THE CALCULATION OF POSITIONS FOR A MECHANISM WITH TWO INPUT LINKS AND A TRIAD

dr. eng. Cherciu Mirela, Faculty of Mechanics, Craiova, Romania
dr. eng. Popescu Iulian, Faculty of Mechanics, Craiova, Romania

Abstract. It starts from a structural scheme of a mechanism with two input links and a triad. It sets the kinematic scheme and the mechanism is customized consideringthe ternary elementwith two sideshavingzero length. It is shown that at changing of the input linkthe trajectories are the same, but the laws of motion are changed. We give some examples of obtained trajectories, highlightingtheir complicated shapes.

Keywords: triad mechanism, changing of the input link, trajectories

1. INTRODUCTION

The kinematics of mechanisms hasbeen studied for many years,based on writing the equations for positions, whichequations derived with respect to time, allowed the calculation of velocities and accelerations. The problem seemed difficult when it switched to solving the equations for positions.

It reached difficult to solve nonlinear algebraic systems. With the distances method were obtained convenient equations, but Newton-Raphson algorithm did not ensure the convergence [1].The closed loop method resulted insystems of very complicated trigonometric equations, taking into account the classification of trigonometric functions into quadrants.In [2] it is shown that structurally , several mechanisms maybe obtained if it changes theinput link. It exemplifies with the mechanism of Watt.In [3] it is studied the direct kinematics of a planar manipulator with three degrees of freedom, leading to polynomial relations with several solutions. In [4] it is shown how to convert mechanisms, starting from Watts and Stephensohn linearization mechanisms, by changing the input links, but there are not given analytical computation methods. In [5] it is studied the positional analysis of a seven links mechanism,analytically, by eliminating unknowns successively, resultinga polynomial equation of 14^{th} degree .In [6] there are studiedthe positions of a tetrad, ie four links Assur group and 6 joints, leading by successive elimination of unknowns to a polynomial 6^{th}degree, with four real solutions. In [7] the positional analysis of an Assur group of 3rd class is made, using the method of distances, leading to a polynomial which is solved by numerical methods, resulting several solutions, some complex, unreal. In [8] it is used the same method, but for the cases with two and three prismatic joints. In [9] there are studiedthe positions of a mechanism with pentad (Assur group of fifth class), using the method of changingthe input link, leading to a mechanism with dyads.

The aim of this paper is to study the trajectories and the lows of motion for a mechanism with two input links and a triad, based on the method of changing the input link.

2. THE STUDIEDMECHANISM

We started from the structural scheme of Fig. 1 that comprises a triad of 3th order, whosepoints of entry have beenlinked at the ground and at two input links.

The structural scheme was then transformed into the kinematic scheme of Fig. 2.

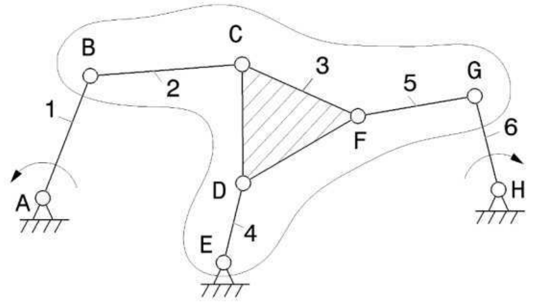

Fig. 1. The structural scheme

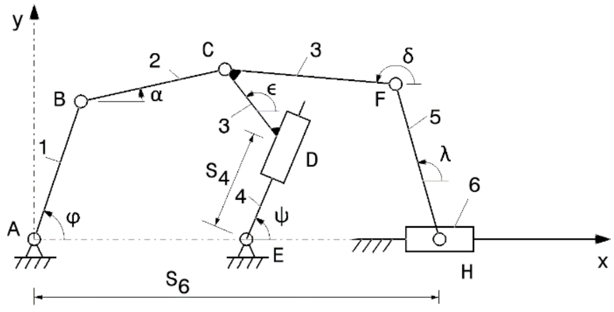

Fig. 2. The kinematic scheme

3. POSITIONS EQUATIONS OF THE MECHANISM

Based on the closed loop method the following equations are written:

$$x_B=AB\ \cos\varphi;\ y_B=AB\ \sin\varphi. \quad (1)$$

$$x_C=x_B+BC\cdot\cos\alpha=x_E+S_4\cos\psi+DC\cos\varepsilon=S_6+HF\cos\lambda+FC\cos\delta. \quad (2)$$

$$y_C=y_B+BC\cdot\sin\alpha=y_E+S_4\sin\psi+DC\sin\varepsilon=HF\ \sin\lambda+FC\sin\delta \quad (3)$$

where:

$$\delta=k_1+\psi \quad (4)$$

$$\varepsilon=k_2+\psi \quad (5)$$

k1, k2 are constructional constants

The original mechanism (Fig.1) has two input links, respectively the elements 1 and 6 in the structural diagram, so φ and S_6 are known. From equations (1), (2) and (3) are calculated: α,ψ,λ,S_6.Solving the system is however difficult because complicated trigonometric equations are involved requiring discussion for signs $\pm\sqrt{\ }$ and for the arctangentfunction , which varies with trigonometric quadrants. Changing the input link, ie the second input link to be element 4 instead of element 6, turns the mechanism with an Assur group of 3rd class into one with two Assur groups of second class. In this case φ and ψ are known, α and S4 are calculated from the dyad DCB, type PRR, λ and S6 are determined from the dyad FHH, type RRP. The value of ψ is calculated with the relationship $\psi = c\cdot\varphi$, where c is a conveniently chosen multiplier, to obtain, for example, interesting connecting rod curves.

4. RESULTS

For example, the following sizes were adopted to the mechanism:
AB = 32; BC = 33; DC = 17; FC = 26; HF = 28; XE = 38 mm: k1 = 115: k2 = 55 degrees.
Thus, for c = 0.1, that is, the element 4 rotates counterclockwise, there result the successive positions of the mechanism given in Fig. 3 and the trajectory of the point C given in Fig. 4.

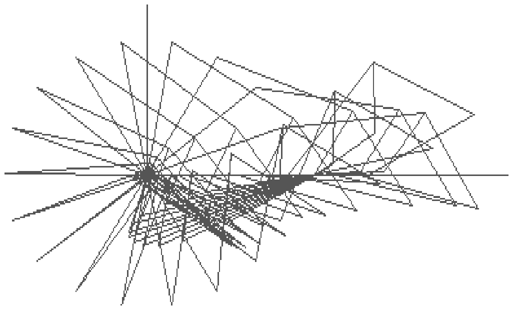

Fig. 3. The successive positions for c=0.1

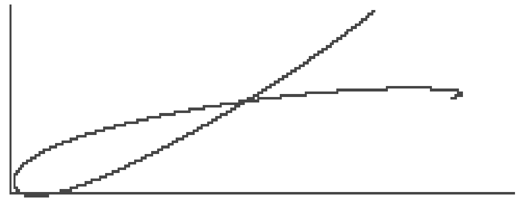

Fig. 4. The trajectory of point C for c=0.1

If the element 4 rotes clockwise, ie comes back at the right end position (so that c= -0.1), it results the trajectory from Fig. 5, different from that of Fig. 4.

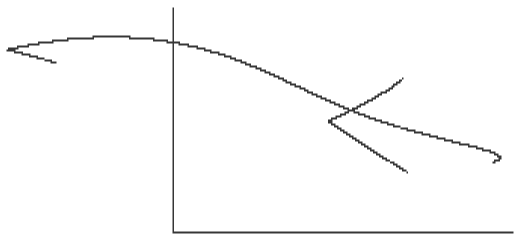

Fig. 5. The trajectory of point C for c= -0.1

For a full cycle, that is the element 6 moving in both directions, the resulting trajectory is represented in Fig. 6,where there are two branches of the curve.

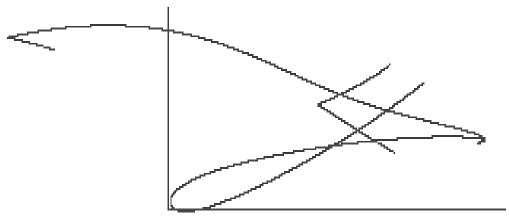

Fig. 6. The trajectory of point C for c= -0.1 şi c=0.1

These trajectories are specific to this mechanism, being open curves with intersections and turning points. Referring to Fig. 6 it is noticed that the two curves are extended, so linked, not independent.
For the case c = 1 and c = - 1, i.e. the element 4 moves in both directions, resulting the trajectory of Fig. 7 with links between branches.

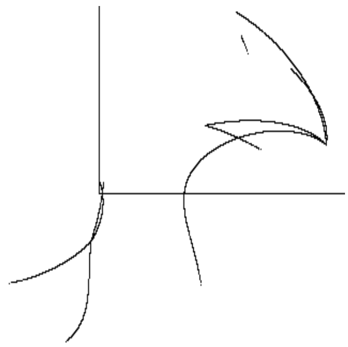

Fig. 7. The trajectory of point C for = 1 şi c= - 1

We have also obtained the trajectories from Fig. 8, 9, 10, which are complicated, open curves, with many discontinuities.

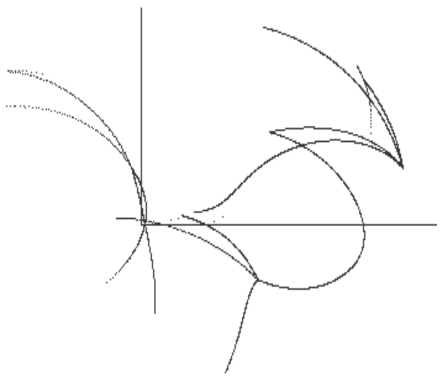

Fig. 8. The trajectory of point C for c=2 şi c= - 2

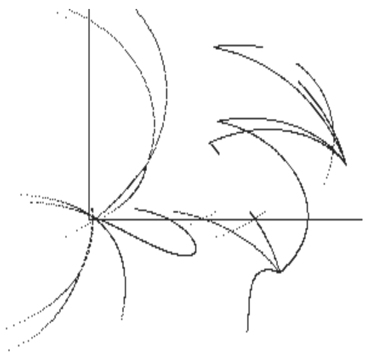

Fig. 9. The trajectory of point C for c=3 şi c= - 3

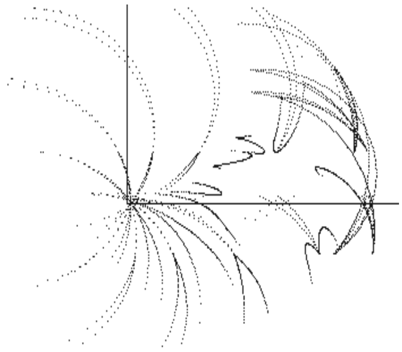

Fig. 10. The trajectory of point C for c=10 şi c= - 10

5. ADVANTAGES AND LIMITATIONS OF THE METHOD OF CHANGING THE INPUT LINK

The method of changing the input link is based on a simple experiment: if on a model of mechanism, any of its link is moving, the movement of mechanism is the same. However, this method has its limits.It is taken a typical example: the slider -crank mecanismfrom Fig. 11, with AB=30 mm and BC=70 mm.

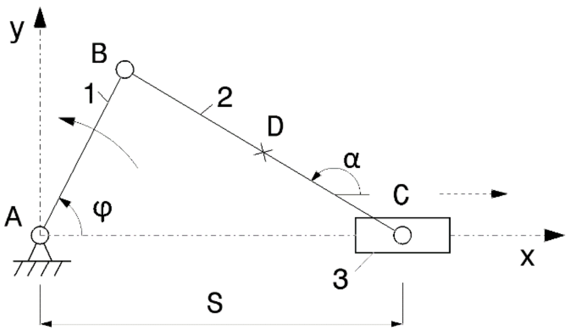

Fig. 11 The slider-crank mechanism

The trajectory of point D, representing the middle of the connecting rod, BC, is an ellipse (Fig. 12), regardless of whether 1 or 3 is the input link.

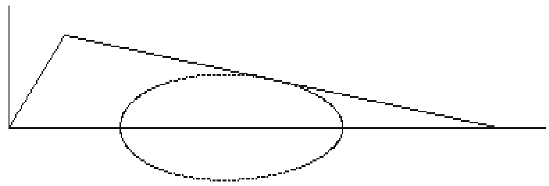

Fig. 12. Trajectory of point D

There are represented the transfer functions for both types of input links. Thus, the function $S(\varphi)$, given in Fig. 13 shows a symmetrical variation of S; S descends to the minimum at = 180 degrees, then rise up to = 360 degrees.

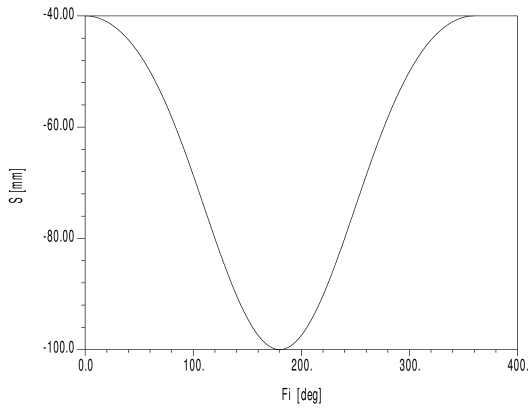

Fig. 13 The diagram $S(\varphi)$

If the input link is the element 3, the diagram in Fig.14 is obtained, clearly different from that in Fig.13.

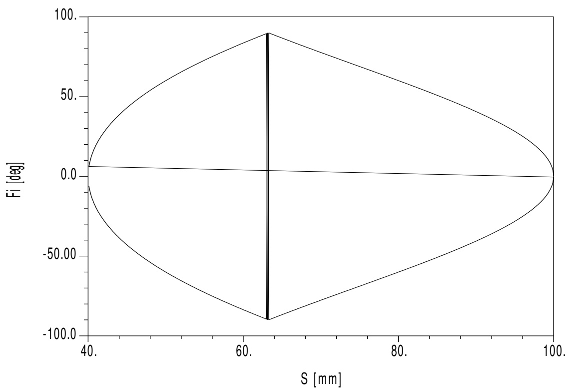

Fig. 14. The diagram φ(S)

The diagram has discontinuities at $\varphi = 90°$ and $\varphi = 270°$. The lines in the diagram join the points at the ends of the subintervals where the curves branches are formed. If follows that the method of changing the input link provides the same trajectory, but changes the transfer functions.

5. CONCLUSIONS

We studied a mechanism with two input links and a triad. The triad was customized, considering the ternary elementwith two sides havingzero length.
It was demonstrated on the slider-crank mechanism that, changing the input link, the trajectories are maintained, but the laws of motion are different.
Another input link was chosen, and it was reached a mechanism with two dyads. We determined the trajectories of some points of interest, resulting interesting shapes, not found in other mechanisms. Actually the mechanism works with triad, but the trajectories are the same regardless of which link is the input link.

REFERENCES

[1] Gans,R. F., Analytical Kinematics. Analysis and Synthesis of Planar Mechanisms.Butterworth-Heinemann Stoneham, SUA, 1991.
[2]Gans, D., Analytical Kinematics:Analysis and Synthesis of Planar Mechanisms, Elsevier,2013.
[3] Gosselin, M.C., Sefrioui, J., Richard, J.M., Solutions Polynomiales au Probleme de la Cinematique Directe des Manipulateurs Paralleles Plans a Trois Degree de Liberte. Mechanism and Machine Theory, vol.27, no 2, pp 107-119, 1992.
[4] K. van der Werff, Kinematic and dinamic analysis of mechanisms, a finite element approach. Delft University Press., 1977.
[5] Innocenti,C. - Position analysis in analytical form of the 7-link Assur kinematic chain featuring one ternary link connected to ternary links only, Mechanism and Machine Theory Vol. 32, Issue 4, 501–509, 1997
[6] Mitsi S., Position analysis in polynomial form of planar mechanisms with a closed chain of the Assur group of class 4, Mechanism and Machine Theory Vol. 34, Issue 8 , pp 1195–1209, 1999.
[7] Mitsi,S., Bouzakis, K.D., Mansour G., Popescu, I., Position analysis in Polynomial Form of Planar mechanisms with Assur Groups of Class 3 Including Revoluteand Prismatic Joints, Mechanism and Machine Theory, , vol.38, no 12, pp 1325-1344, 2003.
[8] Mitsi, S., Bouzakis, K.D., Mansour G., Popescu, I., Position analysis in Polynomial Form of Class-Three Assur Groups with Two or Three Prismatic Joints, Mechanism and Machine Theory, vol. 43, pp 1401-1415, 2008.
[9] Popescu I., Mitsi S., Cherciu M. – Position analysis of a 5th class mechanism with three prismatic joints, Annals of " Constatin Brâncuşi " University of Târgu Jiu, Engineering Series, 4 (2014) 51-57.