Class V sliding kinematic joint with single added motion

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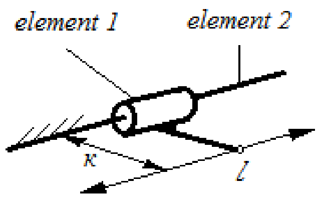
ABSTRACT: The sliding kinematic pair of the Vth class is one of the main building blocks of kinematic mechanisms. This material is a very small sample of the initial stage of the vast theory of kinematic synthesis of long kinematic chains. The difference between constructive addition of motion to the sliding kinematic link and kinematic addition of motion is shown. A method for the possible initial added motions to the sliding kinematic link is demonstrated for the purpose of correction and control of the motion of the end link. The method for transforming the kinematic sliding link into a spatial mechanism of a closed type is shown.

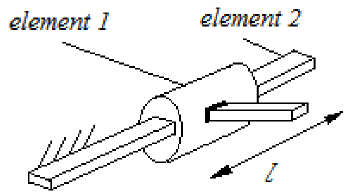
Keywords: sliding kinematic pair, spatial mechanism, synthesis, motion

I. Introduction

The sliding kinematic connection is one of the two possible kinematic connections of the V–th class, according to the officially accepted classifications in Theoretical Mechanics. The sliding kinematic connection scheme shown in Fig.1.a) is the main scheme for designating a sliding connection in the kinematic diagrams of mechanisms [1,2]. It consists of two elements, with element 1 conventionally called a *slider*, and element 2 conventionally called a *sliding rod* or just a *rod*. In the general case of this kinematic connection, the slider has a rigidly attached elongated arm to the side, at a distance *k*. Despite the thus adopted scheme for the slider kinematic connection, a general clarification is made, the slider cannot rotate around the sliding rod. If such a rotation is feasible, then the sliding kinematic connection will not be of the V–th class [3,4]. This necessitates the display of the sliding kinematic connection in a semi-constructive version in Fig. 1.b). It is evident from this diagram that the rod represents a long parallelepiped to which the slider is attached and the two links can only perform the relative sliding motion *l*, relative to each other.



a)



b)

Fig.1. Sliding kinematic joint of V-class.a) Kinematic diagram of a sliding joint; b) semi-structural diagram of a sliding joint.

The external cylindrical shape of the slider is not important for the sliding kinematic connection. The clearance between the slider and the rod in this connection is regulated. Ideally, there is no clearance and the sliding is realized in a transitional assembly. At the structural level, the designer can recommend different types of assemblies if necessary. This clarification suggests that the shape of the rod determines the shape of the slider hole [5-7]. If the shapes of the rod and the slider differ, the sliding kinematic connection is exceeded.

1. CONSTRUCTIVE ADDITION OF MOTION TO THE SLIDING KINEMATIC CONNECTION

The constructive addition of movement to a sliding kinematic connection represents a geometric change in the shape of the links, which changes the functions of the connection itself.

Before deriving the types of sliding connections, it will be specified that from a mathematical point of view, the spatial spiral is the only spatial curve that can, under certain parameters, have a constant value of its period and a constant value of its curvature in each section of it. As a derivative of the spatial spiral, at zero period it becomes a circle, which is a plane curve with constant curvature.

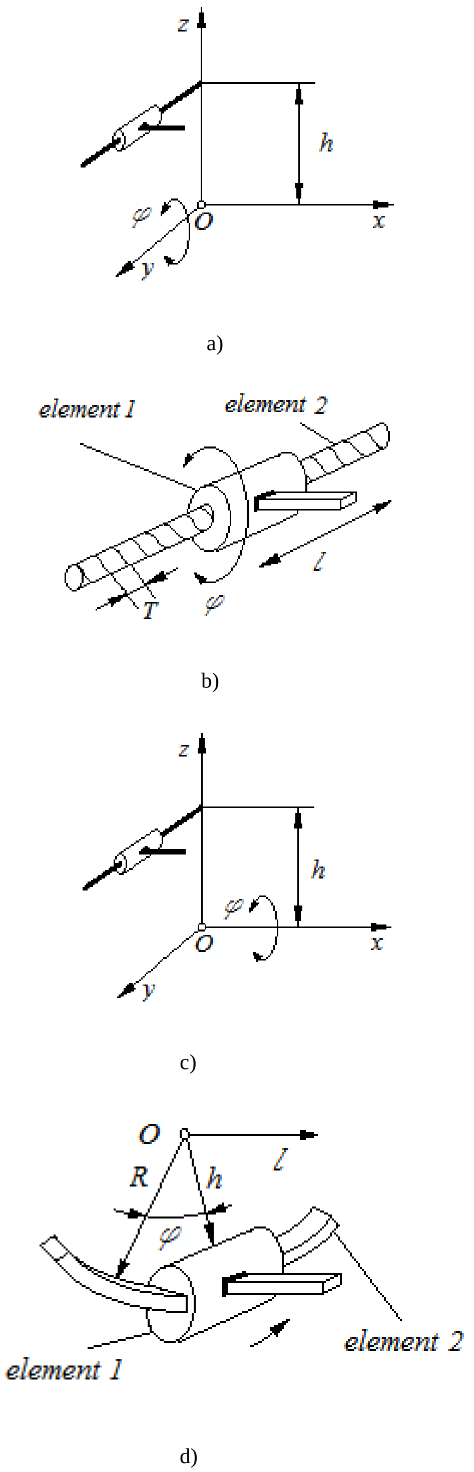


Fig.2. Sliding kinematic joint of V-class with constructively added rotational movement

There are two types of design changes to the sliding kinematic joint units that result in the addition of movement to the joint.

One is an axial change of the rod (element 2) and the slider hole (element 1), which leads to the addition of movement of the entire gear. According to the diagram shown in Fig.2.a), if the rod is twisted in the form of a spiral with a period $T = const.$ around the y axis and a diameter $2h = const.$ and a hole is made in the slider copying the shape of the rod, a sliding kinematic connection with axial movement along the y axis and rotational movement around the same axis will be obtained.

If we put $2h = 0$, we get the semi-constructive scheme Fig.2.b), which in practice is a scheme of the screw mechanism well known from Mechanics.

The scheme shown in Fig.2.c) demonstrates the introduction of additional movement into the sliding kinematic connection by constructively changing the links around an axis perpendicular to the axis of the rod. In this case, an added rotational movement around the axis x is shown, around which the helix of the rod is located. Fig.2.d) shows the semi-constructive scheme of this sliding kinematic scheme.

The addition of rotational movement around the axis z is also obtained in an absolutely analogous way, but in this case the difference is that the helix of the rod is around the axis z

I. PRESENTATION

In practice, the first steps in the synthesis of modular kinematic chains, as well as Long kinematic chains, begin with adding movements to the kinematic links (in this case, the sliding kinematic link) as needed.

1. KINEMATIC CONSTRUCTIVE ADDITION OF MOTION TO THE SLIDING KINEMATIC CONNECTION

In practice, in addition to *the Constructive Added Motion* to the sliding kinematic connection, there is also *the Kinematic Added Motion*. The Kinematic Added Motion is more applicable due to the fact that sliding kinematic connections with a straight rod have found wide application in industry and are mass-produced.

The synthesis scheme is shown in other publications, and involves obtaining motion from one link, converting it through a suitable kinematic chain and adding the resulting motion to the motion of the other link. Thus, by adding a parallel kinematic chain to the existing kinematic link, a spatially closed kinematic chain with adjustable motion of the end link is obtained. This is no longer a sliding kinematic link of the V-th class, but a spatial mechanism of a closed type.

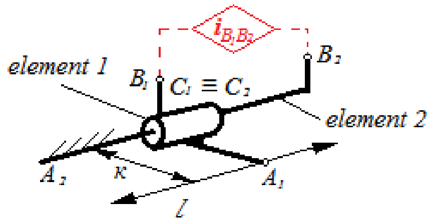


Fig. 3 Scheme of kinematic superstructure of a sliding kinematic connection

The kinetic connection scheme shown in Fig.3 is superimposed with the spatial kinematic chain $i_{B_1B_2}$. The scheme shown thus demonstrates that elements 1 and 2 are not binary but have at least three points of contact with other links (in the shown scheme, the contact between the two links in the kinematic connection chain is at the points $C_1 \equiv C_2$). Points A_1 and A_2 are respectively the starting and ending points for the mechanism (in the case of constructively added movement, point A_2 is not always the ending point of the mechanism), and points B_1 and B_2 are the points of contact with the added kinematic chain $i_{B_1B_2}$ (these points can be more than two). The additionally synthesized and added kinematic chain $i_{B_1B_2}$, can receive its motion from element 1, transforming it and adding it to the motion of the element 2. In this way, the motion of the second link is corrected and in more complex added kinematic chains $i_{B_1B_2}$, the final link can describe complex spatial curves.

The added kinematic chain $i_{B_1B_2}$ can contain motor-reducer groups that add additional, independent, movements (in the presence of motor-reducer groups, it is possible to synthesize multiple added kinetic chains of the first, second, and higher order of control), thus the movement of the end link can describe different types of volumes, through a series of spatial curves. The use of an added kinematic chain $i_{B_1B_2}$ with additional motor-reducer groups makes it possible to eliminate the restriction in the constructive added movement for the movement of the end link along a spatial curve with a constant step and constant curvature. Thus, the synthesized mechanisms can describe any spatial curves.

II. CONCLUSION

The described methodology of primary synthesis of spatial mechanisms allows for an initial start of synthesis of spatial mechanisms for various technological needs for the production of parts with a complex shape (various types of turbines, rifling of weapon barrels, ergonomic shapes of parts in medicine, etc.).

Thus, the described methodology of initial synthesis allows for the synthesis of spatial closed (in particular, open) long kinematic chains for the implementation of certain technological tasks.

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