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APPLICATION OF THE CORRECTING DRIVE FOR GENERATING THE MANIPULATORS OF EFFECTOR'S TRAJECTORY

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Abstract: The article presents the application of an additional correcting drive in a mechanism (manipulator), which enables shaping effector's trajectory by fluent modification of the supporting point's position of a passive module, without the change in speed of the main drive's angular velocity. The conducted research and computer simulations pertain to a flat mechanism in the form of an articulated quadrilateral. The author shows the application possibilities of the correcting drive in shaping (to a certain extent) arbitrarily given trajectories of manipulator's effector.

Key words: manipulator, mechanism, effector, trajectory, computer simulation.

Generating trajectories

Testing and synthesis of mechanisms and marking out the parameters of mechanism movements during realization of definite trajectory of the effecting module (effector) have always caused many difficulties and called for special methods. Mostly the requirements concerning planed trajectory of the effector movement refer to only some of its parts. On definite segments it should have a required shape (path), speed or acceleration (movement parameters) [1, 2]. The author propose to use one mechanism that would realize different trajectories through introducing, out of the main drive, and additional unit with a correcting drive [3]. Such a mechanism would realize trajectories being parts of any trajectories from family of curves which could be traced by the effector of mechanism with different parameters (of position and speed) of a correcting drive. An articulated quadrilateral mechanism was taken for tests. The introduction of a correcting drive causes the change of the bearer position in vertical, horizontal and on circle placed over and under the bearer according to the controlling program. The examples of generated trajectories with a correcting drive are shown on Fig. 1.

In this mechanism, the additional drive is to cause the alteration of E support position of a passive module. The essential condition is the fact that the change in positioning cannot lead the mechanism into the odd locations. Odd locations are understood as locations in which the mechanism cannot make further movement (will be blocked) as well as the movement of a contact block enables more than one location of passive modules. In order for it to happen, it should be obeyed that in every location of point E, the Grashof conditions should be met, which describe geometric interdependencies between the mechanism's modules [4]. The sum of crank's length and every other module of the crank-wishbone mechanism is smaller than the sum of other modules' length.

In the case of the studied quadrilateral, the following inequalities should be fulfilled [5]:

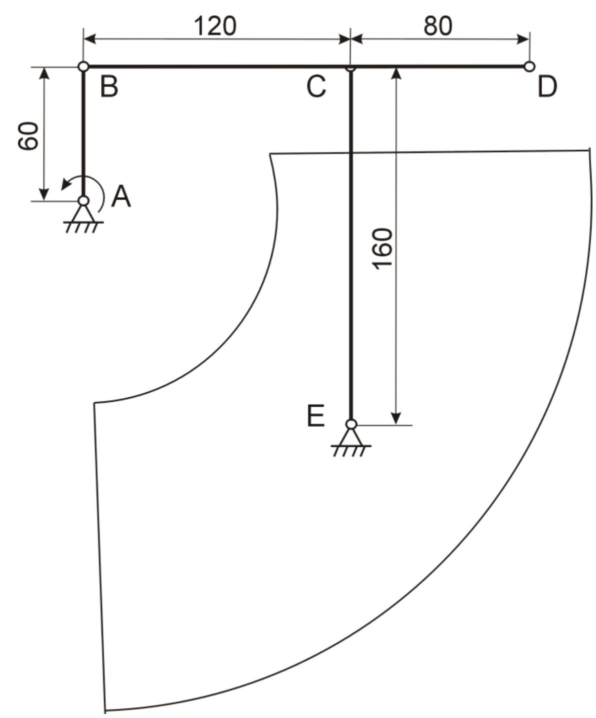

Fig. 1: The scheme of articulated quadrilateral used for tests.

$$\begin{aligned} |AB| + |BC| &< |AE| + |CE| \\ |AB| + |CE| &< |AE| + |CE| \\ |AB| + |AE| &< |BC| + |CE| \end{aligned} \tag{1}$$

These conditions describe the scope of possible changes in a wishbone's support position. In case of the studied mechanism, the lengths $|AB|, |BC|$ as well as $|CE|$ remain stable. The $|AE|$ distance changes. The normal sizes of particular modules were assumed as follows: $|AB| = 60[mm]$, $|BC| = 120[mm]$,

$|CD| = 80[mm], |CE| = 160[mm]$. Thus, from the inequalities (1), the $|AE|$ distance can be determined.

$$|AE| > |AB| + |BC| - |CE| = 60 + 120 - 160 = 20 \Rightarrow |AE| > 20$$

$$|AE| > |AB| + |CE| - |BC| = 60 + 160 - 120 = 100 \Rightarrow |AE| > 100$$

$$|AE| < |BC| + |CE| - |AB| = 120 + 160 - 60 = 220 \Rightarrow |AE| < 220 \quad (2)$$

The change in distance between points A and E in the scope from 100 to 220 [mm] is acceptable. From point A, two circles should be drawn with the aformentioned radii; between them, there is the field of acceptable changes in E support position. For the test purposes, the thorus shape was restricted to one of its quarters, which was presented in Fig. 1.

Trajectories of the articulated quadrilateral's effector depending on the e point's position

Changes in position caused by moving the E support vertically, horizontally and by adding the additional rotatable module with the length equalling $\frac{1}{2}$ of the $|AB|$ part, i.e. 30 [mm]. for the selected support's positions, the D point trajectory was determined, which was located at the end of part 2. These trajectories are presented in Fig. 2.

The module with the correcting drive enables the smooth movement of the effector between the designated trajectories without influencing the constant angular velocity of the main drive. The so-called passing points between trajectories belonging to the family of trajectories generated by a particular mechanism. The determined points with the same position of the main drive's angle (active module) was combined and the lines of a regular angle determining the areas of possible movements from one trajectory to the other were obtained. The areas received in this manner enable to determine the parameters of correcting module's work. Every movement form one line of the regular angle to the other states the exact angular change of the main drive. This change designates the time in which the distortion (position adjustment) of a correcting module is to take place. The size of the distortion is determined by the sequence and number of movements between trajectories.

Implementation of particular shapes of articulated quadrilateral effector's trajectories

An example selected to implementation trajectories of D point are shown in Fig. 3. In the trajectory (Fig. 3a), two straight perpendicular sections of a track were assumed and in the trajectory (Fig. 3b), two parallel sections of a track are necessary. The other parts of a trajectory (a dashed line in Fig. 3) can take various shapes. In the mechanism, the variant was selected in which the correcting drive was introduced in the shape of an additional module placed above the nominal E support's position (Fig. 2d) and the variant with the movement of E support takes place vertically (Fig. 2b). The first option allows to obtain the assumed trajectory with perpendicular sections and

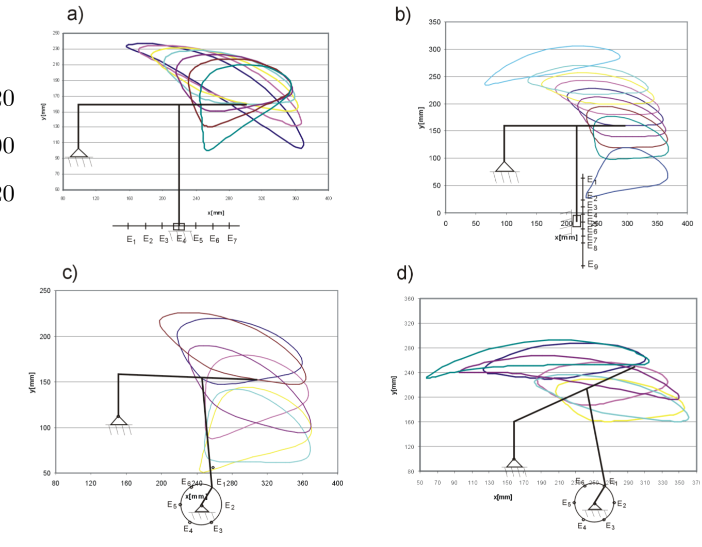

Fig. 2: Determined trajectories with the position change of E support as follows: a) horizontally b) vertically c) in a tangent circle below the support d) in a tangent circle below the support.

the second one – with parallel ones. Each of the two mechanisms was provided with two trajectories (Fig. 4), where each one implements one of the assumed sections.

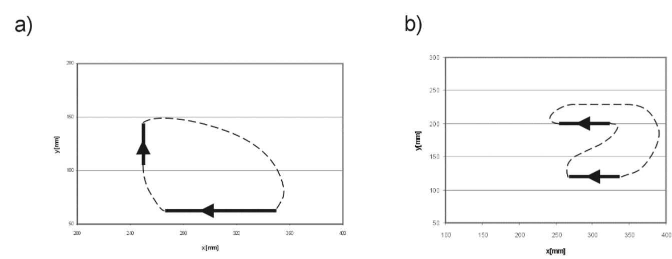

Fig. 3: The assumed shapes of quadrilateral's effector trajectories, a) trajectories with two perpendicular sections b) trajectories with two parallel sections

For the implementation of the given trajectory with two perpendicular parts, two trajectories were selected (show in Fig. 4a) from the family of curves, obtained from the mechanism with a rudder placed under the nominal point of E support. For the implementation of the given E trajectory with two parallel sections, two trajectories were selected (shown in Fig. 4b) from the family of curves, obtained from the mechanism with a correcting drive situated under the nominal point of E support.

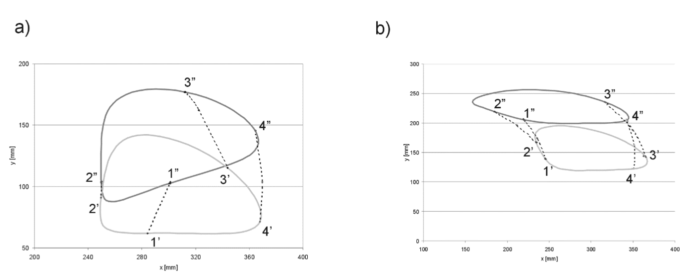

Fig. 4: Selected trajectories implementing the demanded track sections. 1 – regular angle's lines of the main drive, 1',1",2',2" – passing points

For the implementation of the demanded trajectories, the passing from one track to another must take place. This passing, conducted by the correction of E support's position with the use of the additional drive, will take place between two lines of the main drive's regular angle. During the correcting drive's work, point D of the mechanism's effector passes from point 1' to 2" with the first passing and from point 3' to 4" – with the second one. Points 1', 2", 3', 4" belong to proper tracks of M point with various positions of the additional correcting module.

Simulation results and conclusions

After conducting simulations, trajectories were obtained, which implement the given tracks of the assumed trajectories A and B. The remaining courses are shown in Fig. 5.

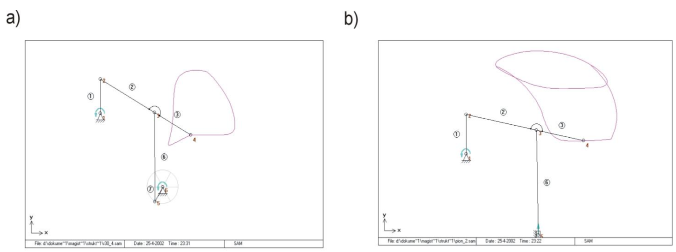

Fig. 5: Resulting trajectories implemented by mechanisms with an additional correcting drive.

In Fig. 6, the graphs were presented showing the work of the main and the correcting drives. These are the values of the drive's inclination angle in time function.

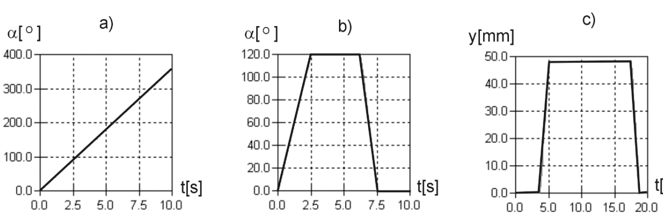

Fig. 6: Graphs presenting the work of the following drivers: a) main, b) correcting with a rotatable module, c) correcting with a movable support.

The conducted studies prove that the implementation of an additional module with a correcting drive can smoothly cause the change of the mechanism working point's trajectory. It does not demand introducing additional changes in the mechanism's geometrical parameters or changes in angular velocity of the main drive. The potential change of the given trajectory entails only the necessity to change working parameters of the correcting drive. Obtaining such a change will ensure proper management of the stepper motor. By implementing proper algorithms of selecting drive's work, the finite number of trajectories can be implemented by using the same kind of mechanism. Further studies are conducted in order to create algorithms allowing to obtain the assumed trajectories in the fields of passages between the lines of the main drive's regular angle in the way so as to implement the assumed track sections during the work of a correcting drive.

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