https://doi.org/10.26160/2474-5901-2019-14-20-26

ACTIVE LINK IN THE KINEMATIC SCHEME WITH INSTANT KINEMATIC INDEFINABILITY

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Keywords: four-link mechanism, redundant links, active link, motion uncertainty dead point, S. Abdrainov's lever drummers, the gap in the hinge.
Abstract. Examples of four-linking hinged-lever devices with a special position of links, in which their kinematic pairs are located on one line, are considered. Analyzed the properties that ensure the certainty of the movement of the output link. It was proposed to consider the lever shock mechanisms of S. Abdraimov as mechanisms of variable structure with an *instant, non-retaining, active bond.*

АКТИВНАЯ СВЯЗЬ В КИНЕМАТИЧЕСКОЙ СХЕМЕ С МГНОВЕННОЙ КИНЕМАТИЧЕСКОЙ НЕОПРЕДЕЛИМОСТЬЮ

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Ключевые слова: шарнирно-четырёхзвенный механизм, избыточная связь, активная связь, неопределённость движения, мёртвая точка, рычажные ударники С. Абдраимова, зазор в шарнире.
Аннотация. Рассмотрены примеры четырёхзвенных шарнирно-рычажных устройств с особым положением звеньев, в котором их кинематические пары расположены на одной линии. Проанализированы свойства, обеспечивающие определённость движения выходного звена. Предложено рассматривать рычажные ударные механизмы С. Абдраимова как механизмы переменной структуры с мгновенной, неудерживающей, активной связью.

The lever shock mechanisms proposed by S. Abdraimov based on a hinged-lever four-link mechanism of a crank-rocker type with a special position in which all kinematic pairs are located on the same line have established themselves above all by ease of manufacture and high efficiency.

Many years of experience in creating, formed an idea of the nature of the motion of the input and output unit - crank and rocker drummer at the time of the strike. The peculiarity lies in the fact that the kinematic connection of the rocker arm with the crank in the area close to the impact, and therefore in the area close to the special position of the links, is practically lost. The mechanism is dual-motion.

About this feature of the four-link lever mechanism with a special position of the links has long been known. For example, in his work Reshetov L.N. [1], describing the peculiarities of schemes with "degeneration of Assur groups", indicates their inherent "harmful mobility and redundant bonds" in a "dead position" (Figure 1, solid lines).

To exclude the second mobility, without specifying additional generalized coordinates to the output link, i.e. without using the second drive, practicing machine scientists, once the common drive mechanism for the driving wheels (sparok) of a locomotive, many design techniques were suggested. Of all the variety of techniques, in the locomotive technique has found the use of the second connecting rod with a spaced "phase of movement" of 90 degrees (Figure 2).

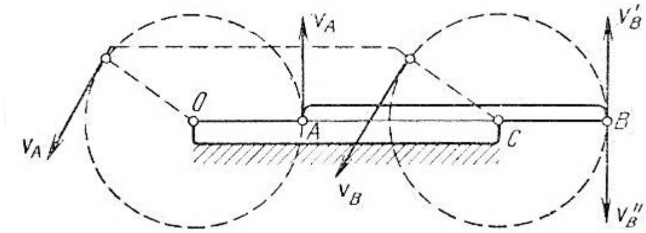

Fig. 1. The mechanism of a parallel crank in a dead position (solid lines) and in an arbitrary (dashed lines) [1, p.81]

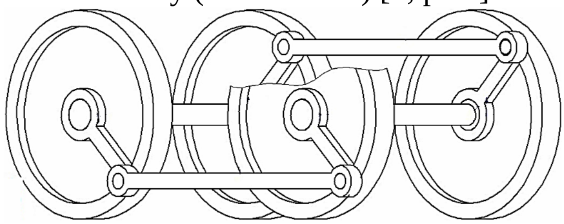

Fig. 2. Coupled cranks

The overwhelming majority of authors agree on the presence of a dead center in this mechanism. This reflected Kraynev A.F. in [2, p.217].

Figure 3a shows the scheme in which the B_0B_2 rocker, due to inertia, passes the dead point. At the same time, having definiteness of movement, the yoke together with the connecting rod turns out to be in one of “two possible positions” either at point B^I_2 or at point B^{II}_2.

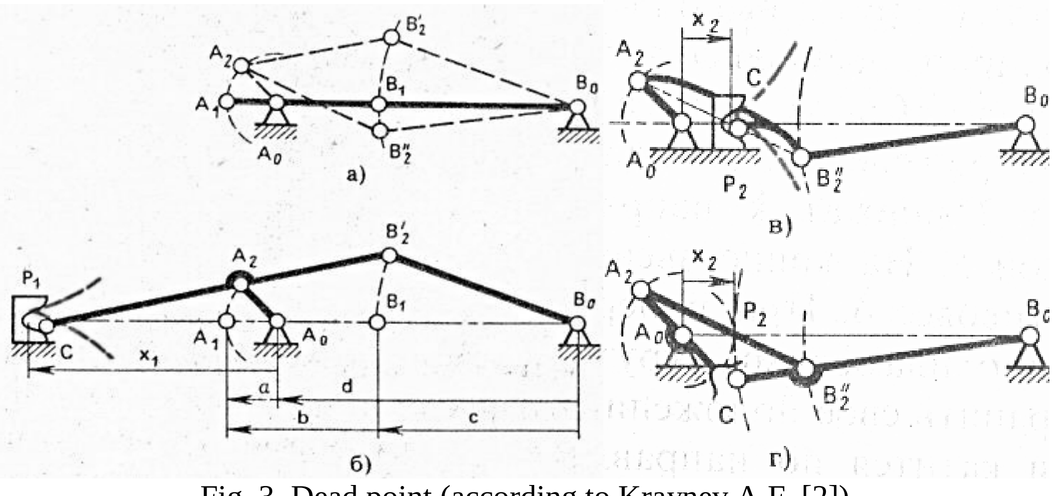

Fig. 3. Dead point (according to Kraynev A.F. [2])

In many cases, the exclusion of ambiguous direction of motion occurs at the expense of inertia forces. But for low-speed mechanisms with small inertia forces, constructive solutions such as forks-hooks were proposed, examples of which are shown in Fig. 3 б, в, г. Subsequently, for "mechanisms of parallel cranks," these solutions were transformed into a scheme with the highest kinematic pair - toothed gearing, which made it possible to raise the transmission speed of the mechanism's rotation and abandon the second connecting rod.

Apparently, the opinion of the presence of a dead position for the movement of links, in any direction, was formed by the first machinist practitioners, somewhere at the turn of the end of the 18th century - the beginning of the 19th century. In the period of the birth of the industrial revolution, on the first samples, the mechanism probably broke down in a special position. Of course, we are not able to provide concrete examples in support of the above. But it can be assumed that the first cause of breakdowns at that time was associated with errors in manufacturing, leading to gaps in the hinges, due to which the efforts on the links occurred in a coaxial direction, causing both the occurrence of peak stresses and the uncertainty of movement in specific moment.

The modern level of technology allows minimizing the impact of manufacturing errors and virtually eliminating the coaxial direction of effort. This makes it possible to challenge the assertion about the dead center. Although, the presentation of the submitted authors already creates a contradiction: on the one hand, it is argued that the second mobility is possible in the opposite direction, on the other hand, even the “double dead point” argues.

It may be noted that the second mobility of the output link is inherent in all mechanisms of the second class, in which a two-branch Assyrian group is used with leads that create a special position of the links.

In particular, we consider a crank-slider mechanism, which is derived from a hinged-lever mechanism in which the leading crank is replaced by a link with a progressive kinematic pair. For convenience of presentation, let us consider the classic, for modern automobile engines, axial layout, where the axis of the slide passes through the axis of the crank (Figure 4).

In the special position of the mechanism corresponding to the extreme positions of the slider, and the crank (output link) to both positions marked “DP”, the crank has a second mobility. The second mobility, manifesting itself in the opposite direction of the crankshaft of the engine, could have resulted in injury to the driver. When starting old models of engines manually, the start handle could hit the driver’s hands. In this case, special driver skills were required to avoid injuries to the hands.

The main feature of the considered scheme is with a leading polisher and a driven crank, the occurrence of coaxially directed efforts along links at both points “DP” (dead point), creating a dead position for the movement of links.

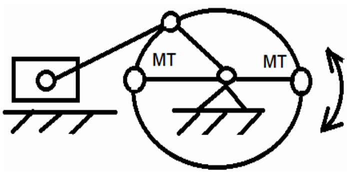

Fig. 4. Diagram of the axial crank-slider mechanism

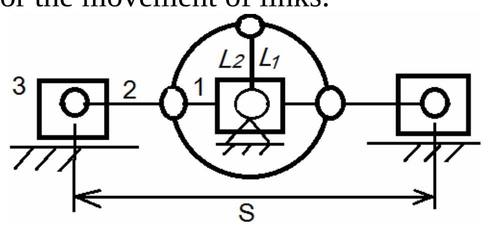

Fig. 5. Diagram of the variable class mechanism

However, if the leading link is a crank, and the slider is driven, as in presses, then the coaxiality of the efforts does not arise and there can be no dead position. Only violation of the operating conditions led to a dead position, i.e. jamming presses.

Noteworthy is the experience of creating clutchless presses based on slider-type slider-type circuits, in which the length (L) of crank 1 and connecting rod 2 are equal: L1 = L2 [3] (figure 5). When combining the axis of rotation of the kinematic pair on the slider with the axis of rotation of the crank, the circuit creates a condition for an additional bond that holds the slider on the support. As a result, an idle mode appears in which the slider, remaining in place, does not make a working stroke, while the connecting rod continues to rotate along with the crank. In idle mode, the press is converted to a first-class mechanism. In the operating mode, when the circuit is converted back to the second-class mechanism, the slide stroke S can get more than four crank lengths L1.

It should be noted Artobolevsky I.I. in the reference manual [4], did not use the phrase "dead point", used only the term "motion uncertainty" or "position uncertainty", both for the pivot-lever mechanisms (Figure 6) and for the crank-slider mechanisms.

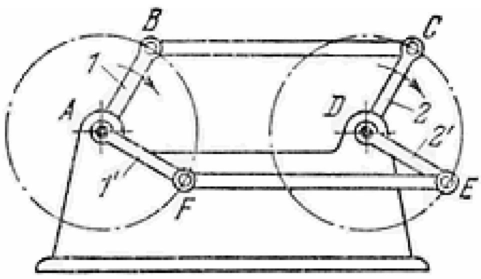

Fig. 6. The mechanism of a double articulated parallelogram (according to Artobolevsky I.I. [4])

The term "mechanism with instantaneous kinematic indefinability" is the most accurate description of the characteristics of mechanisms with the uncertainty of movement. This term was met by S.N. Kozhevnikov, as noted by Fokin Yu.A. [5]. Fokin Yu.A. identified three types of mechanisms with kinematic indeterminacy: 1 - at any position of the links, 2 - on a segment and 3 - at a point. The last third kind of mechanisms is the subject of discussion in this article.

In our opinion, as a clarification of the terminology used, the following should be noted. If the movements of links are kinematically indefinable at a point, then this group of links cannot be called a mechanism, since this contradicts its definition. By definition, a mechanism is a kinematic chain that transforms one specific movement of the input link into the desired movement of the output link.

Therefore, in case of uncertainty of the output link movement, it is more correct to replace the word "mechanism" with the expression "kinematic scheme". In other words, the kinematic scheme with instantaneous kinematic indeterminacy turns out to be a mechanism in the case of the additional use of links providing the given law of motion of the output link in a particular position.

Instant kinematic indeterminacy arises in a special position not due to the influence of gaps in the hinges. It is present in schemes with ideal connections due to the fact that the links in a special position are lined up where degeneration of Assur groups occurs.

As noted above, many approaches have been developed in the practice of design, to ensure the required law of motion at the moment of instantaneous kinematic indeterminacy. Of all the variety, choose those cases in which the certainty of motion is achieved due to the occurrence of bonds along the geometric surfaces of the contacting bodies. Due to the superficial approach to this topic, and as a result of its static indefinability, all cases are combined using additional redundant or passive connections.

The main feature of redundant (non-harmful) bonds is that they “do not affect the nature of the movement of the mechanism as a whole” [6, p.39]. Although it is precisely on this basis that the presented examples of the use of additional links, which ensure the certainty of movement in special situations, and therefore "actively affecting the nature of the mechanism's motion," are simply erroneous to combine with redundant links. Moreover, despite the reference material on the parallelogram mechanism with the second connecting rod, this scheme is presented in all new textbooks on the Theory of mechanisms and machines as an example of a mechanism with a passive link. Korenyako A.S., however, noted [7, p.22] "in some cases, passive connections are necessary to ensure certainty of movement." As an example, he gave a hinged parallelogram, in which "the cranks are connected by a passive link - the second connecting rod". The term "repetitive communication" proposed by Ozol OG [8, p.39], yet better reflects the essence of the "locomotive mechanism".

Indeed, the links involved in the "certainty of movement" of links, and therefore the whole mechanism should be considered separately. Examples of various designs show that the considered bonds can be both retaining and non-retaining of instantaneous action, while they “actively influence the nature of the movement of the mechanism” in a particular (undefined) position Then, in our opinion, one can call them “active bonds”, as suggested in [9]. For example, the drive of locomotive wheels is an example of active coupling of the holding type, the rest, fig. 3, б, and г - are examples of non-retaining active instantaneous bonds that ensure the certainty of motion at the instant of instantaneous kinematic indeterminacy. Discussion of the features inherent in active relations will allow us to introduce an understanding of the creation of new leverage devices. Moreover, the lever devices with non-retaining active instantaneous coupling due to their peculiarities can be classified as variable structure mechanisms (MVS). An example would be the lever shock Mechanisms of variable structure of Abdraimov S., whose structural features are noted in [9].

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Received 24.03.2019