Creating the variable editor

The editor is divided into 4 group fields (scale offset, tool, gearing, calculations). Both the values of the tool and gearing input parameters from the program database and other input parameters that were not defined in the program database were transferred into the tool and gearing group box. For the gearing groups these were the parameters α_n – angle of view in the normal plane, β_0 – angle of inclination of the teeth of the machined wheel. (see Fig. 1). For the instrument group these were the parameters instrument angles of the back and forehead, helix pitch angle (α_H – angle of the back on the head of the tooth, γ_H – angle of the forehead on the head of the tooth). The editor has been set up so that input parameters can be pulled automatically from the program database or entered manually. Input parameters that were not from the program database were entered manually in the variable editor or in a more user-friendly environment called set external model variables. Since these are all angular measurements, the input parameter values are entered in the form *degrees_minutes_seconds*. The decision to automatically convert input parameter values or to enter them manually was conditional on entering and individual condition for the parameters from the program´s database. For example, the expression *z_hand==0?z_database:z_hand* from the group array gearing means that if the value of *z_hand* equals 0, then the value of *z* is pulled from the program database. The determining parameter from which the other input parameters were derived was the modulus of the gearing. All functionally dependent relationships were programmed into the group field calculations.



Group field: Machined gear

m	11	11
beta_0_seconds	0	0
beta_0_minutes	11	11
beta_0_degrees	11	11
beta_0	beta_0_degrees+(beta_0_minutes/60)+(beta_0_seconds/3600)	11.183333
alfa_n_seconds	0	0
alfa_n_minutes	0	0
alfa_n_degrees	20	20
alfa_n	alfa_n_degrees+(alfa_n_minutes/60)+(alfa_n_seconds/3600)	20

Fig. 1: Create a group array of gearing with input parameters from the program database (m – module of gearing) and other input parameters that are not from the program database (α_n and β_0). The fields marked in green can be freely set and thus change the geometry of the gearing.

3.3 Creation of the tool model

Consists of several strategies:

Ejection

The area dimension of the tool has been changed to the volume dimension, depending on the gearing module (in the program database, the diameter and lenght of the cylinder was assigned to each module, changing the module automatically changes the cylinder model) or manual input of dimensional characteristics (as far as it is logical from the point of view of production).

Drilling

The strategy designed for the modular cylindrical hob cutter with hole and groove. Material extraction based on the dimensions given by the standard from the program database or individual requirements. A basic hole and groove dimension standard for module size 5 from DIN 138 was created on the 3D model using fixed datums. The hole and groove dimension values are automatically changed based on a change in the module and its associated dimensions from the program database or by special selection. This is made possible by a program tool called *variable program listing*.

Transformations

The right or left handed helix with a fixed forming point is threaded onto a cylinder model that has been created by the *Ejection* strategy. The helix formed is the trajectory of the forming point, which lies at the intersection of the back and front surfaces of the tool tooth (on the outer diameter of the model of the future tool). The axis of the helix is the axis of the cylindrical model, thus it is uniquely determined by the forming point and the screw movement. The screw movement is determined by the axis of the hob cutter, orientation and the value of the thread height. Thread height in this case is the angle that corresponds to a rotation by angle of magnitude radian $\varphi = 2\pi$ and has been programmed into the program with the formula $v = 2\pi v_0$, where v_0 represent the reduced thread height, which expresses the magnitude of the displacement when rotated by an angle of φ = 1°.

The creation of the helix on cylindrical surface was realized through the Monge projection, which shows the helix in the position in which it is perpendicular to one of the two projection. The procedure is as follows. The helix is wound on a rotating cylindrical surface whose axis coincides with the axis of the helix and whose radius is equal to the distance of the forming point from its axis. The 13 points that lie uniformly on the surface lines of the rotating cylindrical surface were chosen to represent the helix. There are a total of 12 forming lines, where the condition is that one forming line passes through a forming point *Q*. Each forming line passes into an adjacent forming line when rotated about the axis of the helix by an angle of magnitude *π/6* (the magnitude of the displacement in this case was *v/12*). So, the projection of the thread of a helix in a projection perpendicular to its axis is a circle whose centre lies in the projection of the axis of the helix and of a given radius. The projection of the selected 13 forming points of the helix thread are evenly distributed on the circle (each passes into an adjacent one when rotated around the centre of the circle by an angle of magnitude *π/6*). Parametric equations for right hand and left hand helix were introduced into the program. An option to manually change a right hand helix to left hand helix has been created in the program.

For right hand helix:

$$x = \alpha . cos\varphi\,,\ y = \alpha sin\varphi\,,\ z = v_0\varphi \tag{16}$$

For left hand helix:

$$x = \alpha . cos\varphi\,,\ y = \alpha sin\varphi\,,\ z = -v_0\varphi \tag{17}$$

The next step was to create the surface of the helix (sides of the tooth), which was formed as a network of the set of all positions of the curve forming (evolvent) set of all helices formed by the individual points of the curve forming. All helixes have a common axis and all have the same thread height.

Boolean 1

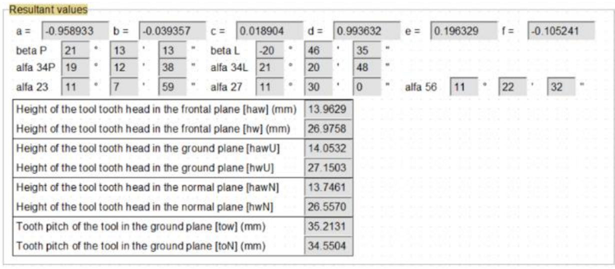
This strategy involves creating individual tooth ridges by pulling in a straight line or along a curve (helix). Most often after the helix, then again the strategy is used *Transformations*. The number of tooth grooves are given from the program database (module) or individually.

Boolean 2

This strategy solves the angle of inclination of the tooth face of the hob cutter. The strategy of drawing a forming line perpendicular to the axis of the tool or at a certain angle. Automatically changeable. In the case of the roughing hob cutter design, the angle of the tooth face will be inclined at a positive angle 2-3°.

3.4 Output of the hob cutter program

The numerical output of the program will be a clear summary control table (path to parameters table Set external model variables), where we can find a summary of the input parameters for the tool and the input parameters for the gearing. At the same time we can find the calculated parameters of the tool and gearing (see Fig. 2). Another output will be the automatic generation of a 3D model of hob cutter whenever the input parameters of the tool and gearing are changed (see Fig. 3). The output of the program will also include a 2D drawing where the tool will be shown in the basic and normal (production) planes (see Fig. 4).


Resultant values

a = -0.958933 b = -0.039357 c = 0.018904 d = 0.993632 e = 0.196329 f = -0.105241

beta P 21 ° 13 ' 13 " beta L -20 ° 46 ' 35 "

alfa 34P 19 ° 12 ' 38 " alfa 34L 21 ° 20 ' 48 "

alfa 23 11 ° 7 ' 59 " alfa 27 11 ° 30 ' 0 " alfa 56 11 ° 22 ' 32 "

Height of the tool tooth head in the frontal plane [haw] (mm)	13.9629
Height of the tool tooth head in the frontal plane [hw] (mm)	26.9758
Height of the tool tooth head in the ground plane [hawU]	14.0532
Height of the tool tooth head in the ground plane [hwU]	27.1503
Height of the tool tooth head in the normal plane [hawN]	13.7461
Height of the tool tooth head in the normal plane [hwN]	26.5570
Tooth pitch of the tool in the ground plane [tow] (mm)	35.2131
Tooth pitch of the tool in the ground plane [toN] (mm)	34.5504

Fig. 2: Output control summary table of the program which will be the basic for generating the 3D model of the tool.

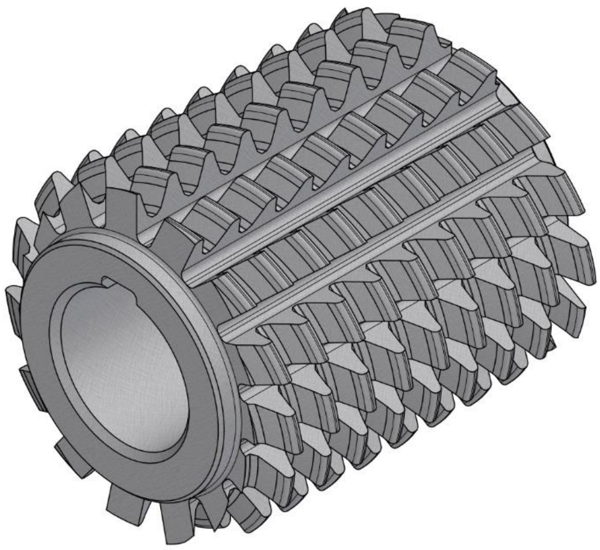


Fig. 3: Graphic output 3D model automatically generated from CAD program T Flex CAD (cylindrical right hand double pass hob cutter with hole, with 15 cutting grooves and with left hand sense).

4 SUMMARY

An involute gear hob cutter is a multi-tool that produces an involute gearing by the hob motion and the resulting feed in the direction of the tooth. T Flex CAD is a parametric and solid modeler built on the proven Parasolid core. Includes a wide range of highly innovative parametric modelling tools that allow designers to quickly create basic elements by simply adding common shapes (holes, curves, chamfers).

The main part of the practical output of the work is a computer program programmed in the 3D CAD system T Flex CAD, where on the basis of the calculated tool parameters it is possible to automatically generate the tool – modular hob cutter as a 3D model (see Fig. 3) or in the form of a 2D technical drawing (see Fig. 4). In this case, the technical drawing shows the right hand double pass modular hob cutter (tolerances class AA according to the standard 3968) with a hole diameter 22H5, module 2 with angle of view 20° and with 15 cutting grooves with left hand sense. The program generates an arbitrary hob cutter with a hole or shank with right or left hand helix with the necessary number of teeth and ridges. Tool modifications are also possible (protuberant profile of the tool tooth). Prior to the actual tool design in T Flex CAD, calculations (tool angles, tooth size, tooth spacing, etc.) were programmed into T Flex CAD based on the input parameters of the gearing (module, pressure angle, etc.) and the tool (number of teeth, number of ridges, tool length, tool outer diameter, number of strokes, helix pitch angle, etc.). The input parameters for the gearing or tool come from standard (for example, the basic profiles, of the teeth), empirical calculations, which are explained in more details as they realistically enter into the programming, calculations (their exact derivation is not part of this article) or is based on the customer ´s specification of the tool parameters or on the required parameters of the workpiece-gear, including shape modifications. The advantage of using T Flex CAD is the combination of the programming and design environments (e.g. the combination of ESCO with Autodesk ´s 2D/3D environments). This is made possible by specific T Flex CAD features such as parametric modeling, adaptive components, assembly modeling by part placement using the coordinate system and degrees of freedom, custom dialog boxes, direct modeling based on embedded empirical relationships. This program in the T Flex CAD modeler can be used directly by designers and technologists (interfacing with CAM) in practice or it can be used for further practical training in the design of machine tools.

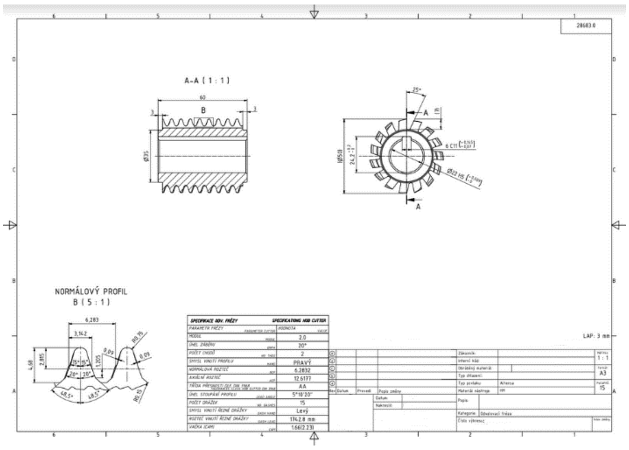


Fig. 4: Graphic 2D output automatically generated from CAD program T Flex CAD (technical drawing of the right hand double pass hob cutter with hole, module 2 mm with angle of view 20° and with 15 cutting grooves with left hand sense, tolerances class hob cutter AA according to the standard DIN 3968).

5 ACKNOWLEDGMENTS

The article has been done in connection with the project Students Grant Competition SP2023/088 „Specific Research of Modern Manufacturing Technologies for Sustainable Economy “financed by the Ministry of Education, Youth and Sports and Faculty of Mechanical Engineering VSB-TUO.

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