Scientific and Technical Journal on "Engineering Mechanics", Iss. 15, Vol. 7, No. 1, March 2024

Azerbaijan University of Architecture and Construction
ISSN 2706-7726

Engineering Mechanics
Scientific and Technical Journal

E-mail: engineeringmechanics@azmiu.edu.az

March 2024	Issue 15	Volume 7	Number 1	Pages 20-22

KINETOSTATIC ANALYSIS OF THE FIVE-FOLD PLANAR MECHANISM

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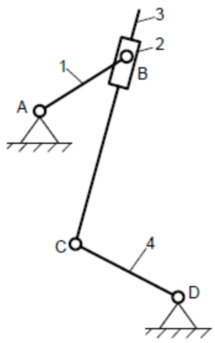
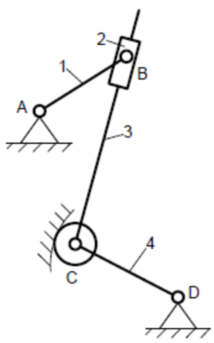
Abstract. The article discusses the kinetostatic analysis of a flat five-link lever rocker mechanism with two degrees of freedom. Having two degrees of mobility, the output link of the CD mechanism makes an indefinite movement. But, if you set a roller moving along a certain trajectory at the point C of the added highest kinematic pair, then the mechanism turns into a mechanism with one degree of freedom. As a result of the roller being installed in the kinematic pair, sliding friction is replaced by rolling friction, which leads to a decrease in friction forces that prevent movement in the support. Since the problems of synthesis and kinematic analysis of this mechanism are considered in [3], the issue of kinetostatic analysis is considered here. For this purpose, the **D'Alembert's** principle was used. The article considers the first problem of dynamics, that is, with a known law of motion of a mechanical system, unknown reaction forces are determined. And also considering the force analysis of the input link, the balancing force acting from the side is determined.
Keywords: five-link, Kulis, degree of freedom, link, kinematic pair, roller.



Pic. 1



Pic. 2

It is known that the five-link lever rocker mechanism has two degrees of freedom (Pic. 1). It is clear that when the input link AB of this mechanism moves according to a given law, its output link CD will make an indefinite movement. This means that its output link CD does not implement the required law of motion. In [2], it was noted that if any point of this mechanism is forced to move according to a certain law, then the mechanism will have one degree of mobility.
It is known that in most cases in leverage mechanisms [1] the law of motion of the output link is implemented approximately.
In technology, the exact implementation of a given law of motion of the output link of the mechanism is always relevant. In this mechanism, you can set the law of motion of the selected point to provide the required law of motion of the 4th output link. A roller is mounted at point C of the output link CD. To this end, a channel with radius DC is made in the fixed post of the mechanism, into which a roller mounted at point C is placed. In this case, one two-movement, i.e.

higher kinematic pair is added to the kinematic pairs of the mechanism. In this case, the mechanism has one degree of freedom;

$$W=3n-2p1 - p2 = 3\cdot 4-2\cdot 5-1=1.$$

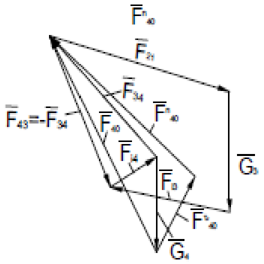
Rotation of the roller around its axis does not affect the overall movement of the mechanism. The problems of synthesis and kinematic analysis of the mechanism are considered in [3, 4]. In this paper, we look at the kinetostatic analysis of this mechanism.

In the kinetostatic analysis of a mechanical system, the first problem of dynamics is considered - with a known law of motion, the forces acting on the system are determined. In a dynamically unbalanced system, inertia forces of the mechanism links are added to the existing known forces, and the system is considered as a balanced system of forces in which dynamics problems are solved using statics equilibrium equations.

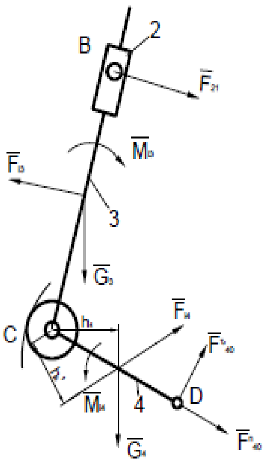
It is known that if the degree of freedom of the kinematic chain (1) is zero, then the system is considered statically definable. For this reason, in the kinetostatic analysis of the mechanism, when determining unknown reaction forces, kinematic chains that are part of these mechanisms, the degree of freedom of which is zero, are first considered. The mechanism under consideration consisting of 2,3,4 links has one kinematic chain the degree of mobility of which is equal to zero.

$$W=3n-2p1 - p2 = 3\cdot 3 -2\cdot 5-1=0$$

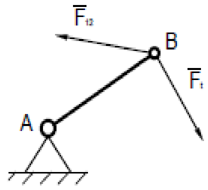
Consider the equilibrium of this chain, distinguishing it from the mechanism (Pic. 3). We apply the corresponding reaction forces to the selected kinematic pairs.



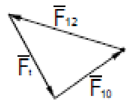
Pic. 3a



Pic. 3



Pic. 4



Pic. 4a

4 link with support form single-movable rotary kinematic pair which is decomposed into components. If you do not take into account the weight of the link stone, then the reaction force of the first link on 2 will be applied at point B and directed perpendicular to the link CB. The reaction force generated by the highest kinematic pair, which includes the roller, will be directed normal to the element of the pair. Modules and directions of inertia forces and moments of inertia forces of the M_{i3}, M_{i4} of the 3rd and 4th links are determined in the kinematic analysis of the mechanism [2, 3, 5].

To determine unknown parameters of reaction forces, we use the graph-analytical method. First, consider the equilibrium of the 4th link and compose the equilibrium equation of the moments of the active forces of this link relative to the point C:

$$F^{\tau}_{40}\cdot CD + F_{i4}\cdot h_1{}' - G_4\cdot h_1 + M_{i4}/\mu_l = 0.$$

where μ_l is the scale of the position plan.

After you define the F^{τ}_{40} force, you draw a force polygon to find the force values. When building a force polygon, you must start with the direction of one of the unknown forces and close the polygon with another unknown force. Pic. 3a shows a power polygon constructed for this kinematic chain. Force arising in rotary kinematic pair installed in point D F_{34} and reaction of forces acting on link stone F_{21} are found from this force polygon.

The arising reaction force F_{12} in a single-motion kinematic pair located at point C is found from the constructed 3a force polygon as F_{21} resultant of the forces acting on the 3rd and 4th links. After that power analysis of AB input link with support, which form conditionally the first class mechanism, is considered (Pic. 4). Since this system is statically indeterminate, an unknown counterbalancing force is applied to it, the application point and direction of which are assumed to be known. Balancing force is the force acting on the mechanism from the side. We apply this force at a point perpendicular to the AB link. The balancing F_t and the reaction force F_{10} are determined from the force triangle plotted in Pic.4a.

This completes the kinetostatic analysis.

Conclusion

1. In the kinetostatics of the five-link flat-link mechanism, which includes the highest kinematic pair, the D'Alembert's principle was used.
2. The reactions of forces arising in kinematic pairs were determined.
3. When considering the force analysis of the input link of the mechanism, a balancing force was also determined.

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