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I. Zh. Zhanashev[1], R. K. Nauryzbayev[1], E. T. Saparbayev[1], S. M. Abikenova[1], K. K. Anuarbekov[1], O. O. Polushkin[2]

[1]Kazakh National Agrarian University, Almaty, Kazakhstan,
[2]Don State Technical University, Rostov-on-Don, Russia.
E-mail: izhanashev@mail.ru, yerjigit1966@mail.ru, salta_84@inbox.ru, kanat.anuarbekov@kaznau.kz, o.polushkin@gmail.com

STRUCTURAL–NON-ASSURING GROUP WITHIN THE KINEMATIC CHAIN OF SELF-ALIGNING SPATIAL THREE-LINK CAM MECHANISMS

Abstract. The degree of mobility specified new three-link assuring and four-link nonassuring structural self-aligning spatial cam mechanism is defined under the new formula. The named formula easily defines a construction principle of the given mechanisms.

Key words: non-assuring, three-link, four-link, assuring, self-aligning.

Introduction. Scientific problem: "Building a harmonious theory of structural synthesis, defining clear boundaries of assuring and nonassuring structures, creating fundamentally new, statically definable - self-aligning spatial cam mechanisms, designing and implementing promising and innovative technical solutions of actuators with rational parameters within drives of various working bodies of agricultural machines, and also machines of other branches of production " [1, 2].

Relevance. Structural analysis and synthesis are the initial, early and most crucial phases in the development of fundamentally new, statically definable - self-aligning spatial cam mechanisms without hazardous redundant links and unnecessary mobility. The problem tasks of the development of structural synthesis methods for self-aligning spatial cam mechanisms are important in the theory of mechanisms not only from a scientific point of view, but also of great practical importance in improving the technical level and operational qualities of various engineering sectors. The introduction of self-aligning spatial cam mechanisms in engineering practice is very effective. The latter will significantly improve operational reliability based on the proposed actuators. Currently in machinery, inter alia: agricultural one urgently needs to use fundamentally new, statically definable - self-aligning actuators [1-7]. These requirements are best satisfied by self-aligning spatial cam mechanisms. They have a sufficiently large load capacity, durability, high efficiency, lower requirements for accuracy of manufacturing. Ways of further development of the fundamentals of rational design of spatial cam mechanisms and the creation of an innovatively new class of general-purpose machines based on self-aligning spatial cam mechanisms of assuring and nonassuring structures are relevant [8, 9].

The objects of research are fundamentally new self-aligning spatial cam mechanisms of the zero family, according to the classical classification of mechanisms by families, proposed by I.I. Artobolevskiy Academician of the USSR SA. Self-aligning - statically definable spatial cam mechanisms with rigid chains and solid kinematic pairs and of general functionality purpose are technological in manufacturing.

The theoretical development of rational design of self-aligning spatial three-link cam mechanisms is based on the further development of the classical approaches of the theory of mechanisms – the fundamental pillars of the structural theory of mechanisms and machines. Development of the proposed universal engineering methods for rational design of self-aligning spatial three-link cam mechanisms is

very important not only from a scientific point of view, but also of great practical importance - they open up a new scientific direction of research work, provide broad prospects for the design and scientific development of their unified theory of structure, kinematics and dynamics.

Methods. The idea of developing the proposed engineering methodology is extremely important in theoretical, practical and engineering activity of bachelor, master and doctor (PhD) engineers in creating the most common methods of structural, kinematic and dynamic research of nonassuring self-aligning spatial three-link cam mechanisms. The new structural feature is a structural group and will serve as the basis for the development of the theory of the kinematic chains of self-aligning spatial three-link cam mechanisms of non-assuring structure of construction. In creating a harmonious theory of synthesizing chains of self-aligning spatial nonassuring groups, the NRK will serve as a mathematical tool - a single key structural formula of the modern theory of mechanisms and machines of Professor R. K. Nauryz-bayev.

This formula has the following entry:

$$\begin{cases} W = m(n + n_1 + n_2 - 1) - \sum_{k=1}^{k=m-1} (m-k)p_k, \\ m = 6,5,4,3,2. \end{cases} \quad (1)$$

"A nonassuring structural group is such a single-link kinematic chain, which, when attached by the outer free elements of pairs to a rack, will have a zero degree of mobility, i.e. turns into a rigid, self-aligning (statically definable) spatial fixed mechanical system". /Dr. of Technical Sciences, Professor R.K. Nauryzbaev, 2001/.

The elementary group is a non-assuring group (figure 1) single-link with the number of moving links. Its degree of freedom equals to zero. The condition of group structural synthesis is determined by a system of algorithms of the following form:

$$\begin{cases} W_{II(n)} = 6n - 5P_1 - 4P_2 - 3P_3 - 2P_4 - P_5 = 0, \\ n = 1, \\ P_1 = 1, \\ P_2 = 1,\ P_3 = 0,\ P_4 = 0, \\ P_5 = 1, \\ m = 6, \\ (n + n_2 - 1) = 0. \end{cases} \quad (2)$$

The formula for the structure of a group is that a non-assuring structural group is defined with an entry of the following form:

$$-II(n). \quad (3)$$

The class of a group – a nonassuring structural group – is determined by the number of kinematic pairs with which the group joins the rack.

The order of a group – a nonassuring structural group – is determined by the number of kinematic pairs with which the group joins the rack. For example, a space group – a nonassuring one-link group (figure 1) belongs to the zero family according to the general classification of kinematic chains of zero mobility, according to the rank recognized by the structural group, according to the families of Academician of the Academy of Sciences of the USSR, Doctor of Technical Sciences, Professor I.I. Artobolevskiy, (m = 6). The new concept structural group is a nonassuring group in the kinematic chain of a self-aligning spatial three-link cam mechanism of IInd class of the zero-family (figure 1). This is a very important structural feature from the position of the modern theory of mechanisms and machines. Thus, a spatial group is a nonassuring structural group in the chain of the cam mechanism (figure 1), this is a

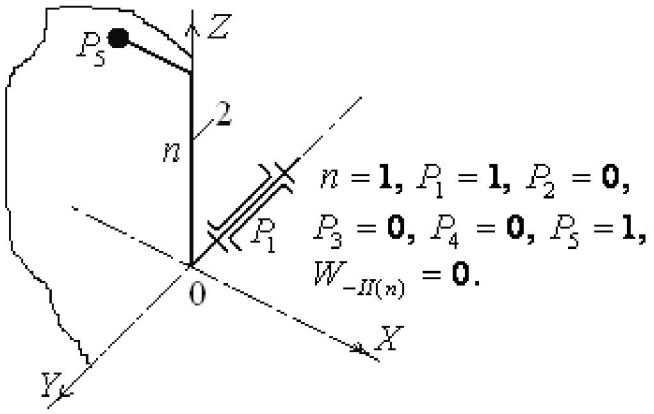


Figure 1 – The single-link structural group is a non-assuring structural group of the 2nd class and the zero family of the 2nd order

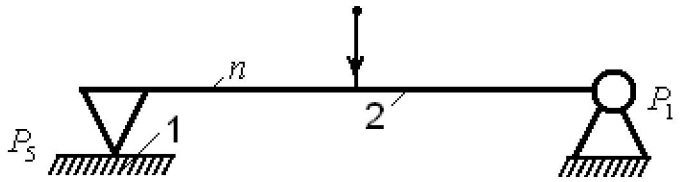


Figure 2 – Zero degree of mobility is a rigid self-aligning (statically definable) fixed spatial mechanical system

Table 1 – Fundamental classification of kinematic pairs of A.P. Malyshev in 1923

No. of class of kinematic pair	I	II	III	IV	V
S – No. of superimposed connections of kinematic pair	1.	2.	3.	4.	5.
$W_{kin.p.}$ – No. of degrees of freedom of kinematic pair	5	4	3	2	1

single link kinematic chain, which, after connecting the pair to the rack with the outer free elements, will have a zero degree of mobility, i.e. turns into a rigid statically definable spatial mechanical system (figure 2). In numerous constructive varieties of a single link kinematic chain (figure 1) almost all types of kinematic pairs may be present according to the classification of Doctor of Technical Sciences, Professor A.P. Malyshev.

The fundamental classification of kinematic pairs in the form of table 1 was first developed by A.P. Malyshev in 1923. In the system of algorithms (2) - the condition of the structural synthesis of the group, the indices of kinematic pairs correspond to the degrees of freedom of this pair construction. In accordance with the table in the system of algorithms (2) the number of superimposed connections - (S) corresponds to - (№) class of each kinematic pair. Kinematic pairs are of Ist, IInd, IIIrd, IVth, Vth class.

Cam mechanism is the base of the chain of which is single-link group, is a nonassuring structural group, which called a self-aligning (statically definable) spatial three-link cam mechanism of a nonassuring structure of the construction - figure 3.

Self-aligning i.e. statically definable. 1-leading link (cam), modeled by the parameter (n_1) - 2-slave link (rocker) is modeled by the parameter (n) - 3-rack (bed).

A new principle of formation (of logical formation) of self-aligning (statically definable) spatial three-link cam mechanisms of nonassuring structure consists in joining the driving link – to the mechanism of the Ist class and the rack - of nonassuring structural groups. The formula for the structure of the mechanism (figure 3) will be written as a record of the form:

$$I\ (1,3) \longrightarrow II\ (2) \qquad (4)$$

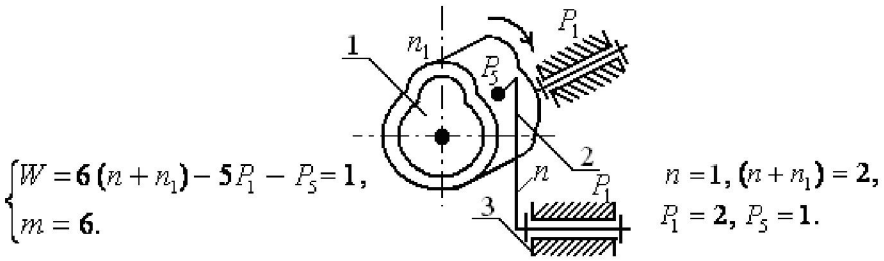


Figure 3 – The self-aligning (statically definable) spatial,
three-link cam mechanism of a nonassuring structure of the II[nd] class and of the zero family.

$$m = 6,\ (n+n_1) = 2,\ P_1 = 2, P_5 = 1.$$

From the formula (4) of the structure of the three-link spatial cam mechanism the following is obvious:

- *I* (1.3) there is a formula for the structure of the mechanism of class I, cam 1 with a pair of P_1 with a rack 3. *II* (2) - there is a space group of the NRK - nonassuring one-link self-aligning (statically definable) group of the 1st class and zero family, 2nd order – link of 2 models - with pairs P_1 and P_5 (figure 1).

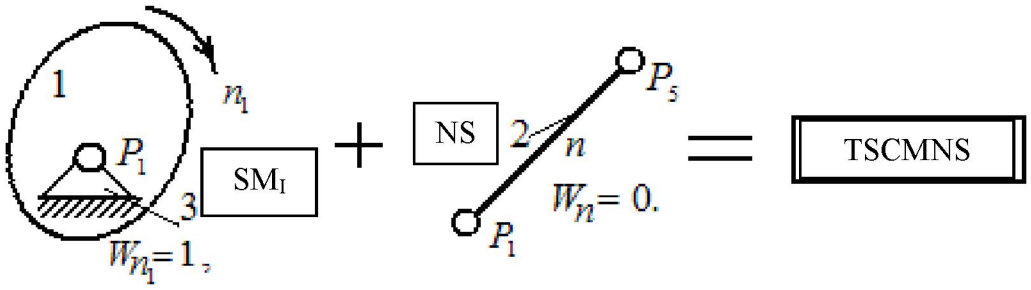


Figure 4 – TSCMNS development

SM1 - self-aligning two-link, leading cam mechanism of I[st] - class with the number of degrees of freedom W = 1. This mechanism consists of a leading link 1-(n1) and a rack 3. The number of degrees of freedom of a mechanism of I[st] class is determined by following formula:

$$W_{n_1} = 6n_1 - 5P_1 = 6 \cdot 1 - 5 \cdot 1 = 1. \tag{5}$$

NSG - space group - nonassuring structural group, link 2-kinematic chain from one link (n = 1). The number of degrees of freedom of the spatial group – NSG – of the nonassuring structural group is determined, for example, by the following formula:

$$W_n = 6n - 5P_1 - P_5 = 6 \cdot 1 - 5 \cdot 1 - 1 = 1. \tag{6}$$

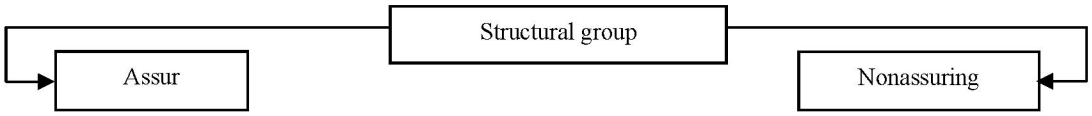
TSCMNS - three-link self-aligning cam mechanism of nonassuring structure. Note that in the development of the classical structural formula (6) of P.O. Somov - A.P. Malyshev has the following form of record [1-3]:

$$\begin{cases} W = 6(n + n_1 + n_2 - 1) - 5P_1 - 4P_2 - 3P_3 - 2P_4 - P_5, \\ m = 6. \end{cases} \tag{7}$$

P.O. Somov (1887) – A.P. Malyshev (1923) – R.K. Nauryzbaev (1991).

Results. Let us highlight some of the fundamental differences between the classical-elementary Assur group and the nonassuring group, a single-link structural group.

Table 2 – Differences between Assur and nonassuring group:

1. The elementary Assur group is two-link with the number of moving links $(n + n_1) = 2$ (see figure 5). 2. The Assur group cannot be divided into simpler independent kinematic chains of zero mobility. 3. Classically, the principle of the formation of self-aligning four-link cam mechanisms is attached to the drive link and the rack of assuring groups of two moving links. 4. Elementary mechanisms of Assur - four-link cam mechanisms, self-aligning flat and spatial.	1. The elementary nonassuring group is one-link with the number of moving links $n = 1$ (see figure 1). 2. When joining the leading link and the rack of a nonassuring group, three-link cam mechanisms do not fit into the framework of Assur classical structural theory. 3. The new principle of formation on the basis of nonassuring groups allows to synthesize nonassuring mechanisms with different design and functional capabilities, in particular, three-link cam mechanisms with self-aligning features of the structure (figure 6).
	
Classic structural attriburte in kinematic chain of self-aligning cam mechanisms.	New structural attribute in kinematic chain of self-aligning cam mechanisms.

И. Ж. Жанашев[1], Р. К. Наурызбаев[1], Е. Т. Сапарбаев[1],
С. М. Абикенова[1], К. К. Ануарбеков[1], О. О. Полушкин[2]

[1]Қазақ ұлттық аграрлық университеті, Алматы, Қазақстан,
[2]Дон мемлекеттік техникалық университеті, Ростов-на-Дону, Ресей

ҮШ ЗВЕНОЛЫ АССУРЛЫҚ ЕМЕС ҚҰРЫЛЫМДЫҚ ӨЗІҚАЛЫПТАСҚЫШ КЕҢІСТІК ЖҰДЫРЫҚШАЛЫ МЕХАНИЗМДЕР

Аннотация. Жұмыста көрсетілген жаңалық үш звенолы ассурлық емес және төртзвенолы ассур құрылымдық өзіқалыптасқыш кеңістік жұдырықшалы механизмдердің еркіндік дәреже сандары тек жаңа құрылымдық формуламен анықталады. Келтірілген формуланың көмегімен үшзвенолы және төртзвенолы ассурлық және ассурлық емес механизмдердің құрылғылық принциптері оңай шешіледі.

Түйін сөздер: ассурлық емес, үшзвенолы ассур, төртзвенолы ассур, ассурлық, жұдырықшалы механизм.

И. Ж. Жанашев[1], Р. К. Наурызбаев[1], Е. Т. Сапарбаев[1],
С. М. Абикенова[1], К. К. Ануарбеков[1], О. О. Полушкин[2]

[1]Казахский национальный аграрный университет, Алматы, Казахстан,
[2]Донской государственный технический университет, Ростов-на-Дону, Россия

СТРУКТУРНАЯ–НЕАССУРОВАЯ ГРУППА В СОСТАВЕ КИНЕМАТИЧЕСКОЙ ЦЕПИ САМОУСТАНАВЛИВАЮЩИХСЯ ПРОСТРАНСТВЕННЫХ ТРЕХЗВЕННЫХ КУЛАЧКОВЫХ МЕХАНИЗМОВ

Аннотация. В статье структурная–неассуровая группа в составе кинематической цепи самоустанавливающихся пространственных трехзвенных кулачковых механизмов определен под новой формулой. Названная формула легко определяет принципиальное строительство данных механизмов.

Ключевые слова: ассуровых и неассуровых конструкции, кулачковый механизм, трехзвенный, четырехзвенный.

Information about authors:

Isabek Zhanashev, Candidate of Technical Sciences, Professor of the Department of "Mechanics and design of agricultural equipment", Kazakh National Agrarian University, Almaty, Kazakhstan; izhanashev@mail.ru; https://orcid.org/0000-0003-2412-0261

Rakhymzhan Nauryzbayev, Doctor of Technical Sciences, Professor of the Department of "Mechanics and design of agricultural equipment", Kazakh National Agrarian University, Almaty, Kazakhstan; izhanashev@mail.ru; https://orcid.org/0000-0002-1561-5994

Yerzhigit Saparbayev, senior lecturer of the Department of "Mechanics and design of agricultural equipment", Kazakh National Agrarian University, Almaty, Kazakhstan; yerjigit1966@mail.ru; https://orcid.org/0000-0001-7167-1571

Saltanat Abikenova, PhD doctor, senior lecturer of the Department of "Water resources and melioration", Kazakh National Agrarian University, Almaty, Kazakhstan; salta_84@inbox.ru; https://orcid.org/0000-0001-7786-741X

Kanat Anuarbekov, PhD doctor, senior lecturer of the Department of "Water resources and melioration", Kazakh National Agrarian University, Almaty, Kazakhstan; kanat.anuarbekov@kaznau.kz; https://orcid.org/0000-0003-0832-6980

Oleg Polushkin, Doctor of Technical Sciences, Professor, Director of Scientific Laboratory, Rostov-on-Don, Russia; o.polushkin@gmail.com; https://orcid.org/0000-0002-8046-917X

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