При современном уровне программного обеспечения, появления прикладных графических программ, таких как КОМПАС, AutoCAD, T-FLEX и др., язык начертательной геометрии и инженерной графики стал понятен компьютеру. Использование графических редакторов позволяет получать точное графическое решение задач на экране монитора и требует только элементарной компьютерной грамотности. Они позволяют выполнять точность аналитических методов решения задач и наглядность графического решения. Это открывает большие возможности использования компьютеров для повышения эффективности обучения графическим дисциплинам и геометрическому моделированию.

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DESIGNING TUNNEL-SHAPED SURFACES WITH THE USE OF BIQUADRATE TRANSFORMATION

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Designing and building a surface of the tunnel shape demands considerable time and expenses. Therefore perfection of the methods of designing surfaces of underground construction is an actual problem in mine building. It is well known that tunnel surfaces represent complex curvilinear surfaces ought to correspond to the requirements set beforehand.

In the article a new method of designing a surface of the tunnel shape by the conditions set beforehand and using the biquadrate plain transformation of L-type is considered. The article describes designing each section of the tunnel by one equation.

1. The way of receiving curves with the use of biquadrate transformations of *L*-type

The surface section can be set in various ways [1]. In the offered method the prototype (curve) is exposed to geometrical transformation of L-type. Thus the image (required n' curve) [2] turns out. The prototype is set by following equation:

$$x_2 = kx_1 + m,$$

where: k, m are constant factors.

Biquadrate transformation of L_B-type is set by following equations:

$$\begin{cases} x_1' = \sqrt{x_1^2 + x_2^2}, \\ x_2' = \sqrt{x_2^2 - x_1^2} \end{cases} \qquad \begin{cases} x_1 = \sqrt{\dfrac{x_1'^2 - x_2'^2}{2}}, \\ x_2 = \sqrt{\dfrac{x_1'^2 + x_2'^2}{2}} \end{cases}$$

here: x_1' & h_2' are the coordinates of points of an image;
x_1 & x_2 are the coordinates of points of a prototype.

The equation of the received curve p' registers in a kind:

$$\sqrt{\frac{x_1'^2 + x_2'^2}{2}} = k\sqrt{\frac{x_1'^2 - x_2'^2}{2}} + m,$$

here: k & m are constant factors.

2. Designing a surface of the tunnel shape by parameters set beforehand

The essence of transformation consists in following. A few points are taken of the prototype n in conformity. Then each of the points is altered in L-type transformation (fig.-1). We can find sets of points, smoothly connected with each other giving a curve image n'. The n' curve form depends on values of m & k factors of the n prototype.

Fig. - 1

The tunnel surface is formed in a result of moving of the fourth degree flat curve (section) by the axis of the directing curve.

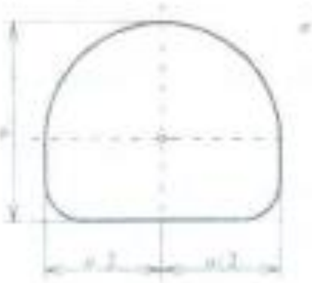

Fig. - 2

Using graphic model of biquadrate *L*-type transformation we design the form of the channel tunnel surface in the following way:

1. Initial data for solving this problem are the axial line channel surface of the tunnel and the laws of changing of the parameters of a and b cross-sections (Figures 2 & 3).

Each cross-section of n tunnel is the fourth degree curve received by the use of *L*-type biquadrate transformation. Thus a and b parameters of each cross-section are defined in formulas:

$$\begin{matrix} a = \gamma(l), \\ b = \gamma(l) \end{matrix} \qquad (1)$$

ere l is distance from the beginning of the tunnel to considered cross-section.

2. We use the biquadrate transformation of *L*-type set by the equations:

$$\begin{cases} x_1' = \sqrt{x_1^2 + x_2^2} \\ x_2' = \sqrt{x_1^2 - x_2^2} \end{cases} \qquad (2)$$

here x_1, x_2 are the coordinates of a point of a prototype;

- x_1', x_2' are the coordinates of a point of an image.

3. As a prototype we accept general degree straight line n which in equation looks like:

$$x_2 = kx_1 + m, \qquad (3)$$

here k & m are constant factors.

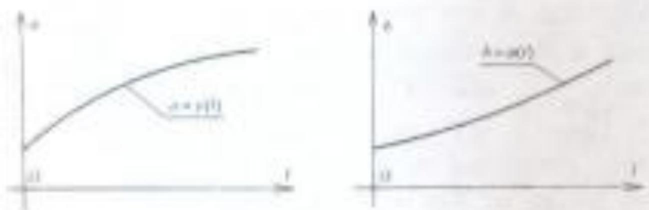

Fig. - 3

4. We determine factors k and m of the equations (3). For this purpose we use properties of L-type biquadrate transformation:

a) B prototype point and image point B_2' have identical height indications. Point B_2' is a sketch point of n' section. Therefore B point of n prototype has co-ordinates as:

$$x_{1_B} = 0, \tag{4}$$

$$x_{2B} = \frac{a}{2}. \tag{5}$$

b) C prototype point is transformed to image points $C_1' = C_3'$ and $C_2' = C_4'$ laying on Ox_1 axis. Point C_1' has coordinates $(b+c;\ 0)$. The point corresponds to C_1' and has coordinates coordinates satisfying a condition:

$$x_{1_C} = x_{2_C}. \tag{6}$$

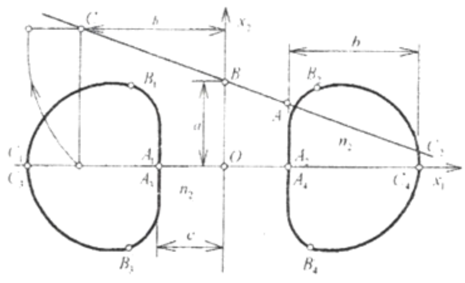

Fig.- 4

Let's define point C coordinates. From a course of construction of C_1' point receiving of the following equation is possible:

$$(b+c)^2 = x_{1_C}^2 + x_{2_C}^2, \tag{7}$$

here $c = a/2$.

Considering a condition (6), from the equation (7) we receive

$$(b+c)^2 = 2x_{1_C}^2,$$

or

$$x_{1_C}^2 = \frac{(b+c)^2}{2} = x_{2_C}^2 \tag{8}$$

The prototype n passes through points B and C. Considering the condition following system of equation turns up:

$$\begin{cases} \frac{a}{2} = k \cdot 0 + m, \\ \frac{b+c}{\sqrt{2}} = k\frac{b+c}{\sqrt{2}} + m \end{cases} \quad (9)$$

Having solved this system of the equations, we receive:

$$m = \frac{a}{2}, \quad (10)$$

$$k = 1 - \frac{a(2b+a)}{2\sqrt{2}}. \quad (11)$$

5. Subjecting a prototype n to biquadrate transformation of L-type, we receive required section of the tunnel satisfying the conditions set beforehand. The algebraic equation of this section looks like:

$$x_1^{\prime\prime} + x_2^{\prime\prime}(k^2+2) + \left(\frac{m}{k}\right)^2 = 0, \quad (12)$$

here k & m *are* the parameters of a prototype described by equations 10 and 11.

The parametrical equation of the section of the tunnel looks like:

$$\begin{cases} x_1' = \sqrt{x_1^2 + (kx_1 + m)^2} \\ x_2' = \sqrt{(kx_1 + m) - x_1^2} \end{cases}, \quad (13)$$

here: x_1 parameters are $\frac{(b+c)^2}{2} \le x_1 \le \frac{c}{\sqrt{2}}$;

$$m = \frac{a}{2};\ k = 1 - \frac{a(2b+a)}{2\sqrt{2}}.$$

6. Similarly we design any demanded section of considered surface of the tunnel (Figure 5).

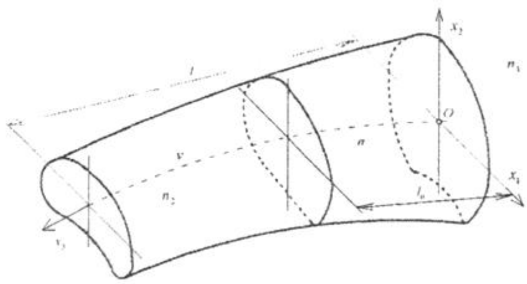

Fig. – 5

7. The equation of the channel tunnel surface registers in a kind:

$$\begin{cases} x_3 = f(x_1), \\ x_2 = l_0. \end{cases} \tag{14}$$

here $f(x_1)$ is the function describing a contour of cross-section of the tunnel; l_0 is the distance from cross-section prior to the beginning of the tunnel, $x_3^{begin} \leq l_0 \leq x_3^{end}$.

Thus, the offered method of designing with use of biquadrate transformation allows to receive various classes channel surfaces and to define the equation of family of cross-sections of the considered surface, that facilitates the further geometrical calculations on the computer.

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