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DEFINITION OF POSITIONS AND SPEEDS OF LINKS OF MECHANISMS OF HIGH CLASSES

Abstract. In this work the analytical method of definition of positions and speeds of any mechanisms of high classes and an exact method of the kinematic analysis of transmission mechanisms of high classes are for the first time offered. The offered approach allowed developing the software according to the kinematic analysis of these mechanisms. The transmission mechanism of IV class is for the first time synthesized.

Keywords: kinematics, mechanism of high classes, position, speed.

1. Introduction. Mechanisms of high classes possess unique opportunities and properties of adaptation to external influences due to circulation of power on the closed contours. These mechanisms can maintain considerable power loadings, lift the mass of big size, operate many parameters, etc. Therefore the classification of mechanisms on the low and high classes offered by academicians I. I. Artobolevsky [1], U.A. Dzholdasbekov [2] has very important scientific and practical value. Originally it is necessary to carry any mechanisms with group of Assur of high classes and special to mechanisms of general purpose – the transfer, directing and moving mechanisms of high classes. Such classification allows developing the general theory of mechanisms of the first group for the purpose of detection of their functionality, and for the second – theoretical bases of calculation of kinematic, power and dynamic parameters and design of mechanisms with the set certain characteristics.

Further, these results can be used at design of lifting devices, working bodies of digging cars, robots with the closed contours, separate devices of aircraft, etc.

2. Kinematic analysis of the mechanism of high classes of general purpose. For the kinematic analysis of any mechanisms of high classes we use approach of work [3].

Statement of tasks. Let the mechanism of high classes consist of n of mobile links. Numbers of output links change from $\overline{1, n-m}$, and entrance from $j = \overline{n-m+1, n}$. Then the vector equations for the mechanism with group of Assur IV class with rotary couples and two degrees of freedom are representable in the form of (fig. 1).

$$\begin{aligned} &\vec{l}_1 + \vec{l}_2 + \vec{l}_3 + \vec{l}_5 - \vec{l}_6 - \vec{l}_0 = 0 \\ &\vec{l}_1^{\,*} + \vec{l}_3^{\,*} + \vec{l}_4 + \vec{l}_5 - \vec{l}_6 - \vec{l}_0 = 0 \end{aligned} \tag{1}$$

where $\vec{l}_i$, $i = \overline{1,4}$, $\vec{l}_j$, $j = 5, 6$. The Asterisk "*" means accessory of a vector $\vec{l}_i^{\,*}$ – to a basic link.

These equations (1) can be presented in projections to axes of motionless system of coordinates

$$\begin{aligned} &l_1 \cos\varphi_1 + l_2 \cos\varphi_2 + l_3 \cos\varphi_3 + l_5 \cos\varphi_5 - l_6 \cos\varphi_6 - l_0 \cos\varphi_0 = 0 \\ &l_1 \sin\varphi_1 + l_2 \sin\varphi_2 + l_3 \sin\varphi_3 + l_5 \sin\varphi_5 - l_6 \sin\varphi_6 - l_0 \sin\varphi_0 = 0 \\ &l_1^* \cos(\varphi_1 - \alpha_1) + l_3^* \cos(\varphi_3 - \alpha_3) + l_4 \cos\varphi_4 + l_5 \cos\varphi_5 - l_6 \cos\varphi_6 - l_0 \cos\varphi_0 = 0 \\ &l_1^* \sin(\varphi_1 - \alpha_1) + l_3^* \sin(\varphi_3 - \alpha_3) + l_4 \sin\varphi_4 + l_5 \sin\varphi_5 - l_6 \sin\varphi_6 - l_0 \sin\varphi_0 = 0 \end{aligned} \tag{2}$$

The task 1 is set. To find provisions of output links of the mechanism with group IV of a class of Assur at the set laws of the movement of entrance links and dimensional parameters of mechanisms of high classes:

$$\varphi_i = \varphi_i(\varphi_5, \varphi_6, P), \quad i = \overline{1,4}, \tag{3}$$

where $P = \{l_1, l_1^*, l_2, l_3, l_3^*, l_4, l_5, l_6, \alpha_1, \alpha_3, l_0, \varphi_0\}$, φ_5, φ_6 – the generalized angular coordinates, φ_i – angular coordinates of output links.

The vector form of record of kinematics equation is widely applied at research of lever mechanisms. Vector transformations accelerate process of an exception of variables, without passing to other forms of record of the equations of kinematics, such as system of the trigonometrical equations or system of the algebraic equations.

Analytical method of definition of positions and speeds of output links mechanism of the high classes. For vector approach from the first equation of system (3) we define $\vec{l_2}$, and from the second – $\vec{l_4}$ and further applying a scalar product, we have

$$\begin{aligned} \left(\vec{l}_2\right)^2 &= \left(\vec{l}_1 + \vec{l}_3\right)^2 + 2\left(\vec{l}_1 + \vec{l}_3\right)\left(\vec{l}_5 - \vec{l}_6 - \vec{l}_0\right) + \left(\vec{l}_5 - \vec{l}_6 - \vec{l}_0\right)^2 \\ \left(\vec{l}_4\right)^2 &= \left(\vec{l}_1^* + \vec{l}_3^*\right)^2 + 2\left(\vec{l}_1^* + \vec{l}_3^*\right)\left(\vec{l}_5 - \vec{l}_6 - \vec{l}_0\right) + \left(\vec{l}_5 - \vec{l}_6 - \vec{l}_0\right)^2 \end{aligned} \tag{4}$$

After simple transformations of this system (4) for finding of vectors $\vec{l}_1$ and $\vec{l}_1^*$, we will receive special system of the scalar equations of a look:

$$\begin{aligned} 2\left(\vec{l}_3 + \vec{l}_5 - \vec{l}_6 - \vec{l}_0\right)\vec{l}_1 &= l_2^2 - l_1^2 - l_3^2 - \left(\vec{l}_5 - \vec{l}_6 - \vec{l}_0\right)^2 - 2\vec{l}_3\left(\vec{l}_5 - \vec{l}_6 - \vec{l}_0\right) \\ 2\left(\vec{l}_3^* + \vec{l}_5 - \vec{l}_6 - \vec{l}_0\right)\vec{l}_1^* &= l_4^2 - l_1^* - l_3^{*2} - \left(\vec{l}_5 - \vec{l}_6 - \vec{l}_0\right)^2 - 2\vec{l}_3^*\left(\vec{l}_5 - \vec{l}_6 - \vec{l}_0\right) \end{aligned} \tag{5}$$

Here it should be noted that it $\vec{l}_1^*$ is connected with $\vec{l}_1$, $\vec{l}_3^*$ and with $\vec{l}_3$, l_i – vector length, $\vec{l}_i$, $\vec{l}_i \cdot \vec{l}_i$ and $\left(\vec{l}_i + \vec{l}_j\right)^2$ are understood as scalar product of vectors. In this system angular coordinates φ_2, φ_4 of vectors $\vec{l}_2$ and $\vec{l}_4$ are excluded.

The last system in a scalar form has an appearance:

$$\begin{aligned} A_1x_1 + B_1y_1 &= D_1 \\ A_2x_1 + B_2y_1 &= D_2 \\ x_1^2 + y_1^2 &= 1, \end{aligned} \tag{6}$$

where

$x_1 = \cos(\varphi_1), y_1 = \sin(\varphi_1)$, $x_1^* = x_1\cos\alpha_1 + y_1\sin\alpha_1$, $y_1^* = x_1\sin\alpha_1 - y_1\cos\alpha_1$,

$x_3 = \cos(\varphi_3), y_3 = \sin(\varphi_3)$, $x_3^* = x_3\cos\alpha_3 + y_3\sin\alpha_3$, $y_3^* = x_3\sin\alpha_3 - y_3\cos\alpha_3$,

$x_4 = \cos(\varphi_4), y_4 = \sin(\varphi_4)$, $x_5 = \cos(\varphi_5), y_5 = \sin(\varphi_5)$, $x_6 = \cos(\varphi_6), y_6 = \sin(\varphi_6)$.

$A_1 = 2(l_3x_3 + l_5x_5 - l_6x_6 - l_0)l_1$, $B_1 = 2(l_3y_3 + l_5y_5 - l_6y_6)l_1$,

$D_1 = l_2^2 - l_1^2 - l_3^2 - (l_5x_5 - l_6x_6 - l_0)^2 - (l_5y_5 - l_6y_6)^2 -$
$- 2l_3x_3(l_5x_5 - l_6x_6 - l_0) - 2l_3y_3(l_5y_5 - l_6y_6)$,

$A_2 = 2\left(l_3^*x_3 + l_5x_5 - l_6x_6 - l_0\right)l_1^*\cos\alpha_1 - 2\left(l_3^*y_3 + l_5y_5 - l_6y_6\right)l_1^*\sin\alpha_1$,

$B_2 = 2\left(l_3^*x_3 + l_5x_5 - l_6x_6 - l_0\right)l_1^*\sin\alpha_1 + 2\left(l_3^*y_3 + l_5y_5 - l_6y_6\right)l_1^*\cos\alpha_1$,

$D_2 = l_4^2 - l_1^{*2} - l_3^{*2} - (l_5x_5 - l_6x_6 - l_0)^2 - (l_5y_5 - l_6y_6)^2 -$
$- 2l_3^*(l_5x_5 - l_6x_6 - l_0)x_3^* - 2l_3^*(l_5y_5 - l_6y_6)y_3^*$.

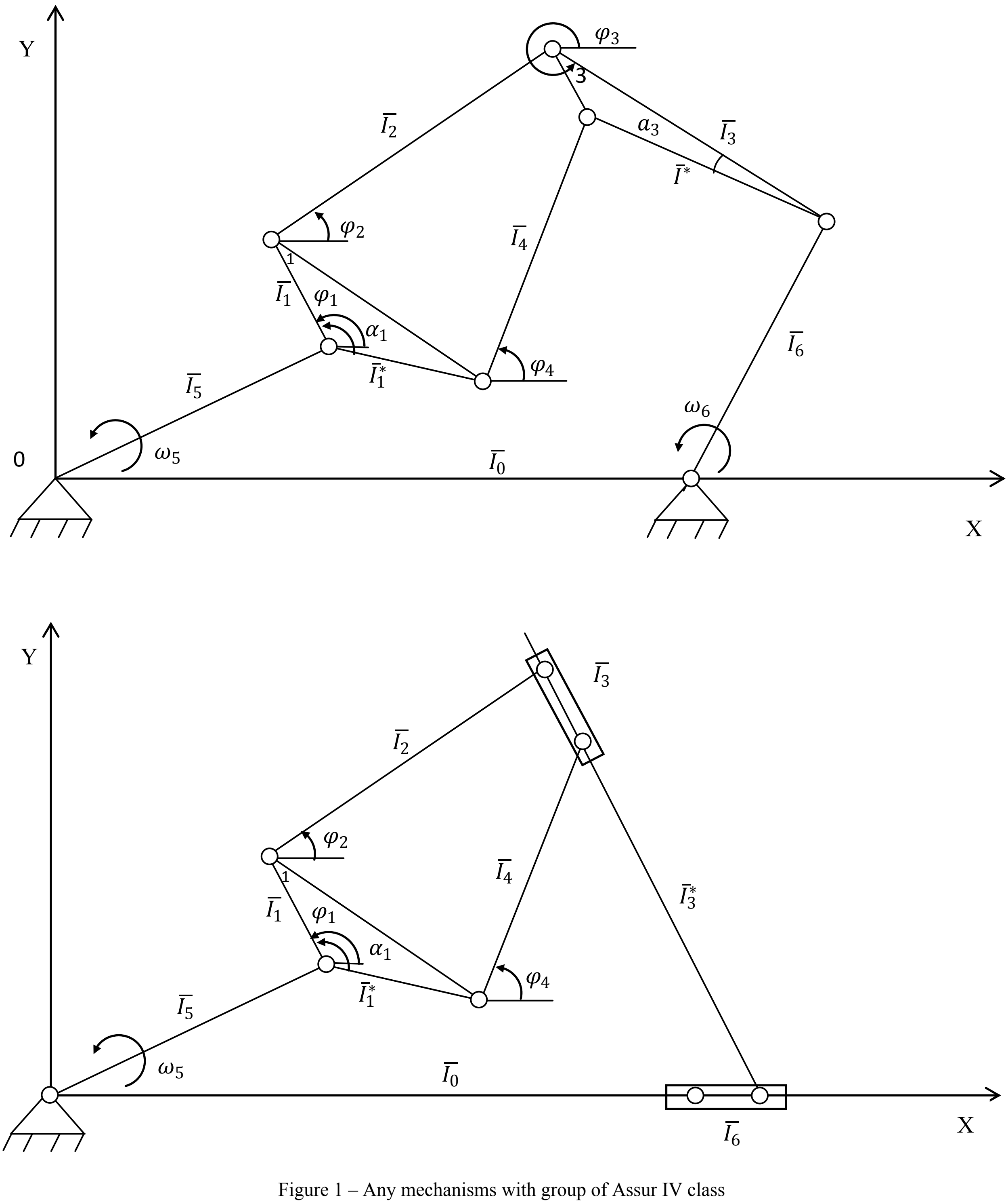

Figure 1 – Any mechanisms with group of Assur IV class

Originality of approach consists in transition from system (6) after application of universal substitution to system of quadratic equations:

$$(A_1 + D_1)u^2 - 2B_1u + D_1 + A_1 = 0 \qquad (7)$$

$$(A_2 + D_2)u^2 - 2B_2u + D_2 - A_2 = 0.$$

It is originally necessary to define materiality of decisions of nonlinear system (6). For this purpose we will find discriminants of these equations (7).

$C_1 = A_1^2 + B_1^2 - D_1^2$, $C_2 = A_2^2 + B_2^2 - D_2^2$. Then there are real decisions of system (2) and (6) if: or $C_1 > 0$, $C_2 > 0$, or $C_1 \geq 0, C_2 > 0$, or $C_1 > 0, C_2 \geq 0$. These conditions provide independence of the equations (7).

Discriminants represent algebraic inequalities of the fourth degree concerning a variable. Therefore it is easy to determine ranges of change of this variable on the basis of /4/. These provisions are the cornerstone of the offered algorithm of definition of provisions of output links of the mechanism IV of a class and allow solving a problem of speeds.

The task 2 is set. To find speeds of output links of the mechanism with group of Assur IV class at the set speeds of the movement of entrance links.

The system of the equations of speeds in a matrix form is:

$$\begin{pmatrix} a_{11} & a_{12} & a_{13} a_{14} \\ a_{21} & a_{22} & a_{23} a_{24} \\ a_{31} & a_{32} & a_{33} a_{34} \\ a_{41} & a_{42} a_{43} & a_{44} \end{pmatrix} \begin{pmatrix} \dot{\varphi}_1 \\ \dot{\varphi}_2 \\ \dot{\varphi}_3 \\ \dot{\varphi}_4 \end{pmatrix} = \begin{pmatrix} b_{11} b_{12} \\ b_{21} b_{22} \\ b_{31} b_{32} \\ b_{41} b_{42} \end{pmatrix} \begin{pmatrix} \dot{\varphi}_6 \\ \dot{\varphi}_5 \end{pmatrix} \tag{8}$$

where $a_{11} = l_1 y_1$, $a_{12} = l_2 y_2$, $a_{13} = l_3 y_3$, $a_{14} = 0$,$a_{21} = l_1 x_1$, $a_{22} = l_2 x_2$, $a_{23} = l_3 x_3$, $a_{24} = 0$, $a_{31} = l_1^* y_1^*$, $a_{32} = 0$, $a_{33} = l_3^* y_3^*$, $a_{34} = l_4 y_4$, $a_{41} = l_1^* x_1^*$, $a_{42} = 0$, $a_{43} = l_3^* x_3^*$, $a_{44} = l_4 x_4$, $b_{11} = l_6 y_6$, $b_{12} = -l_5 y_5$, $b_{21} = l_6 x_6$, $b_{22} = -l_5 x_5$, $b_{31} = b_{11}$, $b_{32} = b_{12}$, $b_{41} = b_{21}$, $b_{42} = b_{22}$.

From system of the linear equations (6) speeds of output links of the mechanism are defined. However in this system (8) elements of a matrix A are unknown functions: $\varphi_i = \varphi_i(\varphi_5, P)$, $i = \overline{1,4}$.

The offered approach of determination of speeds of output links of the mechanism leans on the vector equations (5) which are presented in a differential form:

$$(l_3 + l_5 - l_6 - l_0)\dot{l}_1 + (l_1 + l_5 - l_6 - l_0)\dot{l}_3 = (l_5 - l_6 - l_0)(\dot{l}_5 - \dot{l}_6) \tag{9}$$

$$(l_3^* + l_5 - l_6 - l_0)\dot{l}_1^* + (l_1^* + l_5 - l_6 - l_0)\dot{l}_3^* = (l_5 - l_6 - l_0)(\dot{l}_5 - \dot{l}_6),$$

$$\dot{l}_2 = -\dot{l}_1 - \dot{l}_3 - \dot{l}_5 + \dot{l}_6, \tag{10}$$

$$\dot{l}_4 = -\dot{l}_1^* - \dot{l}_3^* - \dot{l}_5 + \dot{l}_6.$$

In a scalar form system (9) we will write down in a look:

$$(-A_1 y_1 + B_1 x_1)\dot{\varphi}_1 + \left(\frac{\partial A_1}{\partial \varphi_3} x_1 + \frac{\partial B_1}{\partial \varphi_3} y_1 - \frac{\partial D_1}{\partial \varphi_3}\right)\dot{\varphi}_3 = \frac{\partial D_1}{\partial \varphi_5}\dot{\varphi}_5 + \frac{\partial D_1}{\partial \varphi_6}\dot{\varphi}_6 \tag{11}$$

$$(-A_2 y_1 + B_2 x_2)\dot{\varphi}_1 + \left(\frac{\partial A_2}{\partial \varphi_3} x_1 + \frac{\partial B_2}{\partial \varphi_3} y_1 - \frac{\partial D_2}{\partial \varphi_3}\right)\dot{\varphi}_3 = \frac{\partial D_2}{\partial \varphi_5}\dot{\varphi}_5 + \frac{\partial D_2}{\partial \varphi_6}\dot{\varphi}_6.$$

где

$\frac{\partial A_1}{\partial \varphi_3} = -2 l_1 l_3 y_3$, $\frac{\partial B_1}{\partial \varphi_3} = 2 l_1 l_3 x_3$,$\frac{\partial D_1}{\partial \varphi_3} = +2 l_3 x_3 (l_5 x_5 - l_6 x_6 - l_0 x_0) - -2 l_3 x_3 (l_5 y_5 - l_6 y_6 - l_0 y_0)$,$\frac{\partial A_2}{\partial \varphi_3} = -2 l_1^* l_3^* cos\varphi_1 y_3^* - 2 l_1^* l_3^* sin\varphi_1 x_3^*$, $\frac{\partial B_2}{\partial \varphi_3} = -2 l_1^* l_3^* sin\varphi_1 y_3^* - 2 l_1^* l_3^* cos\varphi_1 x_3^*$,$\frac{\partial D_2}{\partial \varphi_3} =$ $2 l_3^* (l_5 x_5 - l_6 x_6 - l_0 x_0) y_3^* - 2 l_3^* (l_5 y_5 - l_6 y_6 - l_0 y_0) x_3^*$.

Then from system (11) we determine speeds $\dot{\varphi}_1$ and$\dot{\varphi}_3$, and then – from (10)

$$\dot{\varphi}_2 = (l_6 y_6 \dot{\varphi}_6 - l_5 y_5 \dot{\varphi}_5 - l_1 y_1 \dot{\varphi}_1 - l_3 y_3 \dot{\varphi}_3)/l_3 y_3,$$

$$\dot{\varphi}_4 = (l_6 y_6 \dot{\varphi}_6 - l_5 y_5 \dot{\varphi}_5 - l_1^* y_1^* \dot{\varphi}_1 - l_3^* y_3^* \dot{\varphi}_3)/l_4 y_4.$$

This offered approach of determination of speeds directly comprises an analytical method of definition of provisions.

3. Design of the mechanism of high classes of a special purpose. In case of mechanisms of a special purpose, i.e., the transmission gear has to consider communication between angular coordinates of some output links with the entrance. Here for simplicity of calculations it is supposed that $l_6 = 0$. Without loss communities, it is possible to put that communication has a concrete appearance:

$$\varphi_3 = \frac{1}{3}\varphi_5 \tag{12}$$

Originally we will substitute the angular coordinate (12) in known coefficients A_1, B_1, D_1, A_2, B_2, D_2, then x_3, y_3 functions will take a form:

$$x_3 = \cos(\frac{1}{3}\varphi_5), \quad y_3 = \sin(\frac{1}{3}\varphi_5) \tag{13}$$

Thus, coefficients $A_1, B_1, D_1,\ A_2, B_2, D_2$ only in an obvious form depend on the generalized angular coordinate φ_5 and lengths of links. Then from system (10) we define

$$x_1 = \frac{D_1B_2 - D_2B_1}{A_1B_2 - A_2B_1}, \quad y_1 = \frac{A_1D_2 - A_2D_1}{A_1B_2 - A_2B_1}. \tag{14}$$

Substituting the found sizes (13) in system (2) taking into account (12), we find trigonometrical functions x_2, y_2, x_4, y_4, and speeds of output links are determined by differentiation by time.

The essence of an exact method of definition of provisions and speeds of links of the special mechanism IV of a class consists in it. This exact method of the kinematic analysis easily extends on other mechanisms of high classes.

For confirmation of the received results the transmission gear IV of a class providing communication between angular coordinates of entrance l_5 and output l_3 links in the form of a ratio (12) (fig. 2) is given. The special mechanism of high classes with rotary couples possessing the set properties according to communication (12) is synthesized.

This transmission mechanism of IV class has the following geometrical sizes:

$l_0 = OD = 51mm,\ l_1 = AB = 26\,mm,\ l_1^* = AC = 19mm,\ l_2 = BF = 77\,mm,\ l_3 = FD = 99\,mm,$ $l_3^* = ED = 109\,mm,\ l_4 = EC = 56\,mm,\ l_5 = OA = 26\,mm,\ l_6 = 0\,mm,\ \alpha_1 = 46^0, \alpha_3 = 8^0.$

At the solution of a problem of kinematics it is considered set the law of change of the generalized coordinate of an entrance link 5 from time t. Then the equation of communication (12) has an appearance: $\varphi_3(t) = \frac{1}{3}\varphi_5(t)$. Other angular coordinates are determined by a formula (14) and from initial system (2) which represents already linear system. In this case speeds of links are differentiation of the found angular coordinates.

4. Algorithm of the solution of a problem of kinematics of mechanisms of high classes. Step 1. Input of dimensional parameters: lengths of links - $l_0,\ l_1,\ l_2,\ l_3,\ l_4,\ l_5,\ l_1^*,\ l_3^*$, corners of links 1 and 3- $\alpha_1,\ \alpha_3$. Range of change of angular coordinate of an entrance link 5:$\varphi_5^{min}, \varphi_5^{max}$. Possible range of change of angular coordinate of an entrance link 3: $\varphi_3^{min}, \varphi_3^{max}$Iteration step – h, accuracy – ε..

Step 2. We set initial approximations for an external cycle $\varphi_5 = \varphi_5^{min}$and internal cycle $\varphi_3 = \varphi_3^{min}$

Step 3. We calculate coefficients $A_1, B_1, D_1,\ A_2, B_2, D_2$

Step 4. We calculate determinant $H = A_1B_2 - A_2B_1 \neq 0$, discriminats- C_1, C_2.

Step 5. Check $C_1 \geq 0, C_2 \geq 0, H \neq 0$If conditions are satisfied:

$x_1 = \frac{C_1B_2 - C_2B_1}{H}, y_1 = \frac{A_1C_2 - A_2C_1}{H}, R_1 = x_1^2 + y_1^2 - 1, \varphi_3 = \varphi_3^{min} + h$

Step 6. We calculate $A_1, B_1, C_1, A_2, B_2, C_2, H_1,\ D_1, D_2$;

Step 7. Check $D_1 \geq 0, D_2 \geq 0, H_1 \neq 0$

If conditions are satisfied $x_1 = \frac{C_1B_2 - C_2B_1}{H}, y_1 = \frac{A_1C_2 - A_2C_1}{H}$,$R_2 = \overline{x_1^2} + \overline{y_1^2} - 1$

If conditions aren't satisfied, we pass to a step 9, otherwise

Step 8. Check $R_1 * R_2 < 0$

If yes, that exists a root

We remember

$\varphi_1 = arctg\frac{y_1}{x_1}, x_1 = \frac{x_1 + \bar{x}_1}{2}, y_1 = \frac{y_1 + \bar{y}_1}{2}$;$x_5 = cos\varphi_5, y_5 = sin\varphi_5$; $x_3 = \cos(\varphi_3^{min} + h), y_3 = \sin(\varphi_3^{min} + h)$; $x_2 = \frac{(-l_1cos\varphi_1 + l_3cos\varphi_3 - l_5cos\varphi_5 + l_0cos\varphi_0)}{l_2}$,$y_2 = \frac{(-l_1sin\varphi_1 + l_3sin\varphi_3 - l_5sin\varphi_5 + l_0sin\varphi_0)}{l_2}$;

$x_3^* = \cos(\varphi_3^{min} + h - \alpha_3), y_3^* = \sin(\varphi_3^{min} + h - \alpha_3)$;

$x_4 = \left(-l_1^*\cos(\varphi_1 + \alpha_1) + l_3^*\cos(\varphi_3 - \alpha_3) - l_5\cos\varphi_5 + l_0\cos\varphi_0\right)/l_4$

$y_4 = \left(-l_1^* \sin(\varphi_1 + \alpha_1) + l_3^* \sin(\varphi_3 - \alpha_3) - l_5 \sin \varphi_5 + l_0 \sin \varphi_0\right)/l_4$

$\varphi_3^{min} = \varphi_3$ - last value (true)

We find speeds from systems (9), (10).

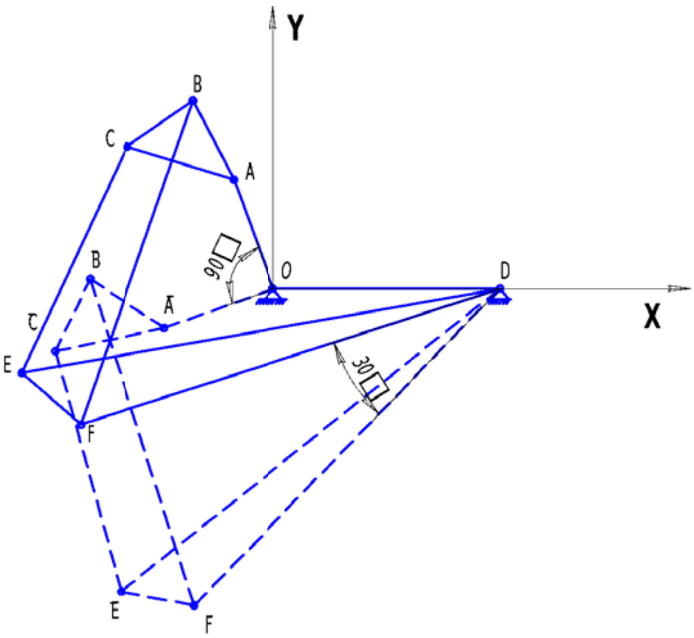

Figure 2 – Transmission mechanism of IV class

Printing (screen) and preservation of results.

Step 9. $ц_3 = ц_3^{min} + h$

Shag10. Check $\varphi_3 \leq \varphi_3^{max}$ if yes – that transition to a step 3, differently - to a step 11

Step 11. $\varphi_5 = \varphi_5^{min} + h$

Step 12. Check $\varphi_5 \leq \varphi_5^{max}$, if yes, we come back to a step 3, differently to the end.

Step 13. End.

Example. For the class mechanism of IV class with rotary kinematic couples computing experiment is made. Constant parameters of the mechanism have the following values: $lo = 10, \varphi_0 = 0,\ l_1 = 2, l_1^* = 2,\ l_2 = 8.268, l_3 = l_3^* = 5,\ l_4 = 5.92,\ l_5 = 8.944,\ \alpha_1 = 60^0, \alpha_3 = 30^0, \varphi_1 = 30^0, \varphi_2 = 0^0, \varphi_3 = 90^0, \varphi_3^* = 120^0, \varphi_4 = 13^0, \varphi_5 = 90^0, \varphi_1^* = \varphi_1 - \alpha_1, \varphi_3^* = \varphi_3 + \alpha_3$. Geometrical lengths are set in centimeters.

5. Discussion of results. Necessary and sufficient living conditions of material decisions of system of the trigonometrical equations (2) and the exact range of change of one of angular coordinates of an output link of the mechanism IV of a class are for the first time found at preset values of angular coordinates of entrance links. Such is an essence of the offered analytical method of definition of positions and speeds. The algorithm is developed and the program in language of Delfi by definition of provisions and speeds of output links of the mechanism IV of a class with any beforehand the set accuracy is written. The transmission gear IV of a class is for the first time synthesized and the exact method of definition of provisions and speeds of this kind of mechanisms is developed. The received results easily extend on mechanisms of higher classes and with a large number of the closed contours.

As the high-class basic mechanism the class mechanism IV as it is similar to the four-unit mechanism II of a class gets out. The offered numbering of links of the mechanism allows to use with grace a vector-matrix form at the solution of various equations of kinematics.

Further these results are used in the power and dynamic analysis of mechanisms of high classes and their enormous advantage in comparison with class mechanisms II is shown, but they didn't enter this work because of volume (and that number – results of computing experiment).

6. Conclusion. In summary it is possible to note that analytical methods of definition of provisions and speeds of links of high classes mechanisms of general purpose and an exact method of the kinematic analysis of transmission gears of high classes are for the first time has been developed. This approach easily extends on mechanisms of higher classes and will allow developing the universal software on design of high classes mechanisms for various devices and cars. The program of Delfi which defines provisions and speeds of links of any mechanisms IV of a class has been written. Computing experiment has been made. The transmission mechanism of IV class has been synthesized for the first time.

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ЖОҒАРҒЫ КЛАССТАРДЫҢ БУЫН МЕХАНИЗМДЕРІНІҢ ЖЫЛДАМДЫҒЫН ЖӘНЕ ОРНЫН АНЫҚТАУ

Аннотация. Жұмыста алғаш рет аналитикалық әдіспен жоғарғы класстардың еркін механизмдерінің жылдамдығы мен орналасуын анықтайтын және жоғарғы класстардың ауыстыратын механизмдерінің кинематикалық талдаудың нақты әдісі ұсынылған. Ұсынылып отырған механизмдердің кинематикалық талдау тәсілдемесі бағдарламаны қамтамасыз етуді әзірлеуге мүмкіндік береді. Алғаш рет IV класстың ауыстыру механизмі синтезделген.
Түйін сөздер: кинематика, жоғарғы класстардың механизмі, орналасуы, жылдамдық.

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ОПРЕДЕЛЕНИЕ ПОЛОЖЕНИЙ И СКОРОСТЕЙ ЗВЕНЬЕВ МЕХАНИЗМА ВЫСОКИХ КЛАССОВ

Аннотация. В работе впервые предложены аналитический метод определения положений и скоростей произвольных механизмов высоких классов и точный метод кинематического анализа передаточных механизмов высоких классов. Предлагаемый подход позволил разработать программное обеспечение по кинематическому анализу этих механизмов. Впервые синтезирован передаточный механизм IV класса.
Ключевые слова: кинематика, механизм высоких классов, положение, скорость.

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