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THE DETERMINATION OF RELATIONS FOR CALCULATION BY PROCESSING THE ELLIPTIC PISTON THROUGH THE MILLING AND RECTIFICATION MACHINES WITH NUMERIC COMMAND BY CYLINDRICAL - FRONTAL TOOLS

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Abstract
In this paper is presented a MATLAB Program-module, with the representation the parametric equations of the manufacturing through milling and rectification the elliptic piston of hydraulic rotary motor (or hydraulic pump).

The processing of the elliptic piston may to make too by tools-machinery with numeric command (MT-NC), wherefore successive positions of the milling or rectification tool will displace on the mathematic curve line close, equidistant roundabout contour profile of the ellipse (fig. 1), thereupon and equations to be ascertain by mathematic calculation. Thus, for processing with milling and rectification tools cylindrical-frontal with radius of the cylinder of the tool **R**, is presented on remain method cinematic for determinate parametrical equations of the positions of centre of the manufacturing cylindrical-frontal tool, curve line close up, equidistant roundabout contour profile of the ellipse around by ellipse's contour. Equation of ellipse with the centre in the original of Cartesian system Oxy is:

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}-1=0; \tag{1}$$

were *a* şi *b* – ellipse parameters [mm].

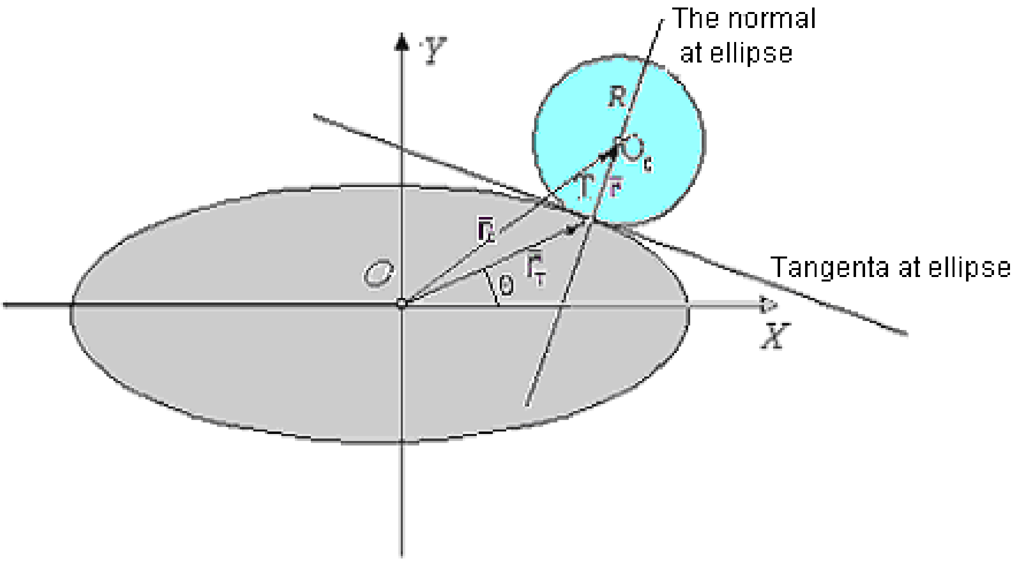

Fig.1. The proceeding of ellipse's contour by manufacturing machinery with numerical command with tools for milling and rectification cylindrical/frontal Centre of the circle from the transversal section of the tool, is moving on the curve line donate by de vectorial equation $\bar{r}_c=\bar{r}_T+\bar{r}$

From equation (1), to result the relation:

$$y = \frac{b}{a}\sqrt{a^2 - x^2} \; ; \tag{2}$$

To take a point from the ellipse: $T(x_{t,}y_t)$;

Thus, result the parametrical coordinate of the vector $\bar{r}_t$ (fig.1). The vectorial equation of the vector $\vec{r}_t$ is:

$$\vec{r}_t = (a \cdot \cos\theta)\vec{i} + (b \cdot \sin\theta)\vec{j} \; ; \tag{3}$$

With projections on the coordinate axes:

$$x_t = a\cos\theta \text{ and } y_t = b\sin\theta ; \tag{4}$$

Were the parameter $\theta \in [0,2\pi]$, and *a, b* are elliptical parameters [mm].

Tangent's equation in the point $T(x_{t,}y_t)$ from ellipse, have expression:

$$y - y_t = f'(x_t)(\; x - x_t \;); \tag{5}$$

Were:

$$f'(x_t) = -\frac{x_t \cdot \frac{b}{a}}{\sqrt{a^2 - x_t^2}} = -\frac{a \cdot cos\,\theta \cdot \frac{b}{a}}{\sqrt{a^2 - a^2 \cdot cos^2\theta}} = -\frac{b \cdot cos\,\theta}{a \cdot sin\,\theta} = -\frac{b}{a} \cdot tg\,\theta \; ; \tag{6}$$

Tangent's equation became:

$$y - a \cdot cos\,\theta = -\frac{b}{a} \cdot tg\,\theta(\; x - b \cdot sin\,\theta \;); \tag{7}$$

Translation of the equation of tangent in parametrical equation: $y = mx + n$, became:

$$y = -\frac{b}{a}\frac{x_t}{\sqrt{a^2 - x_t^2}} \cdot x + y_t + \frac{b}{a}\frac{x_t^2}{\sqrt{a^2 - x_t^2}} \; ; \tag{8}$$

Were:

$$m = -\frac{b}{a}\frac{x_t}{\sqrt{a^2 - x_t^2}} \quad \text{and} \quad n = y_t + \frac{b}{a}\frac{x_t^2}{\sqrt{a^2 - x_t^2}} \; ; \tag{9}$$

and trough substitution the expressions (4) x_t and y_t:

$$m = -\frac{b}{a}\frac{a\cos\theta}{\sqrt{a^2 - a^2\cos^2\theta}} = -\frac{b}{a} \cdot \frac{\cos\theta}{\sin\theta} \; ; \tag{10}$$

$$n = b\sin\theta + \frac{b}{a}\frac{a^2\cos^2\theta}{\sqrt{a^2 - a^2\cos^2\theta}} = b\sin\theta + b\frac{\cos^2\theta}{\sin\theta} = \frac{b}{\sin\theta} \; ; \tag{11}$$

Result parametrical equation of the tangent at ellipse:

$$y = -\frac{b}{a} \cdot \frac{\cos\theta}{\sin\theta} \cdot x + \frac{b}{\sin\theta} \; ; \tag{12}$$

The parametrical equation of the normal at ellipse in the point $T(x_{t,}y_t)$ has expression:

$$y = -\frac{1}{m}x + n ; \tag{13}$$

Were m is the coefficient angular by tangent at ellipse, and *n ordinate* at origin for tangent at ellipse. Through substitution of the parameters (10 and 11), obtain parametrical equation of the normal at ellipse:

$$y=\frac{a\cdot\sin\theta}{b\cdot\cos\theta}\cdot x+b\cdot\frac{\sin^2\theta\cdot+\cos^2\theta}{\sin\theta}=\frac{a}{b}\cdot tg\theta\cdot x+\frac{b}{\sin\theta}; \tag{14}$$

result therefore:

$$m_{norm}=tg\alpha=\frac{OB}{OA}=\frac{a}{b}\cdot tg\theta; \tag{15}$$

Were the angle α is among the normal at ellipse's contour and the axis Ox.
The vectorial equation of the vector $\vec{r}$ is:

$$\vec{r}=(R\cos\alpha)\vec{i}+(R\sin\alpha)\vec{j}\,; \tag{16}$$

Were R [*mm*] is radius of the section for cylindrical-frontal tool al sculei.

Trough substitution the trigonometric functions $\sin\alpha$ and $\cos\alpha$ in function by $tg\alpha$ from expressions (19), result:

$$\begin{cases}\sin\alpha=\dfrac{tg\alpha}{\sqrt{1+tg^2\alpha}}=\dfrac{\frac{a}{b}\cdot tg\theta}{\sqrt{1+\frac{a^2}{b^2}\cdot tg^2\theta}}=\dfrac{a\cdot\sin\theta}{\sqrt{b^2\cos^2\theta+a^2\sin^2\theta}}\,;\\[2ex] \cos\alpha=\dfrac{1}{\sqrt{1+tg^2\alpha}}=\dfrac{1}{\sqrt{1+\frac{a^2}{b^2}\cdot tg^2\theta}}=\dfrac{b\cdot\cos\theta}{\sqrt{b^2\cos^2\theta+a^2\sin^2\theta}}\end{cases} \tag{17}$$

With relation (17), result the parametrical equation of the vector $\vec{r}$:

$$\vec{r}=\left(R\cdot\frac{b\cdot\cos\theta}{\sqrt{b^2\cdot\cos^2\theta+a^2\cdot\sin^2\theta}}\right)\cdot\vec{i}+\left(R\cdot\frac{a\cdot\sin\theta}{\sqrt{b^2\cdot\cos^2\theta+a^2\cdot\sin^2\theta}}\right)\cdot\vec{j}\quad; \tag{18}$$

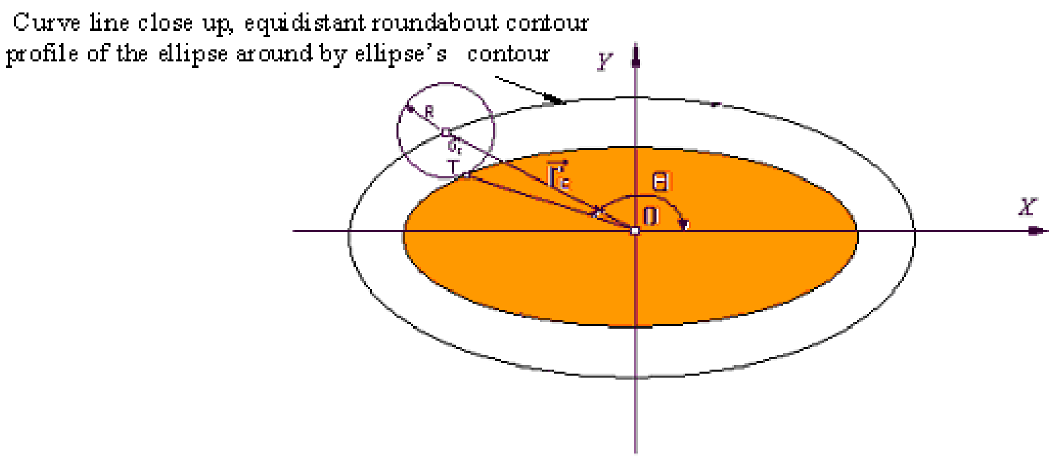

Fig. 2. Curve line close up, equidistant roundabout contour profile of the ellipse around by ellipse's contour

The vector point's position O_c, witch is the centre of the circle by cylindrical-frontal tool, became: $\bar{r}_c=\bar{r}_T+\bar{r}\,;$

Through projection on the coordinate axis, result *parametrical equations* of the curve line equidistance were go on the circle's centre O_c (fig .2), that is axis of the cylindrical-frontal tool:

$$\begin{cases} x_c = a \cdot \cos\theta + R \cdot \dfrac{b \cdot \cos\theta}{\sqrt{b^2 \cdot \cos^2\theta + a^2 \cdot \sin^2\theta}} \\ y_c = b \cdot \sin\theta + R \cdot \dfrac{a \cdot \sin\theta}{\sqrt{b^2 \cdot \cos^2\theta + a^2 \cdot \sin^2\theta}} \end{cases} ; \qquad (19)$$

For assign the close curvilinear (fig. 3), equidistant around by the ellipse's contour, using succession numeric values of the rotary elliptic piston: a = 44 [*mm*] and b = 15 [*mm*], and diameter's tool d_s = 20 [*mm*].The program for processing ellipse's contour has been on the computer machinery SIEMENS NC-00-12.

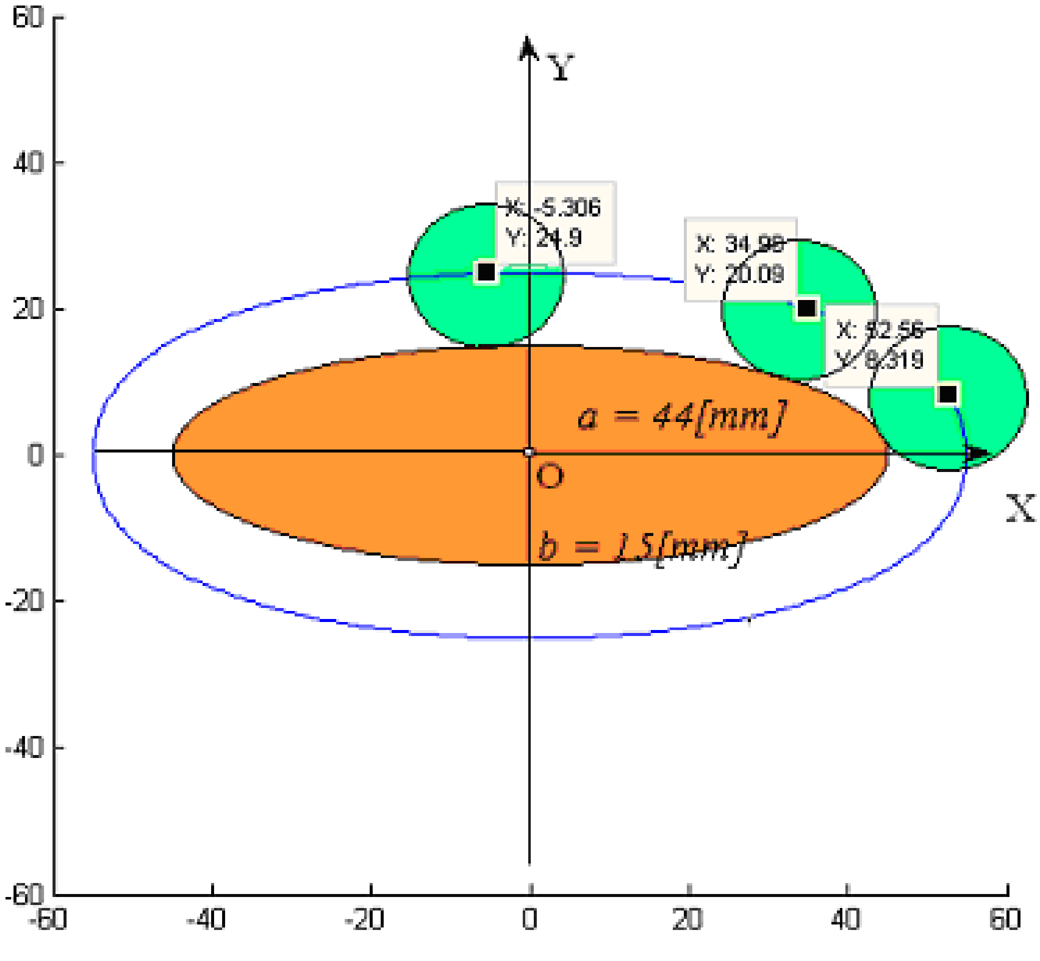

Fig. 3. The program for processing ellipse's contour has been on the computer by machine SIEMENS NC-00-12.

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