MODELLING THE MOVEMENT OF MECHANISMS WITH THREE DYADS OF RRT TYPE. GENERAL CASE

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Abstract. The paper deals with the modeling of mechanisms with three dyads of type RRT and rotating leading element. Generated trajectories are provided, along with the sliders’ laws of motions. The mechanism’s operational angular range is limited to the subinterval 0°...180° because the Grashof conditions are disobeyed. Diagrams depicting the variation of coordinates corresponding to the points presenting practical interest are presented.

Keywords: mechanism with three RRT dyads, trajectories, movement laws

1. INTRODUCTION

The movement of one of the 1,234,620 possible mechanisms with three dyads [2] is modeled, in order to reveal its kinematics. It relies on three RRT dyads. As far as we know, no specialty studies on this mechanism were issued. Instead, mechanisms with 5 and 7 bar presented interest for scientists. For example [3] presents the structured synthesis of the afford mentioned mechanism, based on orthogonal trajectories. Distortions and couplers’ mobility are considered. [1] includes studies on many mechanisms with rotation couplers and glides, used for research dedicated spatial vehicles. Further on we will study a mechanism based on three dyads of RRT type.

2. THE STUDIED MECHANISM

The movement of the mechanism depicted by Fig. 1 was modeled.

![Fig. 1. The studied mechanism](image-url)
It consists of a leading element with a rotation movement AB, the first dyad BCD, linked to the elements 1 and 0 (base), the second dyad EFG of type RRT connected to the 2nd and 3rd element and the 3rd RRT dyad HKL, connected to the 4th and 5th elements. The mechanism’s structural formula [2] is consequently: R-RRT-1+0-RRT-2+3-RRT-4+5.

The mobility degree is: \( M = 3n - 2C_5 - C_4 = 3.7 - 2.10 = 1. \)

Using the contours’ method, the following equations can be written:

\[
\begin{align*}
 x_B &= x_A + AB \cdot \cos \varphi \\
y_B &= y_A + AB \cdot \sin \varphi \\
x_C &= x_B + BC \cdot \cos \alpha = S_3 + DC \cdot \cos \beta \\
y_C &= y_B + BC \cdot \sin \alpha = y_D + DC \cdot \sin \beta \\
x_E &= x_B + BE \cdot \cos \alpha \\
y_E &= y_B + BE \cdot \sin \alpha \\
x_F &= x_E + EF \cdot \cos \gamma = S_3 + S_2 \cdot \cos \beta + GF \cdot \cos \delta \\
y_F &= y_E + EF \cdot \sin \gamma = y_D + S_2 \cdot \sin \beta + GF \cdot \sin \delta \\
tg \beta &= \frac{y_E + EF \cdot \sin \gamma - y_D - GF \cdot \sin \delta}{x_E + EF \cdot \cos \gamma - S_3 - GF \cdot \cos \delta} \\
\delta &= \beta + \varepsilon_1 \\
x_H &= x_E + EH \cdot \cos \gamma \\
y_H &= y_E + EH \cdot \sin \gamma \\
\psi &= \delta - \varepsilon_2 \\
x_G &= S_3 + S_2 \cdot \cos \beta \\
y_G &= y_D + S_2 \cdot \sin \beta \\
x_K &= x_H + HK \cdot \cos \lambda = x_G + S_3 \cdot \cos \delta + LK \cdot \cos \psi \\
y_K &= y_H + HK \cdot \sin \lambda = y_G + S_3 \cdot \sin \delta + LK \cdot \sin \psi \\
tg \delta &= \frac{y_H + HK \cdot \sin \lambda - y_G - LK \cdot \sin \psi}{x_H + HK \cdot \cos \lambda - x_G - LK \cdot \cos \psi}
\end{align*}
\]

3. RESULTS

The dimensions considered by our study are: \( x_A = 18; \ y_A = 22; \ AB = 64; \ BC = 81; \ DC = 70; \ EF = 58; \ GF = 90; \ HK = 47; \ LK = 38; \ y_D = 15; \ EH = 26; \ BE = 40; \ HM = 24; \ \varepsilon_1 = 75; \ \varepsilon_2 = 115; \ \beta = 98; \ \delta = \beta + \varepsilon_1. \)

Fig. 2 depicts the mechanism’s position for \( \varphi = 70^\circ \). Fig. 3 depicts the mechanism’s subsequent positions, considering that the element AB does not perform full rotations owing to the adopted sizes which do not meet the Grashof conditions.
Fig. 2. The mechanism’s position for $\varphi = 70^\circ$

Fig. 3. The mechanism’s subsequent positions

Fig. 4, presenting the trajectories of points B and C, reveal that B describes only a part from the circle and C’s race is small.

Fig. 4. The trajectories of points B and C

The trajectories of points E and D are given in Fig. 4. D moves along a line whilst the trajectory followed by E is an open rod-type curve.
The trajectories described by the points G (in the right side) and F (in the left side) are depicted by Fig. 6. Both fall in the category of rod-type curves with loops.

Fig. 6. The trajectories described by the points G and F

Fig. 7 depicts the trajectories of points L, H and K. They are similar, but shifted.

Fig. 7. The trajectories of points L, H and K

Fig. 8 is used to reveal a comparison between the trajectories of the points K and M from the element EF. They are similar, the one corresponding to M being left-shifted to that corresponding to K.

Fig. 8. A comparison between the trajectories of the points K and M
The variations of traces $S_3$ and $S_2$ are provided by Fig. 9. One can see that the mechanism can operate only for angles $\varphi$ within the range $0^\circ$…$180^\circ$. For angles $\varphi > 180^\circ$ segments appear in the diagram. The program used for simulation joins the ranges’ limits by means of lines.

The variations for the coordinates of points E and G, at the input of the 2nd dyad, given by Fig. 11, represent a new proof for the mechanism’s blocking when $\varphi > 180^\circ$. The curves are normal for the rest of the values.
Similarly in Fig. 12 one presents the variations corresponding to the coordinates of the points H and L from the input of the 3-rd dyad. Conclusions identical to those from above can be drawn.

The diagrams for the coordinates of the points F, K and M (Fig. 13) reveal the already mentioned blocking for \( \phi > 180^\circ \). An interesting aspect is related to the similarity of the curves \( x_i \) and \( y_i \) respectively.
4. CONCLUSIONS
- Studies on the mechanism $R\text{-}RRT\text{-}1+0\text{-}RRT\text{-}2+3\text{-}RRT\text{-}4+5$ were performed.
- Owing to the disobeying of Grashof conditions, the mechanism can operate only for $\varphi = 0^\circ \ldots 180^\circ$.
- The curves generated by the points of interest are open rod curves. Although being characterized by a high degree, they are not spectacular.
- The variations of the glides’ traces variations were also represented. Normal diagrams were obtained.

REFERENCES