KINEMATIC POSSIBILITIES OF SOME MECHANISMS OF THE FOURTH FAMILY

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ABSTRACT: We study the structure and the kinematics of two flat mechanisms of the fourth family, one of them having the mobility degree equal to 1, and the other one having the mobility degree equal to 2. We trace the successive positions and the trajectories of certain points. We find that there are straight trajectories and linear movement laws. We obtain unusual associated positions and trajectories.

KEY WORDS: mechanism of the 4th family, three successive connecting links

1. INTRODUCTION

When classifying the mechanisms in families, we get to the mechanisms of the 4th family which have only two possible moves. When classifying the dyads, we get to the last dyad type, with three prismatic couplers PPP or TTT (translations, establishing that there is no such dyad, resulting actually a mechanism of the family f=4. Based on Lie group, [Chung] studies the movement of a mechanism with M=3 generating three translations and two rotations. [Harve] studies the structural synthesis of some robots providing spatial translations based on the group theory. There are many structural types of these mechanisms. Further on, we study the kinematic possibilities of some mechanisms of the 4th family with connecting links.

2. THE FIRST MECHANISM

We consider the mechanism of fig. 1, composed of three prismatic couplers, and one of them is the leading one (A). The races S1, S2 and S3 are variable, the CB length is constant and the angles are constant. According to fig. 2, any S2 translation movement may decompose in two translations according to the system axes, S1 and S.

Based on fig. 3 it results that the mechanism elements have only two possible movements: translations according to the x and y axes.

The mobility degree is:
\[ M = 2 \cdot n - C5 = 2.2 - 3 = 1 \]
and the AB element is the leading one.
The following relations are written:

\[ x_B = S_1 + S_2 \cos \alpha - x_D + S_3 \cos \beta + CB \cos \gamma \]
\[ y_B = S_2 \sin \alpha - S_3 \sin \beta + CB \sin \gamma \]
\[ \tan \alpha = \frac{(S_3 \sin \beta + CB \sin \gamma)}{(x_D + S_3 \cos \beta + CB \cos \gamma - S_1)} \]
\[ S_3 = \frac{[CB \sin \gamma - \tan \alpha (x_D + CB \cos \gamma - S_1)]}{(\tan \alpha \cos \beta - \sin \beta)} \]

3. THE OBTAINED RESULTS

We adopted the following sizes:

\[ XD = 97; CB = 57; \alpha = 50; \beta = 107; \gamma = 168. \]

For \( S_1 = 12 \) we obtained the mechanism position of fig. 4.

The successive mechanism positions for \( S_1 = -100 \ldots 100 \) with a 10 step, are given in fig. 5. It is find that the C point moves in the settled direction DC, A occupies successive positions on the abscissa, and the B point moves on an oblique line, illustrated in fig. 6 together with the C’s position (the two straight lines are parallel because CB is constant).

4. THE SECOND MECHANISM

The considered mechanism is the one of fig. 8. In report to the angle of fig. 8, the mechanism elements only have two movements, namely translations according to the system axes, therefore \( f = 4 \). The mobility degree results:

\[ M = 2n - C_5 = 2.3 - 4 = 2 \]

Having two leading elements, A and C, namely the races S1 and S2 are given.

The following relations are written:

\[ x_B = S_2 \]
We consider the two input movements as correlated by the relation: 
\[ S_2 = c_1 \times S_1 \], and we should always introduce \( c_1 \)'s value to the program, and the \( c_1 \) field was established as \( c_1 = -5 \ldots 5 \), with a 1 step.
In fig. 9 it is shown the mechanism for the position of \( S_1 = 35 \); \( S_2 = 41 \).

![Fig. 9](image)

The successive positions of the mechanism are given in fig. 10 for \( S_1 = -100 \ldots 100 \) with a 10 step and \( S_2 = c_1 \times S_1 \).

![Fig. 10](image)

In the same conditions, we obtain B's trajectory of fig. 11, namely a succession of points representing the right corners of the squares of fig. 10. We found thus a mechanism tracing points which finally form squares.

B's trajectories for the different values of \( c_1 \), cycling \( S_1 \) with a 1 step, are given in: fig. 12 (\( c_1 = 0.1 \)), fig. 13 (\( c_1 = 1 \)), fig. 14 (\( c_1 = 5 \)), fig. 15 (\( c_1 = -5 \)).

Fig. 16 gives B's trajectory for \( c_1 = -5 \ldots 5 \), with a 1 step.

Other types of mechanisms only with connecting links, of the fourth family, are given in fig. 17, and many others are given in [Popescu]. These are calculated.
similarly to the ones above, by the outlining method.

Fig. 17 a, b, c,d, e, f.

5. CONCLUSIONS

- The PPP (TTT) mechanism, with \( f=4 \) and \( M=1 \), traces only straight line segments as trajectories.
- The output races are linear.
- The mechanism with \( f=4 \) and \( M=2 \), with 4 connecting links, has successive positions similar to the squares of an arithmetic notebook.
- The trajectories of this mechanism are points of the squares (at a big step from the cycling), respectively straight line segments at different values of the \( c_1 \) parameter correlating the two input movements.

REFERENCES