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THE KINEMATIC ANALYSE OF A MECHANISM USED FOR THE FARMING MACHINES ACTUATION

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Abstract: The paper is structured in two parts. In the first part is presented a theoretical kinematic model for a hydraulic lift mechanism used to the farm tractors. Is presented the 3D model of the mechanism, joined with a plough, for which the kinematic analyze is studied. The mechanism is used for the farm machine actuation. The farm machines are joined to the tractor by means of this mechanism. In the second part of the paper, are presented the laws of variation for the mechanism kinematics parameters, which are obtained with the calculus program Maple.

1. INTRODUCTION

The carried farm machine are joined with the tractor (are mounted with the tractor) by means of a hydraulic power lift with three articulated points.

The half carried farming machine is joined with the tractor in two points, with the hydraulic power lift mechanism, from the longitudinal elements.

In figure 1and 2 are presented is presented the kinematic and structural scheme of a mechanism for actuate the farming machines.

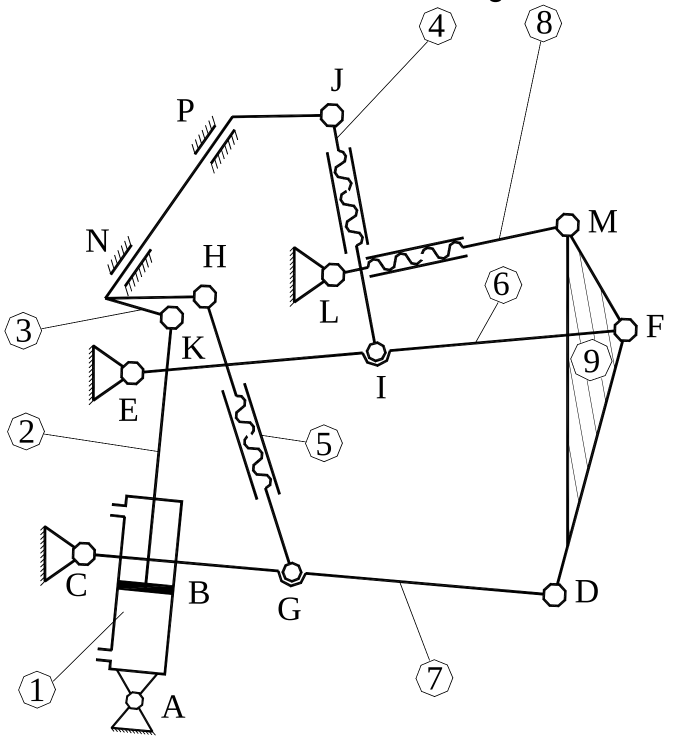

Fig. 1.The kinematic scheme of the hydraulic power lift mechanism

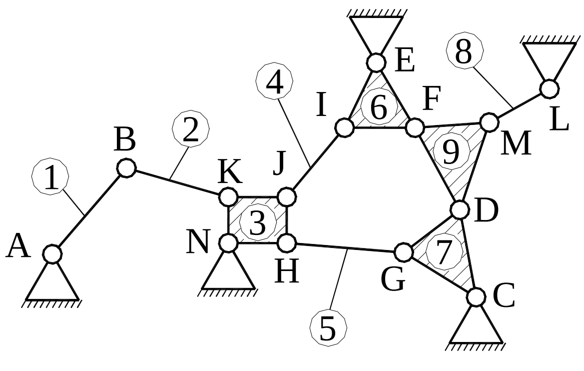

Fig. 2.The mechanism structural scheme

2. THE KINEMATIC ANALYZE

In figures 3, 4 and 5 is presented the mechanism 3D model.

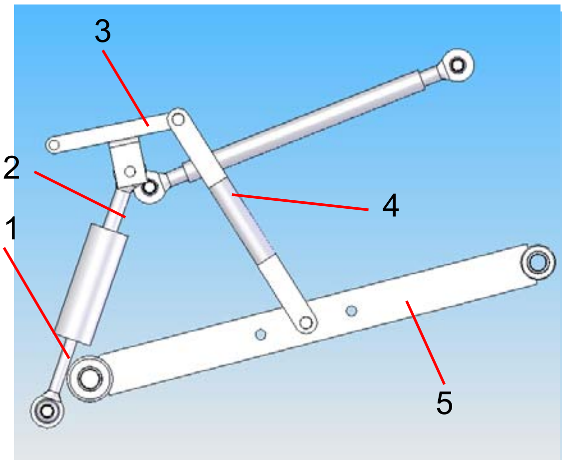

Fig. 3.The mechanism virtual model (lateral view)

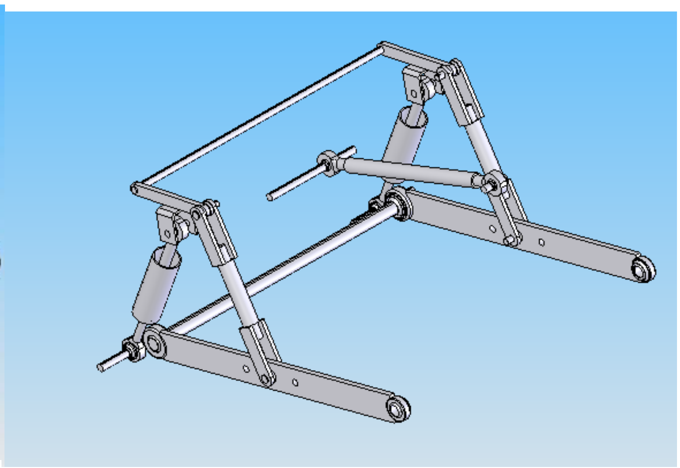

Fig. 4.The mechanism virtual model (isometric view)

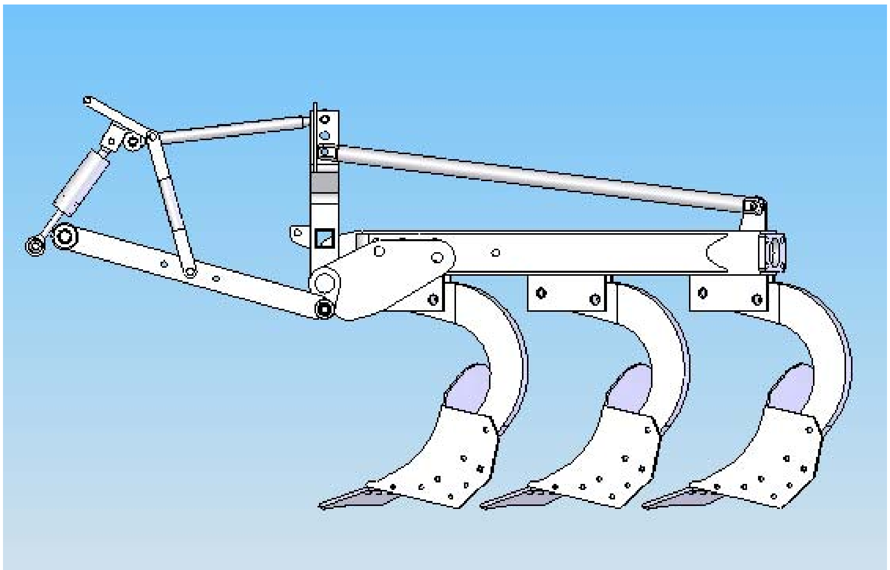

Fig. 5.The mechanism joined with a plough (lateral view)

The study of the kinematics parameters is made upon the basis of figure 6.

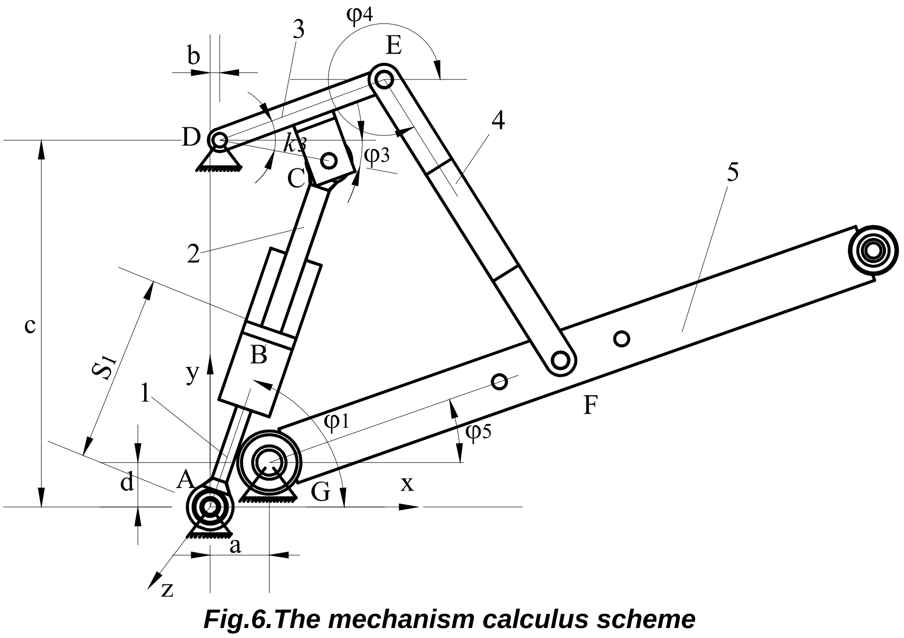

Fig.6.The mechanism calculus scheme

2.1. The positions study

We know: $x_A = y_A = 0$; $x_D = b = 65$; $y_D = c = 489$; $x_G = a$; $y_G = d$.
To determine the position of the point B we write the systems of equations:

$$\begin{cases} x_B = x_A + S_1 \cos\varphi_1 \\ y_B = y_A + S_1 \sin\varphi_1 \end{cases} \quad (1)$$

$$\begin{cases} x_C = x_A + S_1 \cos\varphi_1 + L_2 \cos\varphi_1 = x_D + L_{CD} \cos\varphi_3 \\ y_C = y_A + S_1 \sin\varphi_1 + L_2 \sin\varphi_1 = y_D - L_{CD} \sin\varphi_3 \end{cases} \quad (2)$$

Because in the system of equations (2), $x_A = y_A = 0$, we have:

$$\begin{cases} S_1 \cos\varphi_1 + L_2 \cos\varphi_1 = x_D + L_{CD} \cos\varphi_3 \\ S_1 \sin\varphi_1 + L_2 \sin\varphi_1 = y_D - L_{CD} \sin\varphi_3 \end{cases} \quad (3)$$

In the system of equations (3) we not know S_1 and φ_3.

Or if we know the displacement and speed of the piston, then the unknown in the equation system (3) are φ_1 and φ_3. With these considerations the system of equations (3) becomes:

$$\begin{cases} (S_1 + L_2)\cos\varphi_1 = x_D + L_{CD} \cos\varphi_3 \\ (S_1 + L_2)\sin\varphi_1 = y_D - L_{CD} \sin\varphi_3 \end{cases} \quad (4)$$

$$\left(S_1^2 + L_2^2\right) = x_D^2 + y_D^2 + 2x_D L_{CD} \cos\varphi_3 - 2y_D L_{CD} \sin\varphi_3 + L_{CD}^2 \Rightarrow$$

$$A_1 \sin\varphi_3 + A_2 \cos\varphi_3 = A_3 \quad (5)$$

Where: $A_1 = -2y_D L_{CD}$; $A_2 = 2x_D L_{CD}$; $A_3 = (S_1 + L_2)^2 - x_D^2 - y_D^2 - L_{CD}^2$

By resolving of the equation (5) we determine the angle φ_3.

$$\begin{cases} x_C = x_D + L_{CD} \cos\varphi_3 \\ y_C = y_D - L_{CD} \sin\varphi_3 \end{cases}$$

From the system of equations (3) we determine the angle φ_1.

$$\varphi_1 = arctg \frac{y_C - y_A}{x_C - x_A} = \frac{y_C}{x_C}$$

If we not know the displacement of the piston we act in the following way. We take out S_1 from the system (3), that is:

$$S_1 = \frac{x_D + L_{CD} \cos\varphi_3 - L_2 \cos\varphi_1}{\cos\varphi_1} \quad (6)$$

We introduce the relation (6) in the second equation of the system (3) and we obtain:

$$\frac{\left(x_D + L_{CD}\cos\varphi_3 - L_2\cos\varphi_1\right)}{\cos\varphi_1}\sin\varphi_1 + L_2\sin\varphi_1 = y_D - L_{CD}\sin\varphi_3 \quad (7)$$

We have:

$A_1\sin\varphi_3 + A_2\cos\varphi_3 = A_3$, where:

$A_1 = -L_{CD}$; $A_2 = -L_{CD}tg\varphi_1$; $A_3 = x_D tg\varphi_1 - L_2\sin\varphi_1 + L_2\sin\varphi_1 - y_D$.

By resolving the equation we obtain φ_3.

We introduce the equation (6) in (5) and obtain S_1.

$$\begin{cases} x_E = x_D + L_{DE}\cos(k_3 - \varphi_3) \\ y_E = y_D + L_{DE}\sin(k_3 - \varphi_3) \end{cases} \quad (8)$$

$$\begin{cases} x_F = x_E + L_{EF}\cos\varphi_4 = x_G + L_{GF}\cos\varphi_5 \\ y_F = y_E + L_{EF}\sin\varphi_4 = y_G + L_{GF}\sin\varphi_5 \end{cases} \quad (9)$$

In the system of equations (9) the unknown are φ_4 and φ_5.

We square up the equations and we eliminate φ_4, then we determine φ_5 from whatever equation of the system (9), that is:

$$\begin{cases} L_{EF}\cos\varphi_4 = (x_G - x_E) + L_{GF}\cos\varphi_5 \\ L_{EF}\sin\varphi_4 = (y_G - y_E) + L_{GF}\sin\varphi_5 \end{cases}$$

$$L_{EF}^2 = (x_G - x_E)^2 + (y_G - y_E)^2 + L_{GF}^2 + 2(x_G - x_E)L_{GF}\cos\varphi_5 + 2L_{GF}(y_G - y_F)\sin\varphi_5$$

$A_1\sin\varphi_5 + A_2\cos\varphi_5 = A_3$, where:

$A_1 = 2L_{GF}(y_G - y_F)$; $A_2 = 2L_{GF}(x_G - x_E)$;

$A_3 = L_{EF}^2 - (x_G - x_E)^2 - (y_G - y_E)^2 - L_{GF}^2$.

By resolving the equation we obtain the angle φ_5.

$$\begin{cases} x_F = x_G + L_{GF}\cos\varphi_5 \\ y_F = y_G + L_{GF}\sin\varphi_5 \end{cases} \quad (10)$$

The angle φ_4 is determined with the relation:

$$\varphi_4 = arctg\frac{y_F - y_E}{x_F - x_E}.$$

2.2. Speeds

The speed from the B joint is determined upon the relation (11).

$$\begin{cases} v_{xB} = -S_1 \cdot \omega_1 \cdot \sin\varphi_1 \\ v_{yB} = S_1 \cdot \omega_1 \cdot \cos\varphi_1 \end{cases} \quad (11)$$

The speed from the C joint is determined upon the relation (12).

$$\begin{cases} \dot{x}_C = \dot{S}_1 \cdot \cos\varphi_1 - S_1 \cdot \sin\varphi_1 \cdot \dot{\varphi}_1 - \dot{L}_2 \cdot \sin\varphi_1 \cdot \dot{\varphi}_1 \\ \dot{y}_C = \dot{S}_1 \cdot \sin\varphi_1 + S_1 \cdot \cos\varphi_1 \cdot \dot{\varphi}_1 + \dot{L}_2 \cdot \cos\varphi_1 \cdot \dot{\varphi}_1 \end{cases} \qquad (12)$$

The speed from the E joint is determined upon the relation (13):

$$\begin{cases} \dot{x}_E = \dot{x}_D + L_{DE} \cdot \sin(k_3 - \varphi_3) \cdot \dot{\varphi}_3 \\ \dot{y}_E = \dot{y}_D - L_{DE} \cdot \cos(k_3 - \varphi_3) \cdot \dot{\varphi}_3 \end{cases} \qquad (13)$$

The speed from the F joint is determined upon the system of equation (14).

$$\begin{cases} \dot{x}_F = \dot{x}_G - L_{GF} \cdot \sin\varphi_5 \cdot \dot{\varphi}_5 \\ \dot{y}_F = \dot{y}_G + L_{GF} \cdot \cos\varphi_5 \cdot \dot{\varphi}_5 \end{cases} \qquad (14)$$

2.3. Accelerations

The accelerations from the B joint are determined upon the system of equation (15).

$$\begin{cases} \ddot{x}_B = -\dot{S}_1 \cdot \omega_1 \cdot \sin\varphi_1 - S_1 \cdot \varepsilon_1 \cdot \sin\varphi_1 - S_1 \cdot \omega_1^2 \cdot \cos\varphi_1 \\ \ddot{y}_B = \dot{S}_1 \cdot \omega_1 \cdot \cos\varphi_1 + S_1 \cdot \varepsilon_1 \cdot \cos\varphi_1 - S_1 \cdot \omega_1^2 \cdot \sin\varphi_1 \end{cases} \qquad (15)$$

The accelerations from the C joint are determined upon the system of equation (16).

$$\begin{cases} \ddot{x}_C = \ddot{S}_1 \cdot \cos\varphi_1 - \dot{S}_1 \cdot \sin\varphi_1 \cdot \dot{\varphi}_1 - \dot{S}_1 \cdot \sin\varphi_1 \cdot \dot{\varphi}_1 - S_1 \cdot \cos\varphi_1 \cdot \dot{\varphi}_1^2 - S_1 \cdot \cos\varphi_1 \cdot \dot{\varphi}_1^2 \\ - S_1 \cdot \sin\varphi_1 \cdot \ddot{\varphi}_1 - L_2 \cdot \cos\varphi_1 \cdot \dot{\varphi}_1^2 - L_2 \cdot \sin\varphi_1 \cdot \ddot{\varphi}_1 \\ \ddot{y}_C = \ddot{S}_1 \cdot \sin\varphi_1 + \dot{S}_1 \cdot \cos\varphi_1 \cdot \dot{\varphi}_1 + \dot{S}_1 \cdot \cos\varphi_1 \cdot \dot{\varphi}_1 - 2S_1 \cdot \sin\varphi_1 \cdot \dot{\varphi}_1^2 + S_1 \cdot \cos\varphi_1 \cdot \ddot{\varphi}_1 - \\ - L_2 \cdot \sin\varphi_1 \cdot \dot{\varphi}_1^2 + L_2 \cdot \cos\varphi_1 \cdot \ddot{\varphi}_1 \end{cases} \qquad (16)$$

The accelerations from the E joint are determined upon the system of equation (17):

$$\begin{cases} \ddot{x}_E = \ddot{x}_D + L_{DE} \cdot \cos(k_3 - \varphi_3) \cdot \dot{\varphi}_3^2 + L_{DE} \cdot \sin(k_3 - \varphi_3) \cdot \ddot{\varphi}_3 \\ \ddot{y}_E = \ddot{y}_D + L_{DE} \cdot \sin(k_3 - \varphi_3) \cdot \dot{\varphi}_3 - L_{DE} \cdot \cos(k_3 - \varphi_3) \cdot \ddot{\varphi}_3 \end{cases} \qquad (17)$$

The accelerations from the F joint are determined upon the system of equation (18):

$$\begin{cases} \ddot{x}_F = \ddot{x}_G - L_{GF} \cdot \cos\varphi_5 \cdot \varphi_5^2 - L_{GF} \cdot \sin\varphi_5 \cdot \ddot{\varphi}_5 \\ \ddot{y}_F = y_G - L_{GF} \cdot \sin\varphi_5 \cdot \dot{\varphi}_5^2 + L_{GF} \cdot \cos\varphi_5 \cdot \ddot{\varphi}_5 \end{cases} \qquad (18)$$

3. CONCLUSIONS

We have elaborated a calculus program in Maple, for the numeric calculus of the mechanism kinematics parameters.

The results obtained with Maple are presented in the following.

- The variation of the angle φ_3 is showed in figure 7;

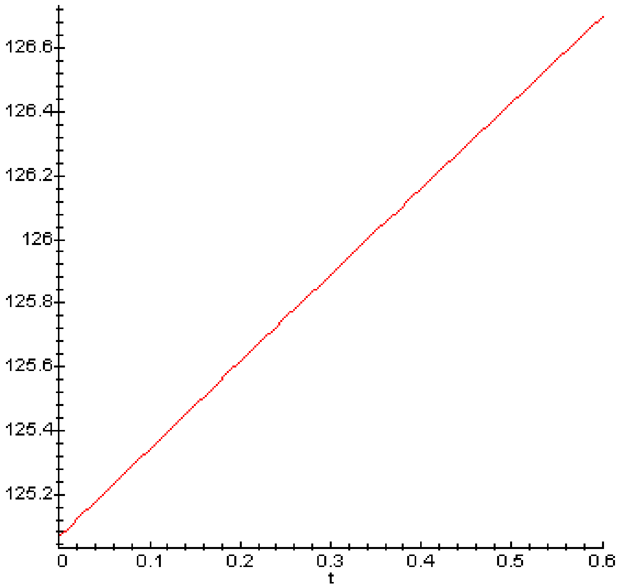

Fig.7.The variation of the angle φ_3

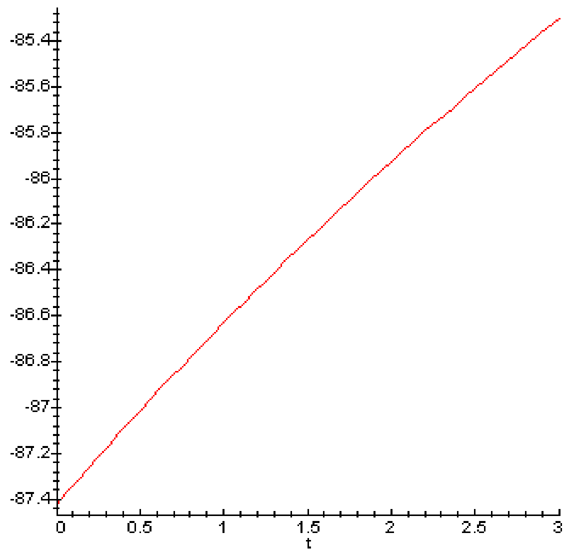

Fig.8.The variation of the angle φ_1

- The variation of the angle φ_1 is presented in figure 8;
- The variation of the coordinates x_C and y_C is presented in figure 9;

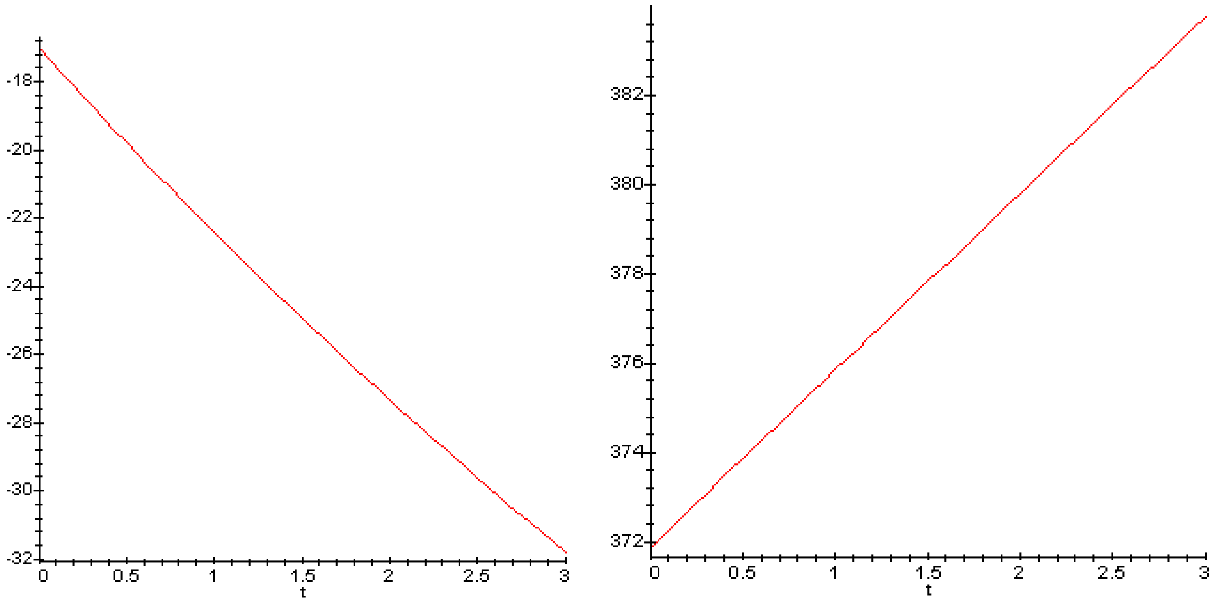

Fig.9.The variation of the coordinates from joint C

- The variation of the coordinates x_B and y_B is presented in the figure 10;

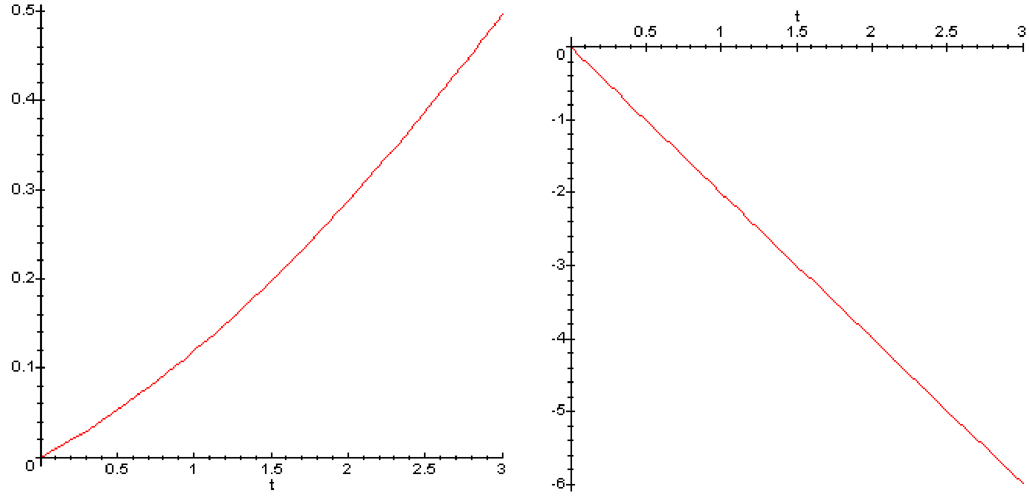

Fig.10.The coordinate's variation from the B joint

- The coordinate's variation from the E joint is presented in figure 11;

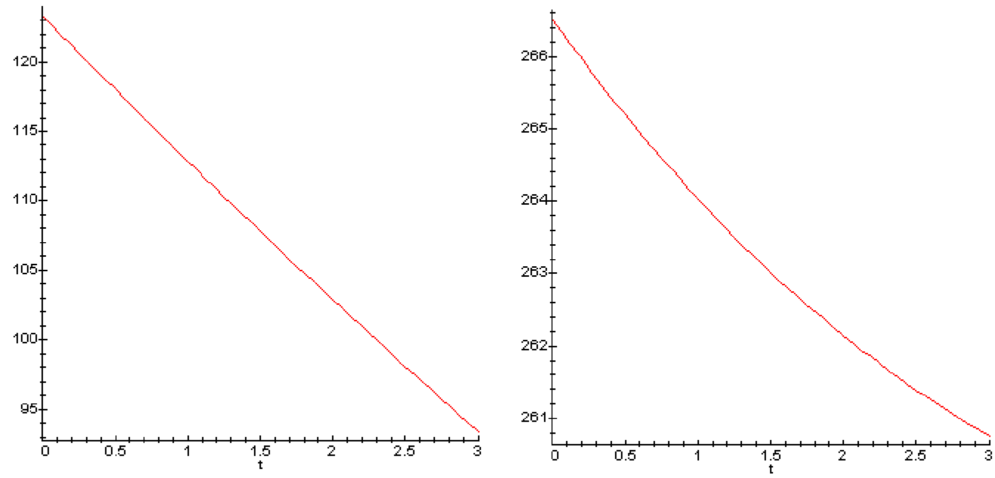

Fig.11.The variation of the displacement components from the E joint

- The variation of the angles φ_4 and φ_5 is presented in the figure 12 and 13;

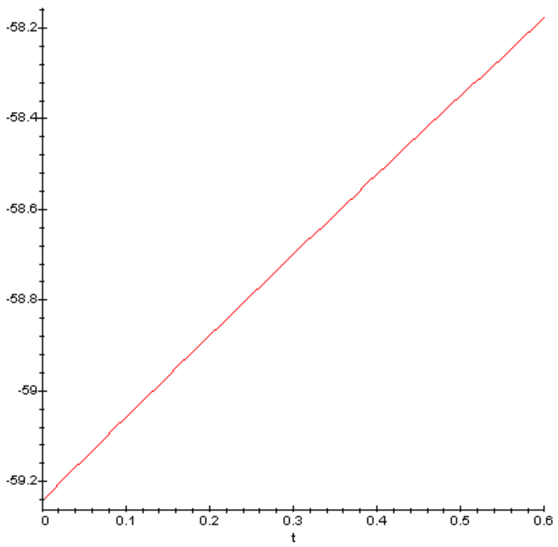

Fig.12.The variation of the angle φ_4

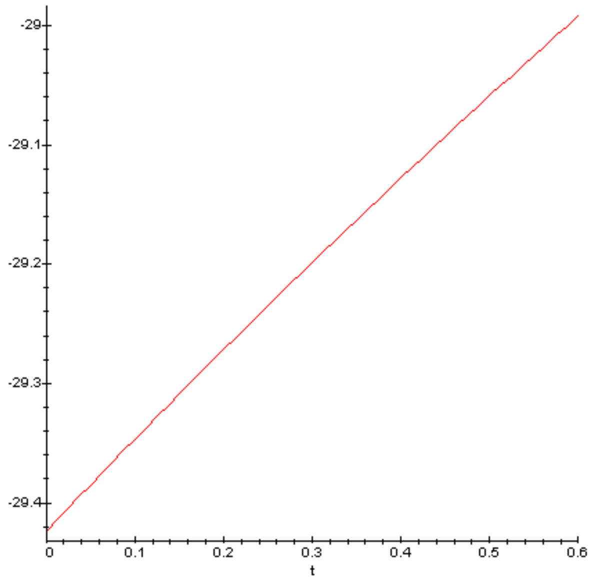

Fig.13.The variation of the angle φ_5

- The speed from the B joint is presented in the figure 14;
- The speed components variation from the C joint is presented in the figure 15;

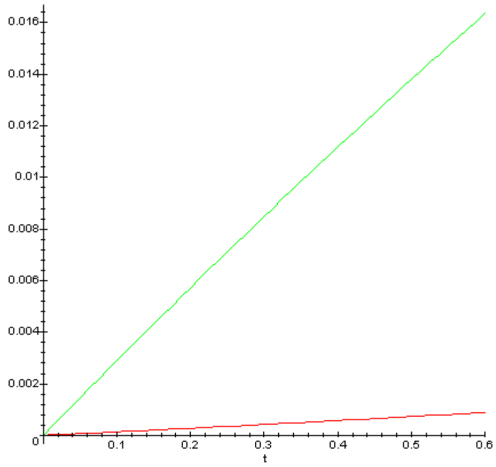

Fig.14.The speed components variation for the B joint

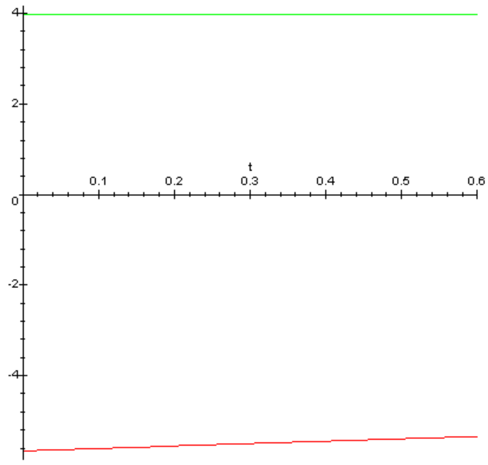

Fig.15.The speed components variation for the C joint

- The speed components variation from the E joint is presented in the figure 16;
- The speed components variation from the F joint is presented in the figure 17;

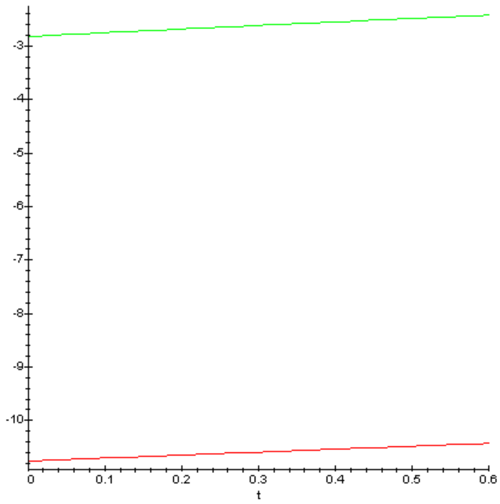

Fig. 16. The speed components variation for the E joint

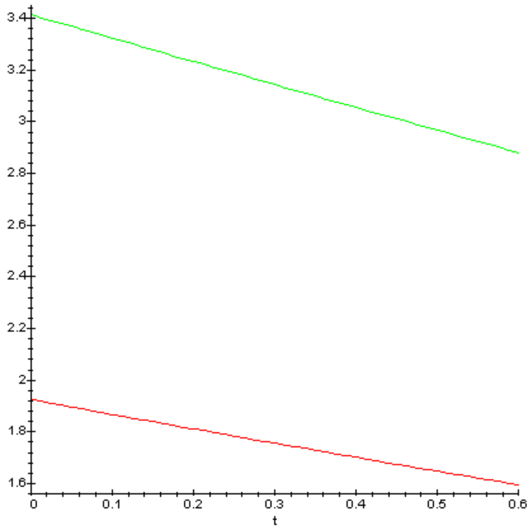

Fig. 17. The speed components variation for the F joint

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