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KINEMATIC ANALYSIS OF DWELL LINKAGE MECHANISMS USING SOLIDWORKS MOTION

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The problem of designing of mechanisms that can provide a prescribed dwell of the output link, during the continuous rotation of the input link, is an important practical task, since these mechanisms are widely used in the design of various modern machines. For this purpose, different types of mechanisms can be used, in particular cam mechanisms, but, as it is known [1–7], in many cases linkage mechanisms have a number of essential advantages due to the absence of higher kinematic pairs and the presence of geometric closure of the links. Thus, they are practically more reliable and durable, and these mechanisms are able to provide higher operating speeds of machines, which is especially important for automatic machines.

To provide a dwell of the output link, linkage mechanisms can be used in such way that the certain part of their coupler curves can be approximated with a straight line or with an arc of a circle.

This paper considers the case of designing of such dwell linkages mechanisms that are based on a circular path generating mechanisms (approximation to an arc of the circle of the coupler curve).

There are a number of methods for the synthesis of linkage path generating linkage mechanisms and dwell mechanisms on their basis. Some of these methods use the conditions of the best approximation conditions according to Chebyshev, however, despite the significant number of works that are dedicated to the synthesis of such mechanisms [2, 5, etc], the variety of shapes of their coupler curves and the range of the choice of geometric parameters are quite limited in comparison to the possibilities of the fourbar linkage mechanism in general case.

Other methods of kinematic synthesis are based on the usage of the theoretical grounds of kinematic differential geometry [1, 4, 6, 7], which provide a much greater variety of kinematic schemes of the mentioned mechanisms. The main idea of those methods is to search for certain special points in the coupler plane of the mechanism, which can be set as a coupler point of the mechanism, and it allows to obtain such coupler curves that have sections which can be approximated to a straight line or to an arc of a circle with high accuracy. Such special points, which can be used for that purpose are: Ball's points, Burmester points and Chebyshev points, which can be also called Ball-Burmester points [6, 7].

By means of the methods of kinematic differential geometry, for the synthesis of the circular path generating mechanisms we can also use any point of the curve of circular points: each point of this curve provides a contact of the coupler curve with it tangent arc of the 3rd order (or hgher), and this curve can be determined for any position of the mechanism [4, 6].

It is also known that for the synthesis of circular path generating mechanisms we can also use the Burmester points, which can be determined for five infinitesimally close positions of the coupler plane and provide a contact of the 4th order, two of these points coincide with the movable hinges *A* and *B* of the mechanism and in the general case provide a contact of any order, and the other two points can be used for the synthesis of circular path generating mechanisms. It must be also noted that these points do not exist in all positions of the mechanism (Fig. 1).

In the Fig. 1 is shown linkage six-linked mechanism that provides a dwell of the output link during the continuous rotation of the input link 1.

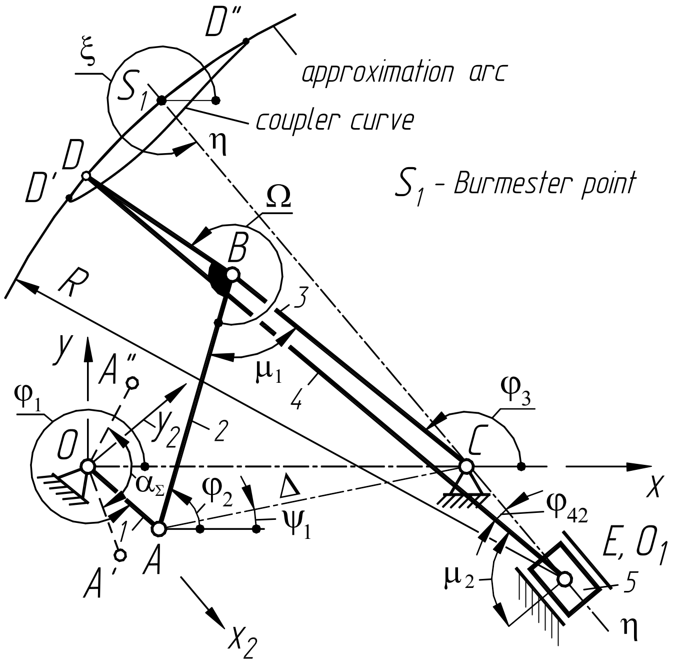


Fig. 1. Dwell linkage mechanism, which is synthesized on the basis of Burmester point

The mechanism operates as follows: to the crank 1, the position of which is determined by the angle φ_1, is connected a structural group 2–3 of the II class of the 1st type (according to the Assur classification), and in the coupler plane a certain point *D* is selected, whose position is determined by the magnitude l_{BD} and angle Ω. Position of this point coincides with the Burmester point S_1 and draws a coupler curve, which in the part $D_1 D_1'$ is aproximated by the arc of a circle. To the basic four-bar mechanism *OABCD* a structural group 4–5 of the II class of the 2nd type is connected in such a way that in one of the extreme positions of the mechanism the slider point *E* coincides with the center of the arc, to which the section $D_1 D_1'$ of the coupler curve is approximated. While the point *D* passes through this section of the coupler curve, link 5 will have an approximate dwell, and the magnitude of the theoretical deviation from a completely stationary position is proportional to the deviation of this section of the coupler curve from the arc of a circle.

The problem of synthesis of linkage path generating mechanisms and dwell mechanisms on their basis, using the kinematic differential geometry methods, are considered in the works [4, 6, 7].

However, in addition to the kinematic synthesis of these mechanisms, an important task is to carry out an analytical study of the kinematics and kinetostatics of these mechanisms, which allows to carry out the optimization synthesis of such linkage mechanisms according to different criteria.

Due to the rapid development of computer technologies, numerical and analytical methods for calculation of mechanisms are implemented in different CAD/CAM/CAE systems. They combine accuracy and speed of calculation, which allows to carry out multiparametric synthesis and allows to design those mechanisms with optimal or predetermined characteristics.

One of the most powerful Computer-Aided Design (CAD) system for designing machines and mechanisms is SOLIDWORKS, which also includes additional Computer-Aided Engineering (CAE) modules, such as SOLIDWORKS Motion, SOLIDWORKS Simulation, SOLIDWORKS Flow Simulation, which allow to carry out engineering analysis of technical systems. In particular, kinematic and dynamic study of mechanisms can be carried out using the SOLIDWORKS Motion.

Methodology for the synthesis of such mechanisms by various criteria was considered in [4]. In this work, we will consider the problem of computer modeling of the mentioned mechanisms and in order to determine their main characteristics using the SOLIDWORKS Motion system.

In the Fig. 2 a model of a linkage mechanism with a dwell of the output link is shown, which is synthesized using a Burmester point, the model was created in the SOLIDWORKS Computer-Aided Design system.

Using the developed computer model, a kinematic and kinetostatic study of such mechanisms was carried out.

In the Fig. 2, 3 some results of the study of the specified mechanism are shown, the calculations confirmed the presence of periodic dwell of the output link, as can be seen from the obtained displacement diagram (Fig. 2).

Fig. 3, *a*, and Fig. 3, *b* show some results of the kinematic study of the dwell linkage mechanism, in particular – velocity and acceleration diagrams of the output link of the mechanism (slider 5).

Thus, the use of modern CAD/CAE software packages, in particular SOLIDWORKS computer modeling system and the

SOLIDWORKS Motion engineering analysis package, it is possible to significantly simplify the design and analysis of linkage mechanisms with a dwell of the output link.

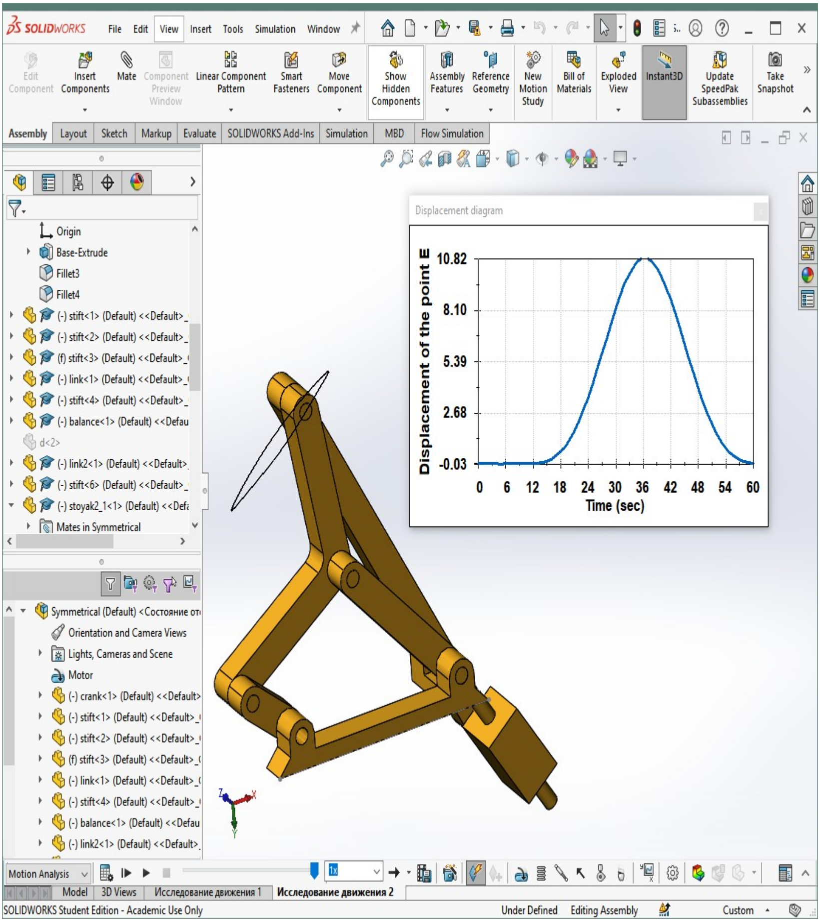
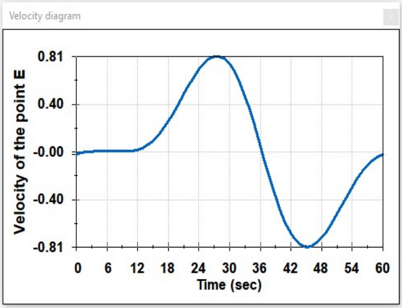
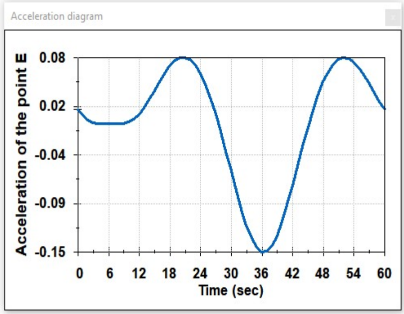


Fig. 2. Model of a linkage mechanism with a dwell of the output link, synthesized using a Burmester point

The prospects of further research is the kinematic systesis of high-class linkage mechanisms and their parametric optimization according to the criteria of the kinematic parameters of their links.



a



b

Fig. 3. Results of the kinematic study of the mechanism:
***a*) linear velocity of the point E (slider 5);**
***b*) linear acceleration of the point E (slider 5)**

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