Algorithm for Gear Hub Tool Profiling by Bezier Polynomial Approximation. The Rotary Helical Screw Compressor Case.

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Abstract: - Gear hobs tool reciprocally enwrapping a profiles whirl, associated with a rolling centrodes are usually designed using the second Olivier theorem [5], enwrapped surfaces having punctiform contact. In the case of rotary helical screw an approximation method by 2^{nd} or 3^{rd} degree Bezier polynomials is proposed, simplifying calculus but still preserving profiling accuracy. Numerical examples are also presented, based on dedicated software.

Key-Words: - Gear hub, Bezier polynomial approximation, rotary helical screw.

1 Introduction

Already know are methods for gear hub primary peripheral surface profiling [1], [4], [5], [6], reciprocally enwrapping with an ordered surfaces whirl, with punctiform contact, based on fundamental theorems: second Olivier theorem, Grohman theorem, intermediary surface method or decomposition of helical movement – Nikolaev[5].

Complex profiles, as is the case of rotary helical screw compressors, can be modeled using analytical representation for those profiles, hear hob profiling being realized using already know theoretical methods.

Also, the problem could be solved, with satisfactory technical precision, by substituting analytical profiles of arcs and segments with parametric Bezier polynomials. The reduced number of points one should know to apply this methodology and also uniformity and mathematical simplicity can be considered important advantages for the proposed method.

2 Rack gear surface

We analyze further, see fig. 1, the rack profile, generating the rotary helical screw compressor. The rack profile is constituted by the following elementary profiles:

 $AB - circle$ arc with radius R_0 ;

BC – straight line segment;

CD – circle arc with radius r_0 ;

- AH Bezier polynomial curve arc;
- HG Bezier polynomial curve arc;

GF – straight line segment;

FE – circle arc with radius R_0 ;

Consecutive elementary profiles are tangent in the common point. Therefore, continues gear hob tools, generating rotary helical screw, are obtained.

Fig.1 . Rack gear generating the rotary helical screw compressor

Let consider the parametric equations for the elementary profiles of the rack:

- cylindrical surfaceAB

$$
S_{AB} \begin{cases} \xi = R_0 \cos \psi - C_0; \\ \eta = -R_0 \sin \psi + t \sin \beta_d \\ \zeta = t \cos \beta_d. \end{cases} (1)
$$

 C_0 - is a constant, *t* and ψ are variable

parameters;
$$
0 \le \psi \le \psi_{\text{max}}
$$
; $\psi_{\text{max}} = \frac{\pi}{2} - \beta$;

planar surface BC

$$
\begin{aligned}\n\zeta &= \zeta_B - u \cos \beta; & \text{ common point} - H \\
\zeta &= t \cos \beta_d, & \text{parameter,} \\
\beta &= \frac{\pi}{2} - \psi_{\text{max}}; \zeta_B, \eta_B - \text{ are determined from} \\
\zeta &= t \cos \beta_d, & \text{parameter,} \\
\beta &= \frac{\pi}{2} - \psi_{\text{max}}; \zeta_B, \eta_B - \text{ are determined from} \\
\zeta &= \zeta_0 - r_0 \cos \nu; & \text{where } 0 \le u_1 \le u_{\text{max}}, & \text{and } \beta_1 \\
\zeta &= t \cos \beta_d, & \text{where } 0 \le u_1 \le u_{\text{max}}, & \text{and } \beta_1 \\
\zeta &= t \cos \beta_d, & \text{where } 0 \le u_1 \le u_{\text{max}}, & \text{and } \beta_1 \\
\zeta &= t \cos \beta_d, & \text{parameters;} \\
\zeta_{\text{co}} &= t \cos \beta_d, & \text{by } 1 \\
\zeta &= t \cos \beta_d, & \text{by } 1 \\
\zeta &= t \cos \beta_d, & \text{by } 1 \\
\zeta &= t \cos \beta_d, & \text{by } 1 \\
\zeta &= t \cos \beta_d, & \text{by } 1\n\end{aligned}
$$

$$
\beta = \frac{\pi}{2} - \psi_{\text{max}}; \xi_B, \eta_B
$$
- are determined from

- cylindrical surface CD

$$
S_{CD} \begin{vmatrix} \xi = \xi_{O_1} - r_0 \cos \nu; & \text{para} \\ \eta = \eta_{O_1} + r_0 \sin \nu + t \sin \beta_d; & (3) \\ \zeta = t \cos \beta_d, & (3) \end{vmatrix}
$$

coordinates of the center of the circle are constructive values,

$$
0 \le v \le \frac{\pi}{2} - \beta \tag{4}
$$

cylindrical surfaces AH and HG For AH we consider a $2nd$ degree Bezier polynomial

$$
S_{BC} \mid \vec{q} = t \cos \beta_{s},
$$
\n
$$
\vec{r} = t \cos \beta_{s},
$$

and similarly

$$
S_{CD} \begin{vmatrix} \eta = \eta_{O_1} + r_0 \sin v + t \sin \beta_d; & (3) & \zeta = t \cos \beta_d, \\ \zeta = t \cos \beta_d, & S_{CD} \begin{vmatrix} \zeta = \zeta_{O_2} - r_0 \cos v_1; & & \\ \zeta = t \cos \beta_d, & S_{CD} \end{vmatrix}
$$

\nt and v are variable parameters; ζ_{O_1}, η_{O_2}
\ncoordinates of the center of the circle are
\nconstentative values,
\n0 \le v \le \frac{\pi}{2} - \beta; & (4) & \text{are constructive values and } L_p \text{ is the length of the rock
\nportfolio along the translation axis.
\nFor AH we consider a 2nd degree Bezier
\npolymomial
\n
$$
\begin{vmatrix} \zeta = \zeta_{O_2}, -r_0 \cos v_1; & \\ \zeta = t \cos \beta_d, & \text{where } \zeta_{O_2}, \eta_{O_2}
$$

\nconclating the translation axis.
\nFor AH we consider a 2nd degree Bezier
\npolymomial
\n
$$
\begin{vmatrix} \zeta = \zeta_{U_{\text{max}}} - \zeta_{1} \zeta_{1} + (1 - \lambda_{1}) \lambda_{1} B_{\zeta} + & \text{for } U_{\text{max}} \end{vmatrix}
$$

\n
$$
+ (1 - \lambda_{1})^2 C_{\zeta}; & DCBAHGFE and the versor \overline{t} can be constructed;
\n
$$
S_{AB} \begin{vmatrix} \eta = P_{\eta_{AB}} = \lambda_{1}^2 A_{\zeta} + 2(1 - \lambda_{1}) \lambda_{1} B_{\zeta} + & \text{for } U_{\text{max}} \end{vmatrix}
$$

\n
$$
+ (1 - \lambda_{1})^2 C_{\zeta} + t \sin \beta_d; & \text{where } \beta \text{ is the inclination angle of the helical screw:\n
$$
\zeta = t \cos \beta_d.
$$

\nwhere $0 \le \lambda_{1} \le 1$,
\nand similarly
\n
$$
\begin{vmatrix} \zeta = P_{\zeta_{AB}} = \lambda_{1}^2 D_{\zeta} + 2(1 - \lambda_{1}) \lambda_{1} E_{\zeta} + & 3 & \text{Gear Hub Prim
$$
$$
$$

determined by the following conditions (for any arbitrary fixed value of parameter*t*):

- o common point A, and common tangent - in A, between S_{AB} and S_{AH} ;
- \circ common point G, and common tangent – in G , between S_{FG} and S_{HG} ;

$$
\begin{aligned}\n\xi &= \xi_B - u \cos \beta; \\
\zeta &= t \cos \beta_d, \\
t, u \text{ are variable } \beta = \frac{\pi}{2} - \psi_{\text{max}}; \xi_B, \eta_B \text{ are determined from} \\
\begin{aligned}\n\zeta &= t \cos \beta_d, \\
\zeta &= t \cos \beta_d, \\
\zeta &= t \cos \beta_d.\n\end{aligned}\n\end{aligned}
$$
\n
$$
\begin{aligned}\n\zeta &= \xi_B - u \cos \beta; \\
\zeta &= \frac{\pi}{2} - \psi_{\text{max}}; \xi_B, \eta_B \text{ are determined from} \\
\zeta &= \frac{\pi}{2} - \psi_{\text{max}}; \xi_B, \eta_B \text{ are determined from} \\
\zeta &= \frac{\pi}{2} - \psi_{\text{max}}; \xi_B, \eta_B \text{ are determined from} \\
\zeta &= \frac{\pi}{2} - \psi_{\text{max}}; \xi_B, \eta_B \text{ are determined from} \\
\zeta &= \frac{\pi}{2} - \psi_{\text{max}}; \xi_B, \eta_B \text{ are determined from} \\
\zeta &= t \cos \beta_d, \\
\zeta &= t \cos \beta_d, \\
t \text{ and } v \text{ are variable parameters}; \xi_A, \eta_A \text{ or } \xi_B = \frac{\pi}{2} - \psi_{\text{max}}; \xi_B, \eta_B \text{ or } \xi_B = \frac{\pi}{2} - \psi_{\text{max}}; \xi_B, \eta_B = \frac{\pi}{2} - \psi
$$

d

are constructive parameters;

[−] planar surface:
\n
$$
\begin{vmatrix}\n\xi(u_1) = \xi_F + u_1 \cos \beta_1; \\
y(x_1) = \eta_F - u_1 \sin \beta_1 + t \sin \beta_d; \\
z = t \cos \beta_d,\n\end{vmatrix}
$$
\nwhere $0 \le u_1 \le u_{1_{max}}$, and β_1 are constructive parameters;
\n[−] cylindrical surface:
\n
$$
\begin{vmatrix}\n\xi = \xi_{O_2} - r_0 \cos v_1; \\
y = [L_P - \eta_{O_2}] + r_0 \sin v_1 + t \sin \beta_d; \\
z = t \cos \beta_d,\n\end{vmatrix}
$$
\nwhere ξ_{O_2}, η_{O_2} - coordinates of the center of the circle are constructive values and L_P is the length of the rock profile along the translation axis.
\nBack profile obtained as above, in rolling motion, generates two helical surfaces of the ordinary compression (male and female). Moreover, once the rock profile is known, the cylindrical surface directed by curve assembly DCBAHGFE and the versor \vec{t} can be constructed;
\n $\vec{t} = \sin \beta \cdot \vec{j} + \cos \beta \cdot \vec{k}$, (9)
\nwhere β is the inclination angle of the helical screw:
\n $\tan \beta = \frac{P_E}{2\pi R_{r_2}}$ (where R_{r_2} is the worm radius)
\n**3 Gear Hub Primary Peripheral Surface**

 $\frac{\pi}{4}$ *a* (4) are constructive values and L_p is the length of the rack profile along the translation axis.

sin $v + t \sin \beta_d$; (3)
 $\begin{cases}\n\xi = \xi_{O_2} - r_0 \cos v_1; \\
\xi = \xi_{O_2} - r_0 \cos v_1; \\
\eta = [L_P - \eta_{O_2}] + r_0 \sinh \theta. \\
\text{ariable parameters } \xi_{O_1}, \eta_{O_1} - \xi_{O_2}, \eta_{O_2} - \text{ coordinates of } \xi_{O_2}, \eta_{O_2} - \text{ coordinates of$ are determined from S_{pq} $\begin{vmatrix}\nS_{pq} & S_{pq} + \mu_1 \cos \rho_1, \\
S_{pq} & S_{pq} + \mu_2 \sin \rho_2 + \mu_3 \sin \rho_3\n\end{vmatrix}$, (7)

are determined from S_{pq} $\begin{vmatrix}\nS_{pq} & S_{pq} \\
S_{pq} & S_{pq}\n\end{vmatrix}$, where $0 \le u_1 \le u_1$, and β_1 are constructive

para E_B , *C_{tri}* are determined noniting the state of the constructive parameters; ζ_0 are constructive parameters; ζ_0 are $\zeta = t \cos \theta_a$, ζ_0 are constructive parameters; ζ_0 are ζ_0 and β_1 are con was 5*g*, *H_B* = are determined non $\frac{u_{Ff}}{f}$ = $\frac{1}{2}$ + *D* = $\frac{u_{Ff}}{f}$ = $\frac{1}{2}$ = *l*₅ = *ξ₀*, *-n₀* (3)

parameters; *ξ₀*, *n₀* =

parameters; *ξ₀*, *n₀* =

cor of the circle are

where *ξ₀*, *n₀* = coordinates of the center of the circle

are constructive values and *L_i* is th parameters; $\epsilon_{0,1}$, $\epsilon_{1,2}$

are of the circle are
 $\epsilon_{0,2}$, $\eta_{0,1}$ coordinates of the center of the circle

are constructive values and L_{μ} is the length of the rack

profile along the translation axis.

Ra **Example 1** are constructive values and L_p is the length of the circle are constructive values and L_p is the length of the rack ces AH and HG profile along the ranchation axis (and profile distantion and change the ra Rack profile obtained as above, in rolling motion, generates two helical surfaces of the rotary compressor (male and female). Moreover, once the rack profile is know, the cylindrical surface directed by curve assembly and contractive value of the probability of the external terms and complete along the translation axis.

Rack profile absort political surfaces of the rotary compressor (male and female). Moreover, once the rack profile i

DCBAHGFE and the versor t can be constructed:

$$
\vec{t} = \sin \beta \cdot \vec{j} + \cos \beta \cdot \vec{k}, \qquad (9)
$$

where β is the inclination angle of the helical screw:

$$
\tan \beta = \frac{P_E}{2\pi R_{r_2}} \text{ (where } R_{r_2} \text{ is the worm radius)}
$$

3 Gear Hub Primary Peripheral Surface Profiling. Algorithm

 λ_1 ² F_ξ ; The profile of the rack and positions of the coordinate's systems axis were defined. We have to determine the characteristics of rack cylindrical surface in contact with primary peripheral surface of the gear hob, see fig. 2. + cos $\beta \cdot \vec{k}$, (9)

ie inclination angle of the helical screw:
 $\frac{\vec{k}}{R_{\gamma_2}}$ (where R_{γ_2} is the worm radius)
 Hub Primary Peripheral Surface

ing. **Algorithm**

dof the rack and positions of the coordinate's

The helical movement generating primary peripheral surface of the gear hob (\vec{V}, p) , can be decomposed in a sum of equivalent movements:

- $\frac{1}{t}$ translation along the vector \vec{t} rack cylindrical surface generator; \rightarrow
- rotation around axis *A* (parallel to vector rotation around axis A (parallel to vector *V* – the helical surface axis – and at a distance $a = p \cdot \tan \theta$ from \vec{V}).

In the equations above, *p* denotes helical parameter of the gear hob, and θ is the angle between vectors *V* and \vec{t} , see fig. 2. \rightarrow \vec{t} , see fig. 2.

Fig.2. Decomposition of the helical movement

$$
\vec{A} = -\cos\omega \cdot \vec{j} + \sin\omega \cdot \vec{k};\tag{10}
$$

see table 1; (coordinates system
$$
\xi \eta \zeta
$$
 has parallel axes
and same orientation as x, y, z, z)

- current vector be
$$
\vec{z} = \vec{Q} \cdot \vec{Q} \cdot \vec{r}
$$

$$
r_1 = O_2 O \cdot i + r,\tag{12}
$$

$$
\omega = \beta_d \pm \omega_s, \tan \omega_s = \frac{p}{R_{r_s}}.
$$
\n(13)
\n
$$
\text{charac}(\text{13})
$$
\n(14)
\n
$$
\text{charac}(\text{14})
$$
\n(15)

Condition used to determine characteristically curve, in the case of helical movement decomposition, has the following form: b determine characteristically curve, in

cal movement decomposition, has the
 $\vec{A}, \vec{N_s}, \vec{r_1}$ = 0, (14)

m:
 N_{Y_0} N_{Z_0} (15)

$$
(\vec{A}, \vec{N_s}, \vec{r_1}) = 0, \qquad (14)
$$

Condition used to determine characteristically curve, in
\nthe case of helical movement decomposition, has the
\nfollowing form:
\n
$$
(\vec{A}, \vec{N_s}, \vec{r_1}) = 0,
$$
 (14)
\nor, in extended form:
\n
$$
\begin{vmatrix}\nN_{X_0} & N_{Y_0} & N_{Z_0} \\
X_0 - a & Y_0 & Z_0 \\
0 & -\cos \omega \sin \omega\n\end{vmatrix} = 0,
$$
 (15)
\nwhere X_0, Y_0, Z_0 are obtained from equations (1-7) using
\nthe transformation:
\n
$$
\begin{vmatrix}\nX_0 \\
Y_0 \\
Z_0\n\end{vmatrix} = \begin{vmatrix}\n\xi \\
\eta \\
\zeta\n\end{vmatrix} - R_r
$$
\n(16)
\nTable 1. Normal vectors for each portions of the rock
\n**portion** Normal vector
\n
$$
\frac{\text{Partial vector}}{\text{S}_{AB}} = (-\cos \omega \vec{i} + \sin \omega \vec{i}) \cos \beta
$$

$$
\begin{vmatrix} X_0 \\ Y_0 \\ Z_0 \end{vmatrix} = \begin{vmatrix} \xi \\ \eta \\ \zeta \end{vmatrix} - \begin{vmatrix} -R_r \\ 0 \\ 0 \end{vmatrix}.
$$
 (16)

following form:	Condition used to determine characteristically curve, in the case of helical movement decomposition, has the
Worm tool's axis or, in extended form: $P\phi_2$	$(\overrightarrow{A}, \overrightarrow{N_s}, \overrightarrow{r_1}) = 0,$ (14)
	$\begin{vmatrix} N_{X_0} & N_{Y_0} & N_{Z_0} \\ X_0 - a & Y_0 & Z_0 \\ 0 & -\cos \omega & \sin \omega \end{vmatrix} = 0,$ (15)
$O_1O_2 = p$ -tg θ the transformation:	where X_0, Y_0, Z_0 are obtained from equations (1-7) using
Fig.2. Decomposition of the helical movement $\begin{bmatrix} Y_0 \\ Z_0 \end{bmatrix} = \begin{bmatrix} \eta \\ \zeta \end{bmatrix} - \begin{bmatrix} 0 \\ 0 \end{bmatrix}$	(16)
Since $N_s \cdot t = 0$, the characteristically curve for surface	
S (rack cylindrical surface) depends only the rotation movement and not the translation component of the movement. Characteristically curve is actually the	Table 1. Normal vectors for each portions of the rack cylindrical surface
Portion projection on surface S of the axis A . S_{AB} Therefore, characteristically curve is the geometric place	Normal vector $\overrightarrow{N_{S_{AB}}} = (-\cos \psi \overrightarrow{i} + \sin \psi \overrightarrow{j}) \cos \beta_d -$
(see 1) of those points of S such that N_s intersects A.	$-\sin \psi \sin \beta_d k$
Let: S_{BC} axis \overrightarrow{A} , in $x_0y_0z_0$ - fixed reference system	$\overrightarrow{N_{S_{BC}}}$ = $(\sin \overrightarrow{\beta i} + \cos \overrightarrow{\beta j}) \cos \overrightarrow{\beta_d}$ –
(see 2) associated to gear hob primary peripheral	$-\cos \beta \sin \beta_d k$
surface, be: S_{CD} $\vec{A} = -\cos \omega \cdot \vec{j} + \sin \omega \cdot \vec{k}$; (10)	$\overrightarrow{N_{S_{CD}}} = (\cos v \overrightarrow{i} - \sin v \overrightarrow{j}) \cos \beta_d +$
(see 3) normal vectors at cylindrical surface S , be:	+ sin $v \sin \beta_d k$
$\overrightarrow{N_s} = N_x \cdot \overrightarrow{i} + N_y \cdot \overrightarrow{j} + N_z \cdot \overrightarrow{k}$, (11) $S_{\scriptscriptstyle\it AH}$ (see 4) see table 1; (coordinates system $\xi \eta \zeta$ has parallel axes	$\overrightarrow{N_{S_{AH}}} = \left(\frac{\partial \eta}{\partial \lambda} \overrightarrow{i} - \frac{\partial \xi}{\partial \lambda} \overrightarrow{j}\right) \cos \beta_d +$
and same orientation as $x_0y_0z_0$)	
current vector be	$+\frac{\partial \xi}{\partial \lambda_1} \sin \beta_d \vec{k}$
$\vec{r}_i = \vec{O_2} \cdot \vec{i} + \vec{r}$, (12) S_{HG}	$\overrightarrow{N_{S_{HG}}} = \left(\frac{\partial \eta}{\partial \lambda_i}\vec{i} - \frac{\partial \xi}{\partial \lambda_i}\vec{j}\right)\cos \beta_d +$
where r is the vector indicating current point on the (see 5) cylindrical surface S and $O_2O = R_{r_s}$ - gear hob radius –	
a technological parameter.	$+\frac{\partial \xi}{\partial \lambda_2} \sin \beta_d \vec{k}$
A similar solution for the same problem can be obtained S $_{FG}$ by replacing profiles in equations (1-3, 6-7) with low degree Bezier polynomials imposing the condition that (see 6)	$\overrightarrow{N_{S_{\scriptscriptstyle{BC}}}} = (-\sin \overrightarrow{\beta_1} \cdot \overrightarrow{i} - \cos \overrightarrow{\beta_1} \cdot \overrightarrow{j}) \cos \overrightarrow{\beta_d} +$
adjacent profiles have continuous tangent. The value of the parameter ω is determined from the S_{EF}	+ cos β_1 sin $\beta_d \vec{k}$ $\overrightarrow{N_{S_{xx}}} = (\cos v_1 \overrightarrow{i} - \sin v_1 \overrightarrow{j}) \cos \beta_d +$
condition that the unfolded helical line of radius Rr is (see 7)	$+\sin v_1 \sin \beta_d k$
parallel to vector t .	Equations $(1-7)$ and condition (15) determine the
$\omega = \beta_d \pm \omega_s$, tan $\omega_s = \frac{p}{R}$. (13)	characteristically curve for each portion of the rack cylindrical surface, denoted by:

Equations $(1-7)$ and condition (15) determine the characteristically curve for each portion of the rack cylindrical surface, denoted by:

This set of curves represents the tangency between surface *S* and gear hub primary peripheral surface.

In helical movement around the axis *V* with helical parameter p , the curve C_S generates gear hub primary peripheral surface:

surface S and gear hub primary peripheral surface.
\nIn helical movement around the axis
$$
\vec{V}
$$
 with helical
\nparameter p, the curve C_S generates gear hub primary
\nperipheral surface:
\n $\begin{vmatrix}\nX_1 \\
Y_1 \\
Z_1\n\end{vmatrix} = \begin{vmatrix}\n\cos \varphi & 0 & \sin \varphi \\
0 & 1 & 0 \\
-\sin \varphi & 0 & \cos \varphi\n\end{vmatrix} \begin{vmatrix}\n1 & 0 & 0 \\
0 & \sin \varphi & \cos \varphi\n\end{vmatrix} \begin{vmatrix}\nX_{C_S} \\
0 & \sin \varphi & \cos \varphi\n\end{vmatrix} = \begin{vmatrix}\nX_{C_S} \\
Y_{C_S} \\
Y_{C_S}\n\end{vmatrix} + \begin{vmatrix}\n0 \\
p\varphi \\
0\n\end{vmatrix}$ \n
\nGear hub primary peripheral surface is a parametric
\nsurface:
\n $\begin{vmatrix}\nX_1 = X_1(\lambda_i, \varphi); \\
Y_1 = Y_1(\lambda_i, \varphi); \\
Z_1 = Z_1(\lambda_i, \varphi), \\
Z_1 = Z_1(\lambda_i, \varphi),$ \nwhere λ_i are generic variables for equations (1-7).
\nImposing the condition
\n $Z_1 = 0$ (18) for the rate, gear reciprocally enwra
\n $\begin{vmatrix}\nX_2 = 0 \\
Y_3 = 0\n\end{vmatrix} = \begin{vmatrix}\nX_1 = 0 \\
Y_2 = 0\n\end{vmatrix}$ \n
\n $\begin{vmatrix}\nX_2 = 0 \\
Y_3 = 0\n\end{vmatrix} = \begin{vmatrix}\nX_3 = 0 \\
Y_4 = 0\n\end{vmatrix}$ \n
\n $\begin{vmatrix}\nX_2 = 0 \\
Y_3 = 0\n\end{vmatrix} = \begin{vmatrix}\nX_3 = 0 \\
Y_4 = 0\n\end{vmatrix}$ \n
\n $\begin{vmatrix}\nX_2 = 0 \\
Y_3 = 0\n\end{vmatrix} = \begin{vmatrix}\nX_3 = 0 \\
Y_4 = 0\n\end{vmatrix}$ \n
\n $\begin{vmatrix}\nX_2 = 0 \\
Y_3 = 0\n\end{vmatrix} = \begin{vmatrix}\nX_3 = 0 \\
Y_4 = 0\n\end{vmatrix} = \begin{vmatrix}\nX_2 = 0 \\
Y_3 = 0\n\end{vmatrix} = \begin{vmatrix}$

Gear hub primary peripheral surface is a parametric surface:

$$
\Pi: \begin{cases} X_1 = X_1(\lambda_i, \varphi); \\ Y_1 = Y_1(\lambda_i, \varphi); \\ Z_1 = Z_1(\lambda_i, \varphi), \end{cases}
$$
 4 C
The pr
ordered

where λ_i are generic variables for equations (1-7). Imposing the condition

$$
Z_1 = 0
$$
 (18) for the r
which and

the axial section of the gear hob is obtained.

Condition (18) represents a relation between λ and φ , language, therefore the action section has a generic form: = $X_1(\lambda_i, \varphi)$;
 $Y_1(\lambda_i, \varphi)$;
 $= Z_1(\lambda_i, \varphi)$,

ariables for equations (1-7).

ariables for equations (1-7).
 $\begin{array}{ll}\n & \text{the profiling m} \\
 \text{ordered profiles} \\
 \text{ariables for equations (1-7).} \\
 \text{the method used with a single graph of the graph of the graph of the graph of the graph.} \\
 & \text{the method used with a single graph of the graph of the graph of the graph.} \\
 & \text{the method used with a single graph of the graph of the graph of the graph$ = $Y_1(\lambda_i, \varphi)$;

= $Z_1(\lambda_i, \varphi)$,

wariables for equations (1-7).

he profiling

variables for equations (1-7).

he profiling

ordered profiling

ordered profiling

ordered profiling

ordered profiling

ordered profiling

$$
\Pi_A: \begin{cases} X_1 = X_1(\lambda_i); & \text{gear no.} \\ Y_1 = Y_1(\lambda_i). \end{cases}
$$

4 Numerical examples

We present further an example of a female rotary helical screw compressor having the following constructive parameters: he distance between the axes of both rotary Gar hub primary peripheral surface is a parametric $\frac{1}{F(g)}$. Software application. Rack profile, gear hob,
 $\text{L} = X_1(\lambda, \varphi)$;
 $\text{L}^1 \cdot \text{L}^2 = X_1(\lambda, \varphi)$;
 $\text{L}^2 = X_1(\lambda, \varphi)$;
 $\text{L}^2 = X_1(\lambda, \varphi)$;
 $\text{L}^2 = X_1$ system are:

D: [-25.267; -52.000]; C: [-24.282; -51.357];

- B: [-19.671;-42.149]; A: [6.938; -30.000];
- G: [20.671; -45.957]; E: [24.057; -51.444];
- F: [24.998; -52.000].

The following table represents several key points of the gear hob axial section.

Table 3. Axial section of the gear hob

X	
46.0000	25.5901
46.1116	25.1343
49.4118	22.5863
46.6735	24.3122
46.1423	24.7947
46.0000	25.3182

Fig.3 . Software application. Rack profile, gear hob, characteristically curve and axial section

4 Conclusion

The profiling method of the gear hub which generates an ordered profiles whirl is based on the principles of the helical motion decomposition.

The method use the Bezier approximation polynomials for the rack-gear reciprocally enwrapping with profiles whirl and is rigorous enough, for usually profiles

and φ , language, was specially design for computing λ): gear hob. A special software, written in Java programming polynomial approximation and the axial section of the

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References:

- [1] Ball, R.S., *A Treatise on the Theory of Screws*, Cambridge University Press, Cambridge, 1990;
- [2] Lukshin, V.S., *Theory of Screw Surfaces in Cutting Tool Design*, Mashinstroyenie, Moscov, 1968;
- [3] Radzevich, S.P., *Kinematic Geometry of Surface Machining*, CRC Press, London, ISBN 978-1-4200-6340-0, 2008;
- [4] Litvin, F.C. *Theory of Gearing*, Reference Publication, 1212, NASA, Scientific and Technical Information Division, Washington, D.C, 1989;
- [5] Oancea, N., Surface generation through Winding, Galati, 2004, ISBN 973-627-206-4;
- [6] Teodor, V., Dima, M., Oancea, N., *Profilarea sculelor prin metode analitice*, Galaţi, 2005, ISBN 973-627-333-4.