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CLASSIFICATION OF THE ADJUSTABLE TOOTH-LEVER MECHANISMS OF PERIODICAL TURN AND A MODERNIZED METHOD OF REGULATING ANGLE

Summary. The current method of controlling the duration of stops in the drives of periodic rotation of automatic machines and its constructive realization in the form of a gear-lever mechanism based on non-circular gear wheels were proposed. Additional design parameters have been determined, making it possible to adjust the gear-lever mechanism to different angles of the output shaft with no change in the lengths of the links of the basic lever mechanism. The essence of the proposed method of controlling the angle of emergence gear-lever mechanism is that in the process of turning the leading link mechanism rotation on the driven shaft is transmitted through non-circular gears, resulting in a change in the conjugate radii of the initial circles of the engaged gear pairs. A classification of possible variants of the structure of adjustable gear-lever mechanisms with non-circular gears was given.

Keywords: gear-lever mechanism, non-circular gear wheels, oval-eccentric, mechanical engineering.

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КЛАСИФІКАЦІЯ РЕГУЛЬОВАНИХ ЗУБЧАСТО-ВАЖІЛЬНИХ МЕХАНІЗМІВ ПЕРІОДИЧНОГО ПОВОРОТУ І МОДЕРНІЗОВАНИЙ СПОСІБ РЕГУЛЮВАННЯ КУТА ВИСОТИ

Анотація. Запропоновано актуальний спосіб регулювання тривалості зупинок в приводах періодичного повороту машин-автоматів і його конструктивна реалізація у вигляді зубчасто-важільного механізму на основі некруглих зубчастих коліс. Визначено додаткові проектні параметри, що дають можливість налаштувати зубчато-важільний механізм на різні кути висоти ведучого вала з відсутністю зміни довжин ланок базового важільного механізму. У машинобудуванні можна визначити великий клас роторних технологічних машин, в яких робочий орган здійснює періодичний поворот із заданими необхідними зупинками, тривалість яких визначається виконуваної технологічною операцією і повинна бути різною. Прикладами таких машин є багатошпиндельні верстати-автомати і револьверні живильники для автоматизації періодичної подачі заготовок в зону обробки. Найбільш частим недоліком застосовуваних для вирішення зазначеного завдання механізмів періодичного руху у вигляді мальтійських, храпових і получервячних механізмів є розрив кінематичного ланцюга приводу з ударами при її замиканні, а також відсутність регульованої тривалості зупинок робочого органу. Інша конструктивне рішення даної задачі являє зубчато-важільні механізми на основі шарнірних важелів і круглих зубчастих коліс, що працюють без розриву кінематичного ланцюга, але також є нерегульованими при незмінній довжині ланок базового важільного механізму. Відомі способи регулювання кута вистою в зубчато-важільних механізмах з круглими зубчастими колесами за рахунок зміни довжин ланок важільного механізму мають обмежені кінематичні можливості, так як діапазони зміни довжини кривошипа і довжини стійки обмежені умовами кінематичної працездатності (неповний поворот кривошипа) і силовий працездатності (перевищення допустимих кутів тиску. Сутність запропонованого способу регулювання кута висоти зубчато-важільного механізму полягає в тому, що в процесі повороту ведучої ланки механізму обертання на ведучий вал передається через некруглі зубчасті колеса, внаслідок чого змінюються відповідні радіуси початкових кіл, що входять у зачеплення пар зубчастих коліс. Регулювання кута вистою також може здійснюватися шляхом зміни кута установки некруглих зубчастих коліс щодо ланок важільного механізму ще до початку технологічного процесу. Запропоновано класифікацію можливих варіантів структури регульованих зубчато-важільних механізмів, що мають некруглі зубчасті колеса.

Ключові слова: круглі зубчасті колеса, зубчато-важільний механізм, некруглі шестерні, овально-ексцентричний, машинобудування, кінематичні ланцюги, шарнірні важелі.

Introduction. In mechanical engineering, it can defined an extensive class of rotary technological machines in which the working body makes a periodic turn with given necessary stops, the duration of which is determined by the technological operation being performed and must be different. Examples of such machines are multi-spindle automatic machines and revolving feeders for automating the periodic supply of blanks to the machining zone [1].

Problem statement. Additional design parameters have been determined, making it possible to adjust the gear-lever mechanism to different angles of the output shaft with no change in the lengths of the links of the basic lever mechanism.

Analysis of recent research and publications confirms. Looking for the most optimal ways to solve Starns G. & Flugrad D.R. [1], Hu Q.C. & Mo H.J. [2], Guan Y.M., Zhang W.Y., Xiao Y.C. & Wang X. [3], Liu Y., Gong J. & Wu X. [8] and others. Analysis of recent research and publications confirms: the most frequent disadvantage of the mechanisms of periodic movement in the form of Maltese, ratchet and half-gear mechanisms used for solving this problem is the breaking of the drive kinematic chain with shocks when it closes, and the lack of controllability of the duration of the working body stops.

Selection of previously unsolved parts of the common problem. The known methods of regulating the angle of the stand in gear-lever mechanisms with round gears due to changes in the lengths of the links of the lever mechanism [2] have limited kinematic capabilities, since the ranges of changing the length of the crank and the length of the rack are limited by the conditions of the kinematic working capacity (incomplete rotation of the crank) and strength working (exceeding the permissible pressure angles). That is why the choice was made of this previously unresolved part of the general problem of regulating the stand angle in gear-lever the mechanisms with round gears.

Another constructive solution of this problem is toothed-lever mechanisms based on articulated levers and round gears, working without breaking the kinematic chain, but also being unregulated with a constant length of links of the basic lever mechanism [3].

Formulation of aims of the article. The essence of the proposed method of controlling the angle of emergence gear-lever mechanism is that in the process of turning the leading link mechanism rotation on the driven shaft is transmitted through non-circular gears, resulting in a change in the conjugate radii of the initial circles of the engaged gear pairs [4].

The dwell angle can also be adjusted by changing the angle of installation of non-circular gear wheels relative to the links of the lever mechanism before the start of the process [8].

Statement of the basic material. Figure 1 shows an embodiment of an adjustable gear-lever mechanism that implements the above method.

This mechanical device is a combination of a lever crank-beam mechanism, the leading (crank 1) and slave (yoke 3) parts of which are pivotally connected to the connecting rod 2 and base 4, and the transmission gear mechanism for transmitting rotation from the crank 1 to the driven shaft (Fig. 1 not shown), located coaxially with the O2 hinge connecting the yoke 3 with the base 4. The gear gear mechanism is made in the form of non-circular gear wheels 5, 6, 7 and 8 interlocking with each other, mounted on the links of the lever mechanism. The wheel 5 and the crank 1 are rigidly fixed to each other in such a way that the wheel 5 rotates relative to the center O1 together with the crank. Wheels 5 and 7 have the ability to rotate and install at angles θ1 and θ2 (adjustable angular displacement of the main axis of non-circular wheels relative to the connecting rod and rocker arm of the lever mechanism when located on one straight crank and connecting rod in the extreme right position of the lever mechanism).

Figure 2 shows the relationship between the rotation angles and the diameter 1 and the rotation angle φ3 fixed on the driven wheels 8 in the gear-lever mechanisms (SPM). Curve 1 shows the angle of elevation φv = 30°, obtained in ZRM with round wheels. On curve 2, the value of the angle of inclination = 120°, obtained as axes with elliptical wheels with different eccentricities of the ellipse e1, e2 equal with respect to the focal space AF5 or BF7 to the length of the larger equivalent ellipse in the same direction with the same (e1 = e2) elliptical wheels.

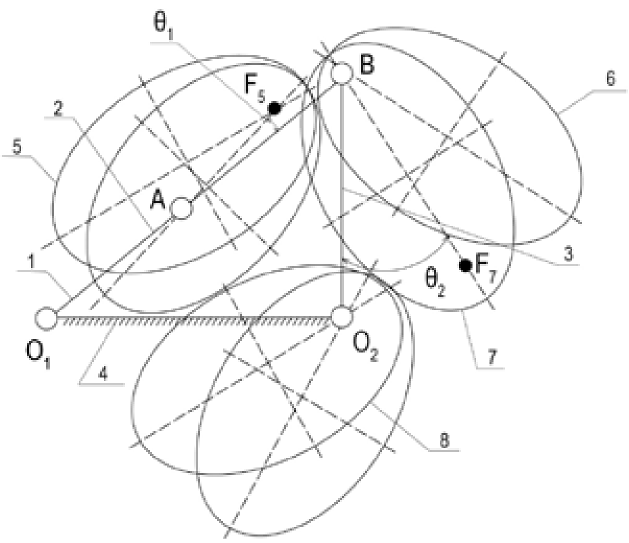

Fig. 1. Scheme of the adjustable gear-lever mechanism with elliptical gears

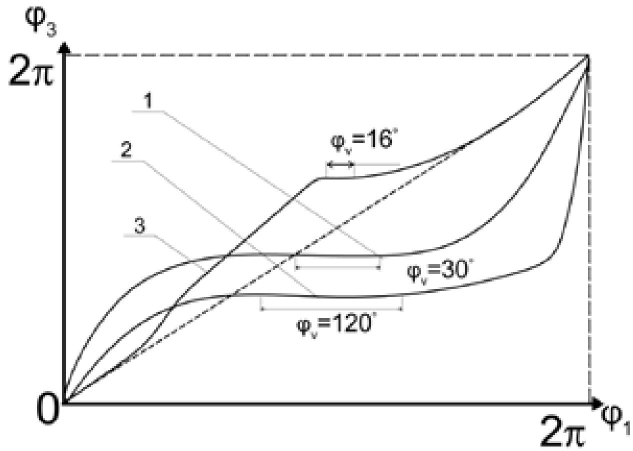

Fig. 2. Graphs of rotation of the driven shaft with stops in gear-lever mechanisms:
1 – with round wheels;
2 – with elliptical wheels with eccentricity e1 ≠ e2;
3 – with elliptical wheels with eccentricity e1 = e2

Figures 3 and 4 show the relationships between the rotation angles φ1 and φ3 in the AAM with elliptical wheels and the dwell angles φv for different mounting angles of installations θ1 and θ2 of non-circular gears relative to the links of the lever mechanism.

From the graphs in Fig. 2, 3 and 4 it follows that the proposed device allows you to adjust the dwell angle in the SPM due to the additionally detected parameters, which allow you to adjust the gear-lever mechanism to different angles of the output shaft output without changing the lengths of the links of the base four-arm 1–2–3–4). Such a parameter is the non-circularity (the radius vectors of the conjugated centroid p1 and p2 are variable values) of the gear wheels that engage, which guarantees the variability of the gear ratio of the entire STM due to the variability of the conju-

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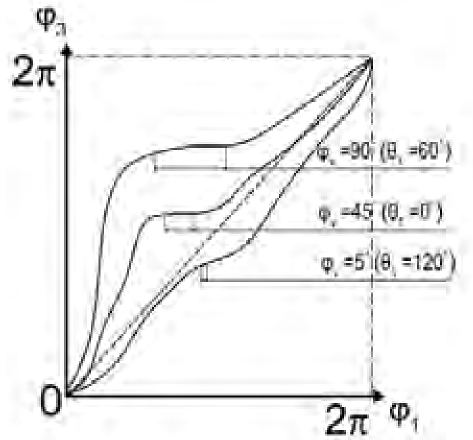

Fig. 3. Graphs of regulation of the angle of dwell due to the angular displacement of 1

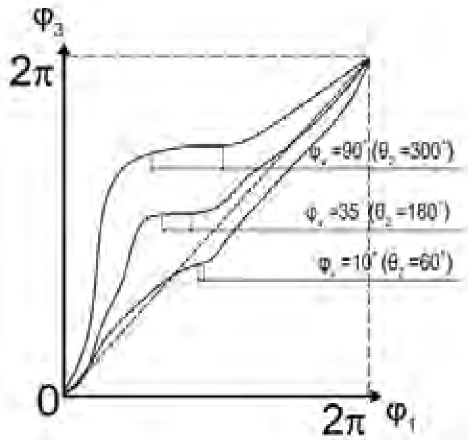

Fig. 4. Graphs of regulation of the angle of dwell due to the angular displacement 2

gate radii of the engaged wheels during their rotation.

The choice of the required installation angles θ1 and θ2 for non-circular gears relative to the links of the lever mechanism also greatly expands the possibilities for regulating and increasing the dwell angle of the SPM (see Fig. 2, 3 and 4).

Given the various design options for the implementation of gear pairs and various possible sets of pairs of mating gears, the following classification of possible options for the structure of gear-lever mechanisms for periodic rotation based on non-circular gears (Fig. 5) has been created. According to this classification in fig. 1 shows a mechanism with a uniform set of elliptical wheels forming uniform gear pairs.

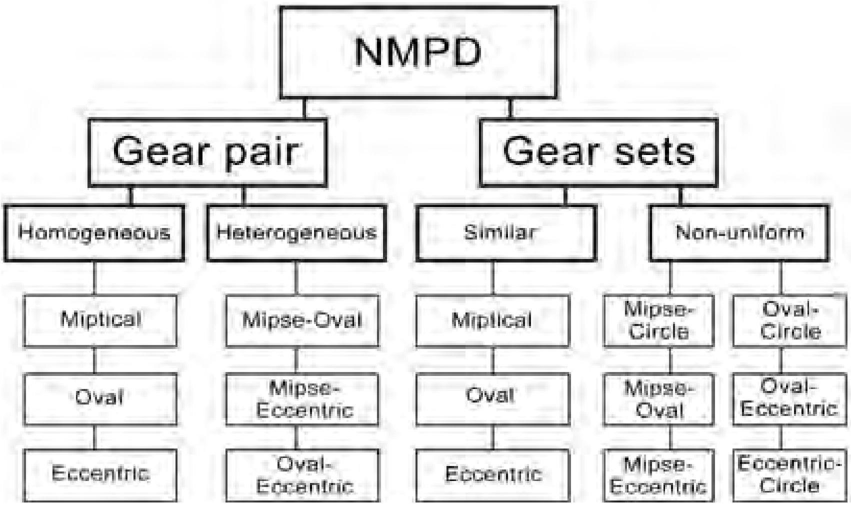

Fig. 5. Structural classification of gear-lever MTD on the basis of non-circular gear wheels (NMPD)

Conclusions from this study. Achieved in the proposed modernized method and implementing its positive effect is as follows:

1. Expanding the kinematic capabilities of the method and adjustable gear-lever mechanism with the help of additional changes and increase the duration of the angle of dwell due to the use of additional control parameters in the form of variables when turning the driving crank of the radii of the initial circles of pairs of gear wheels, variable mounting angles of non-circular gear wheels relative to the links of the lever mechanism and selecting the required eccentricities of the elliptical wheels. The absence of the specified regulatory parameters (p1, p2, 1, θ2, e1, e2) in these gear-lever mechanisms and causes the shortcomings of their regulation.

2. Regulation of the stand angle due to the specified regulatory parameters:

a) does not lead to a change in the frequency of stops of the driven shaft and therefore a given technological cycle of operation of the gear-lever mechanism is maintained;

b) simplifies the design of the SPM by performing one-piece of all links of the lever mechanism (crank, connecting rod, rocker arm, stand);

c) provides a dynamic balance of the lever mechanism (as opposed to the method of adjusting the crank length) in the regulatory process by changing the installation angles θ1 and θ2;

d) in the process of regulating the dwell angle, it is possible (at constant lengths of the links of the lever mechanism) to maintain both kinematic and optimum power efficiency and transfer power to the driven shaft at minimum pressure angles without the risk of jamming of the lever mechanism.

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