Scientific Bulletin of Naval Academy

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Study on new rocker curves generated by a three diades mechanism

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Abstract. Mechanisms generating rocker curves have a great use in the machine building industry. In the specialty literature a lot of papers have been published regarding the analysis and synthesis of mechanisms for rocker curves. In this paper the R-RRR-RPP-RPP mechanism is studied, a three-diade mechanism that generates special rocker curves. There are obtained many rocker curves, most of which are unknown in the mechanisms. A generator point belongs to RPP diade that slides on a rocker and another is on another RPP diade sliding on a rotating moving element. The rocker curves generated by the point that slides on a rocker are more complicated and more interesting than those at which the generator point slides on a rotating motion element. The angles between the welded slides have changed and the same curve shapes have been obtained, with some modifications and different positions on the axis system. In this way a wide range of special rocker curves generated by the mechanisms were obtained. The results obtained from the study can be used in the design of new mechanisms generating of rocker curves.

1. Introduction

Mechanisms have been created by people in order to ease their work. There are known mechanisms used for irrigation dating from antiquity and the Middle Ages.

The problem of the rocker curves occurred in James Watt's steam engine, when it was required that the translatory movement of the piston to be turned into a rotational motion of the wheel. Watt was more pleased with the creation of this mechanism than with the entire machine.

Then there was the question of synthesis of the mechanisms that can trace some trajectories, a matter in which mathematicians like Cebashev were involved. One of the methods used was repeated analysis, made with models, meaning it was executed a mechanism white plate-type rocker and they were drawn using a pencil the curves which are generated by different points on the bar.

Many papers have been published over the years in the literature, on the analysis and synthesis of the mechanisms for the rocker curves. Thus, in [1], it is elaborated and developed the theory of mechanically generating the various mathematical curves. These curves are discussed from the mathematical point of view and they are given examples of such curves.

In [2, 3, 4, 5, 6] they are given many original mechanisms that draw geometric curves, indicating how to construct mechanisms and computational relationships. Many papers address both the analysis and the synthesis of the mechanisms for generating the rocker type curves.

The synthesis of the articulated quadrangle mechanism for generating a particular rocker curve is analyzed in [7]. It is performed the optimization in two steps, starting with the leading element, and then

proceeding to the next step with optimizing the rest of the kinematic chain. The least squares method is used.

The synthesis of a 5-element space mechanism is given in [8], where the author sought to achieve a prescribed motion. Cylindrical couplings that provide rotations and translations are also used. The beam of vectors from the origin and the Euler angles are used. The equations for the vector contour were written, as well as for the analysis of the mechanism.

In [9] we analyze and synthesize the quadrilateral mechanisms that have one or two slides, ie four types of diade. The slides were considered to be rotational couples with infinite joint. A generalization of all diade variants has been made and attention has been paid to the establishment of positions by numerical methods.

The Geneva mechanism having a rotating slider is used in [10] on a paper cutting machine, so that cutting is done in the subinterval where the crank bolt slides through the slider guide, the final disk being blocked. The paper presents the analysis of the mechanism.

Further in this paper the authors analyze a three-diade mechanism and it is presented the rocker curves which are generated by it.

2. The new generator mechanism

We left from the ABCD articulated mechanism (Figure 1), to which the EF diade was added, the E point being on the driving element, then the EG diade was added. Thus, the authors of the paper propose a new mechanism, an original mechanism.
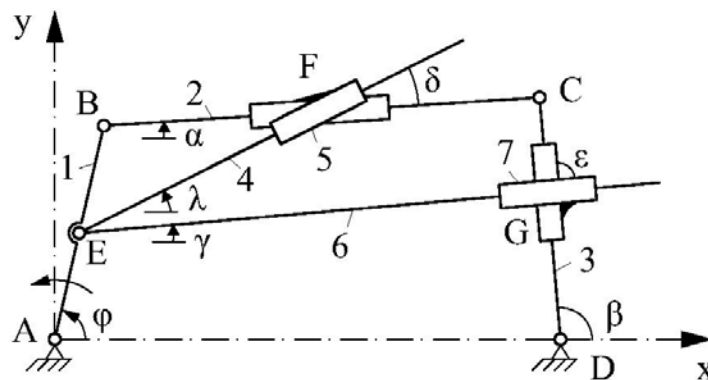

Figure 1. The new generator mechanism

The structural scheme of the mechanism is given in figure 2, from which it results that the mechanism has the AEB driving element, the BCD diade of RRR type, the EFF diade of RPP type and the EGG diade of RPP type.
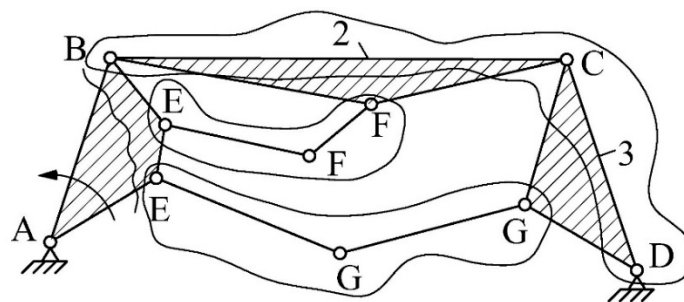

Figure 2. The structural scheme

3. Relations and results

Based on figure 1 are written the relations:

$$x_B = AB\cos\varphi; \qquad y_B = AB\sin\varphi \tag{1}$$

$$x_C = x_B + BC\cos\alpha = x_D + CD\cos\beta \tag{2}$$

$$y_C = y_B + BC\sin\alpha = y_D + CD\sin\beta \tag{3}$$

$$x_E = AE\cos\varphi; \qquad y_E = AE\sin\varphi \tag{4}$$

$$x_F = x_E + EF\cos\lambda = x_B + BF\cos\alpha \tag{5}$$

$$y_F = y_E + EF\sin\lambda = y_B + BF\sin\alpha \tag{6}$$

$$x_G = x_E + EG\cos\gamma = x_D + GD\cos\beta \tag{7}$$

$$y_G = y_E + EG\sin\gamma = y_D + GD\sin\beta \tag{8}$$

$$\lambda = \alpha + \delta; \qquad \gamma = \beta - \varepsilon \tag{9}$$

From the relation (1) they result the coordinates of B, from relations (2) and (3) we obtain the position of C and the α and β angles. From the relation (4) it is obtained the position of E, from relations (5) and (6) it is obtained the position of F, and from relations (7) and (8) the position of G is obtained.

Knowing the angles δ and ε, using the relation (9) they are calculated the angles λ and γ. The initial data were chosen in order to meet the Grashof conditions for the ABCD cinematic chain: AB = 40; BC = 52; CD = 56; XD = 68; AE = 18; δ =30; ε =85 (lengths in millimeters and angles in degrees, here and below).

In figure 3 it is shown the mechanism generated by a program for φ = 80 degrees, and in figure 4 they are shown its successive positions.
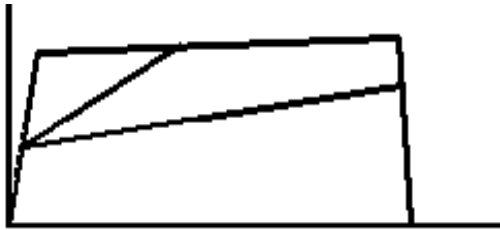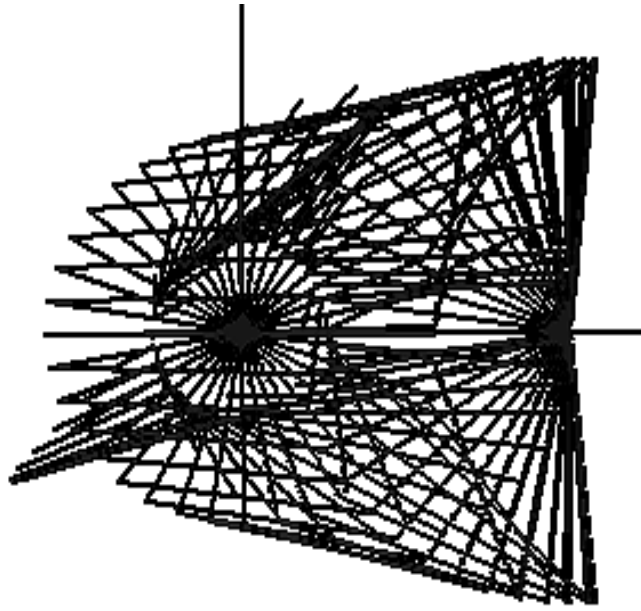

Figure 3. The mechanism in a position   Figure 4. Successive positions

4. Rocker curves generated by F point

With the above data it has been obtained the trajectory of E point (figure 5). From figure 6 it is observed that the two curves are continuous, with a small oscillation at φ =180 degrees, due to the imprecision of the trigonometric functions which appear in equations (2) and (3), as they were used small steps for φ.

However, the curve of figure 5 does not close completely. This rocker curve is interesting, a new curve in the mechanisms field.
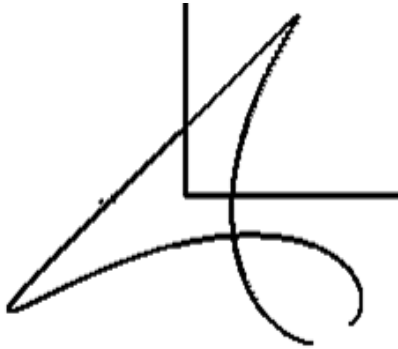

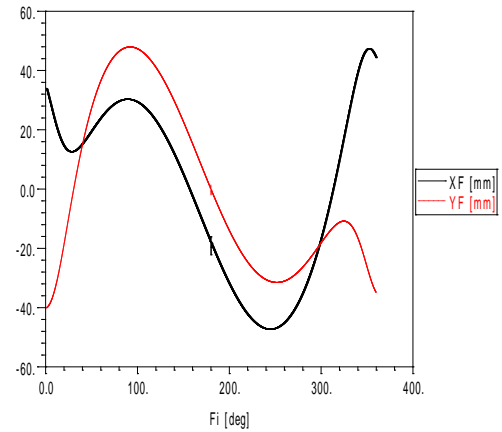Figure 5. The F trajectory for the initial data

Figure 6. Variation of F coordinates

If E is in the origin of the system (AE = 0), the rocker curve of figure 7 is different from the curve of figure 5. If AE = 2AB, it is obtained the rocker curve of figure 8, similar to the curve of figure 5, but larger, having a rectilinear portion.
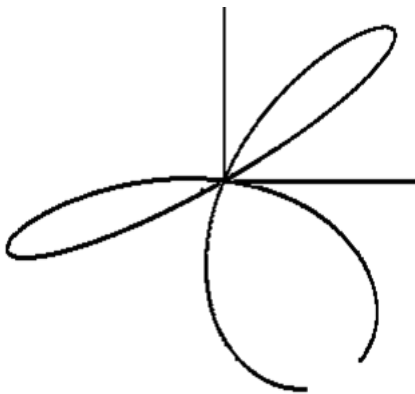

Figure 7. The resulting curve for AE = 0
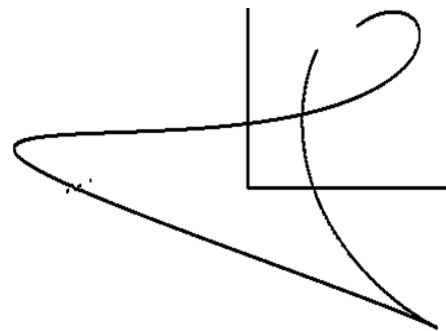
Figure 8. The resulting curve for AE=2AB

Furthermore, the angle δ has been changed, the rocker curves which resulted are shown in figures 9, 10, 11, 12 and 13.
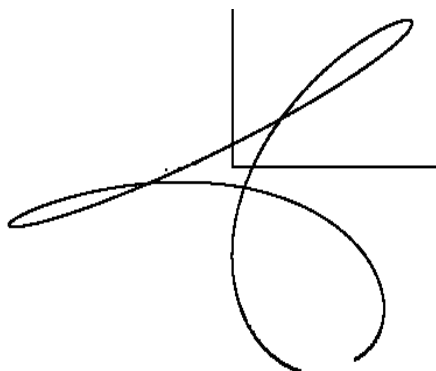

Figure 9. The rocker curve, δ =15

Figure 10. The rocker curve, δ =45
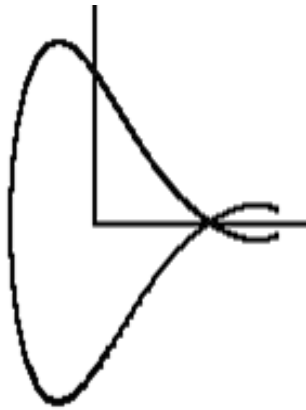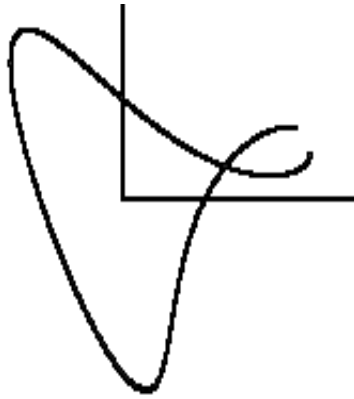
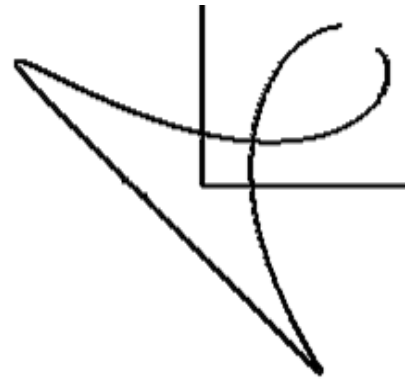Figure11. The curve, δ =90 and 270 Figure12. The curve, δ =120   Figure13.The curve, δ =330

It is found that curves similar to those shown above result, with the exception of the curve of figure 11, with δ =90 and 270, which is actually the representative curve of this mechanism.

For the rocker curves of figures 7, 8, 9, 10, 11, 12 and 13, their artistic forms are noted. Several papers have been published in the literature which have presented studies on mechanisms that generate aesthetic curves. For example, papers [11], [12], [13] and [14] show mechanisms generating curves with special aesthetics.

5. Rocker curves generated by G point

For the initial data, it was obtained the curve of figure 14. The curve is interesting, it has the shape of an ellipse with points of return at the ends. From figure 15 it shows the continuous variation of the curves (with small variations for φ = 180 degrees), and the curve of XG is symmetrical in relation to the ordinate of φ = 180 degrees.
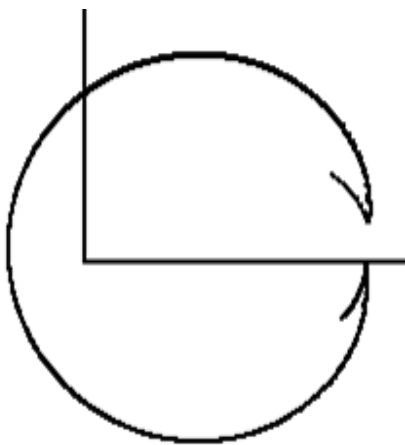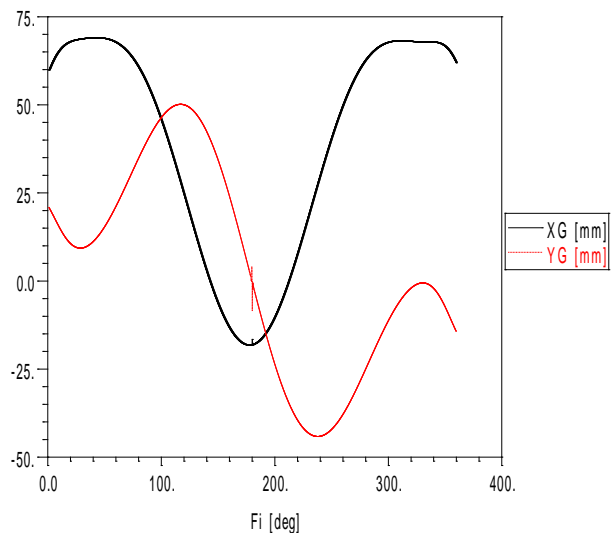

Figure 14. The trajectory of G (initial data)   Figure 15. The coordinates of G (initial data)

For AE = 0, a circle is obtained (Figure 16). Below are given the rocker curves resulting from different ε angle values.
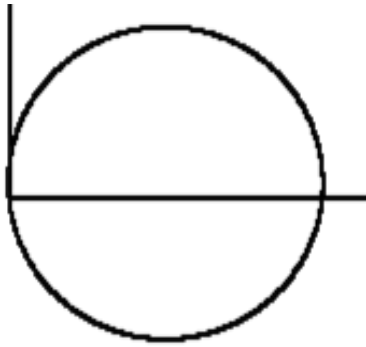
Figure 16. The trajectory of G for AE = 0
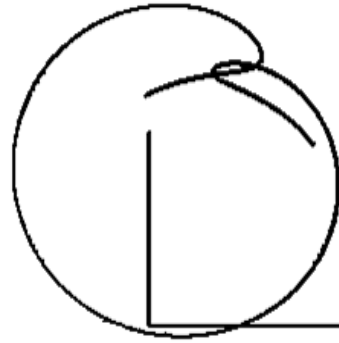

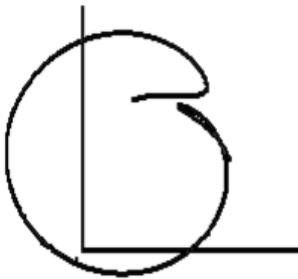Figure 17. The rocker curve, $\varepsilon = 15$

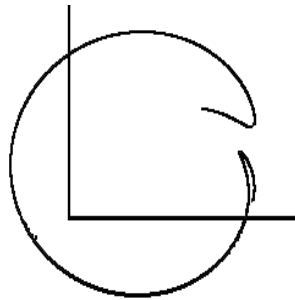Figure 18. The curve, $\varepsilon = 30$

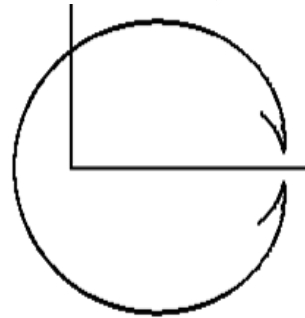Figure 19. The curve, $\varepsilon = 60$

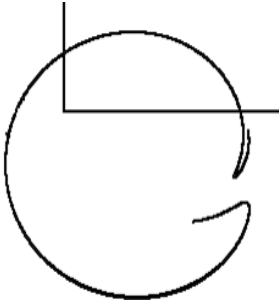Figure 20. The curve, $\varepsilon = 90$
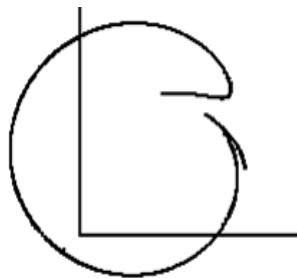

Figure 21. The curve, $\varepsilon = 120$
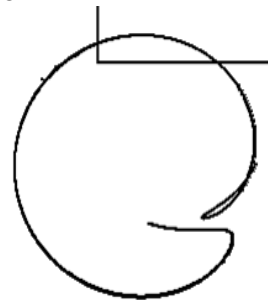

Figure 22. The curve, $\varepsilon = 220$

Figure 23. The curve, $\varepsilon = 330$

The representative curve is for $\varepsilon = 90$ and 270, of figure 20, which is symmetrical, the others being with other dimensions, other loops at the ends and positioned differently with respect to the axes of the system.

6. Conclusions

The rocker curves of the original mechanism (R-RRR-RPP-RPP mechanism) have been studied, generating a wide variety of new curves in the mechanisms. Two generating points were selected, one on a rocker and the other on a rotating element.

Particular cases have also been studied when the point with revolute pair of each RPP diade is at the origin of the axle system, the curves being different from the cases where this point is on the driving element.

Also, the angles between the welded sliders of RPP diads have been changed, as it is found that if this is of 90 degrees, the curves are symmetrical, representative for this mechanism.

The curves obtained for each generating point at the change of angles between the sliders are similar, but having different shapes at the endings, different sizes and different positions. Curves that are more special in appearance were obtained for the generator point on the rocker.

The rocker curves generated by the point that slides on a rocker are more complicated and more interesting than those at which the generator point slides on a rotating motion element. The angles between the welded slides have changed and the same curve shapes have been obtained, with some modifications and different positions on the axis system. In this way a wide range of special rocker curves generated by the mechanisms were obtained. The results obtained from the study can be used in the design of new mechanisms generating of rocker curves.

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