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INTERMITTENT GEARED-LINKAGES FOR AUTOMATION

Abstract. Intermittent geared-linkages are mechanisms generating output-motions with instantaneous dwells. In the dwell-positions of the mechanism angular-velocity and angular-acceleration become zero, and the input-torque becomes zero, too.

Further on the transfer-functions of these mechanisms are free of jerk or shock. By reason of these advantages intermittent-geared-linkages are suitable for different tasks in designing of automatic machines. In this paper some 5-bar-geared-linkages are demonstrated.

1. Introduction

For the automation/mechanization of operations there are required mechanisms generating oscillating or rotating motions with dwells, Fig. 1. The dwells can be exact ($\dot{x} = \ddot{x} = 0$ for a finite time period φ_R) or approximate (instantaneous dwell R with $\dot{x} = \ddot{x} = 0$ in an instantaneous position of the mechanism), Fig. 1a.

The quality of an approximate dwell is assessed from the number of derivative of a transfer function $x(\varphi)$ which become zero at the same time, Fig. 2.

Therefore, in Fig. 1b a reversal dwell UR is two-pointed and an instantaneous dwell ZR is at least three-pointed. The instantaneous dwell R in Fig. 1c is three-pointed, too.

With four-bar-linkages only two-pointed dwells are possible (Fig. 3a). Six-bar-linkages allow better dwells, but have several drawbacks, i.e. a larger space required and dynamically unfavourable curves of functions (vibrational excitation).

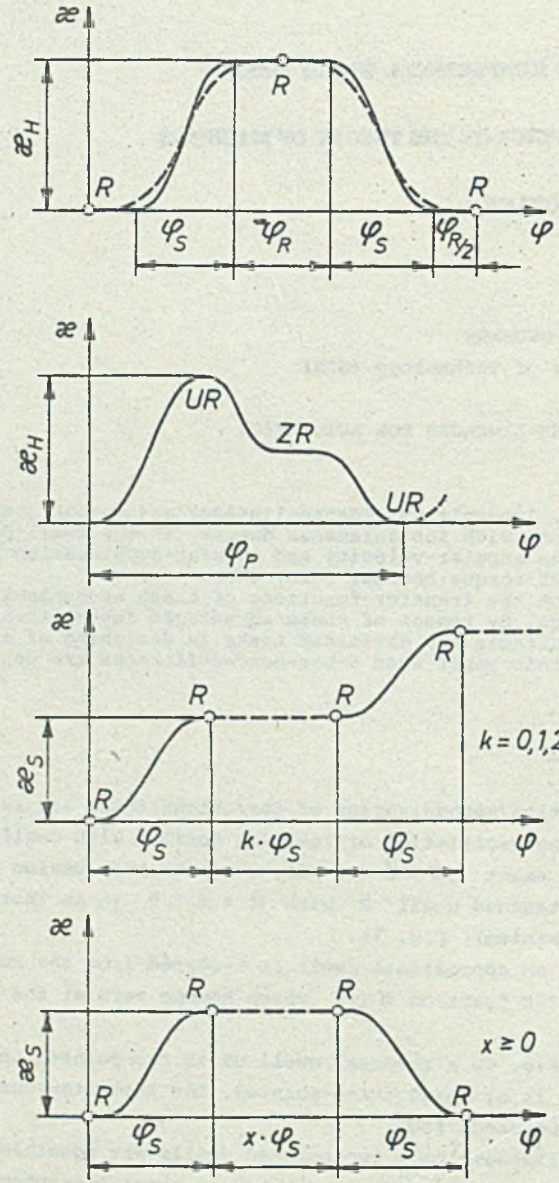
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Fig. 1

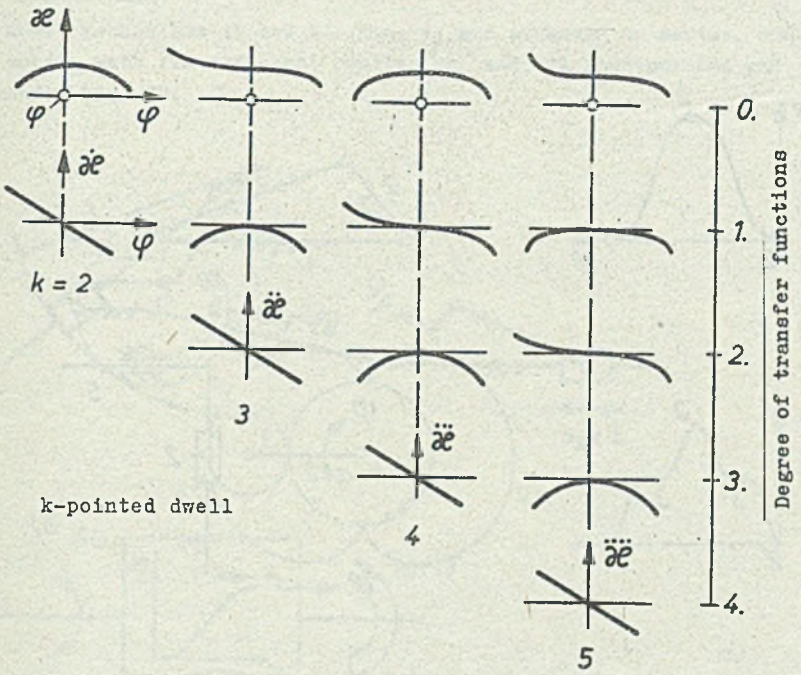

Fig. 2

An instantaneous dwell R results in an exact dwell (with a dwell-duration of $k.\varphi_s$ or $x._s$) if in the position R of the mechanism the power flow is interrupted for a certain period of time, Fig. 1c and d.

Exact dwells can be generated also by means of cam mechanisms; their production, however, is expensive and possibly vibrational problems will result. Moreover, as practice has shown, approximate dwells are dynamically better than exact ones.

2. Geared-linkages

Geared-linkages [1], [2] are combinations of linkages and gearings, e.g. Fig. 3b-c. The minimum number of members is five. These mechanisms perform continuous transfer functions without jerk or shock whose Fourier-coefficients converge rapidly [1].

Therefore they effect only a slight vibrational and noise excitation. Instantaneous three- and four-pointed dwells R can be generated, too, with them. Figure 3 shows a few examples.

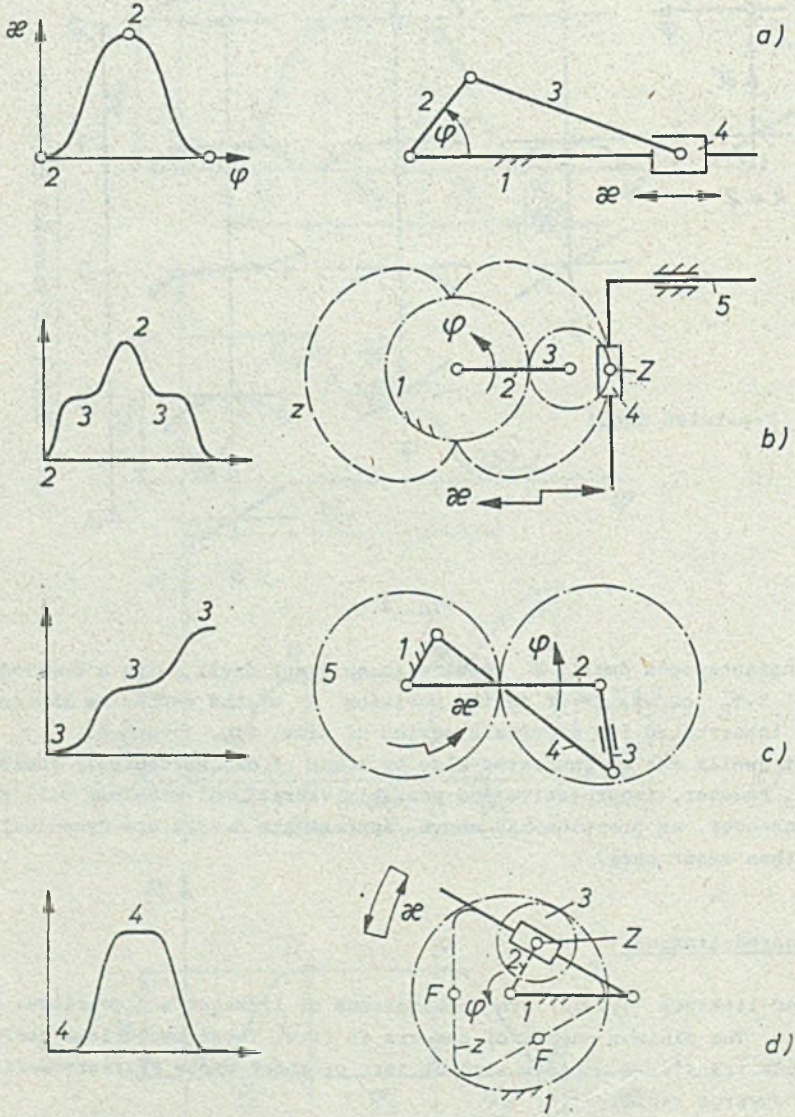

Fig. 3

2.1. Serial-Mechanisms

If two dwell mechanisms (I and II; Fig. 4) are arranged in series, one obtains a motion with two different dwells UR and ZR (two-pointed and three-pointed), Fig. 1b.

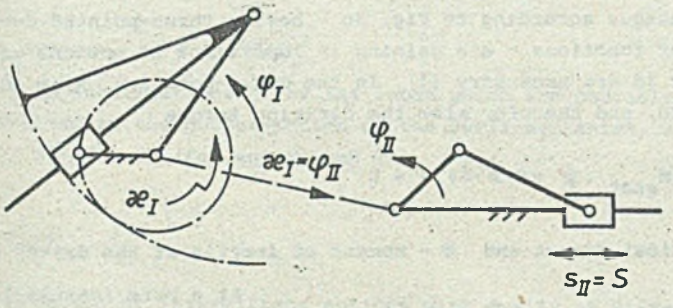

Fig. 4

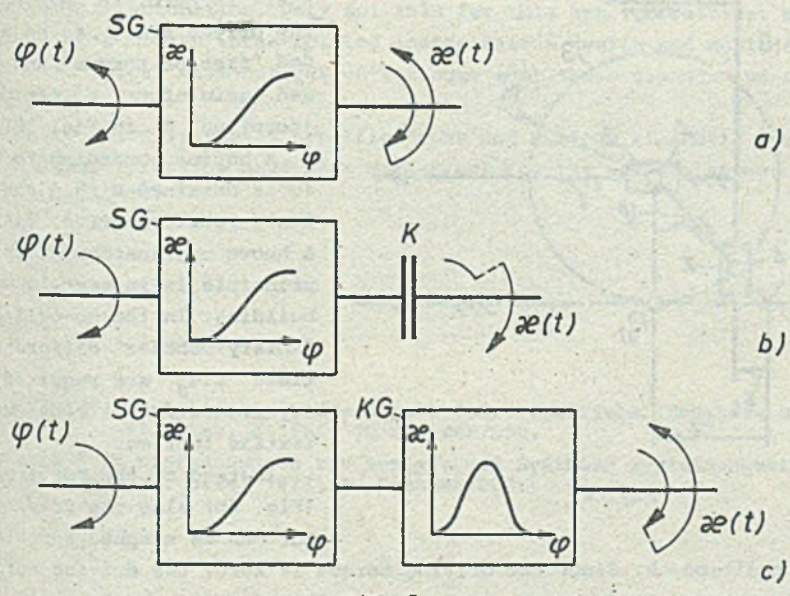

Fig. 5

An essential improvement of the dwell quality in the reverse position of a slider-crank-mechanism results if the dwell-positions of a serial-mechanism (I) coincide with those of the slider-crank-mechanism (II). In this arrangement, the k-pointed dwells of the partial mechanisms (I) and (II) multiply as

$$k_M = k_I \cdot k_{II}. \qquad (1)$$

In the example of the Fig. 4 one then obtains $k_M = 3 \cdot 3 = 6$, six-pointed dwells in an oscillating motion (compare the transfer functions in Fig. 3d and Fig. 5c).

2.2. Start-Stop-Mitions

Geared-linkages according to Fig. 3c - having three-pointed dwells in their transfer functions - are gaining in importance if motions according to Fig. 1c or 1d are necessary (1). In the dwell-position R, $\dot{\mathfrak{x}}(t)$ and $\ddot{\mathfrak{x}}(t)$ are zero, and therefor also the deriving torque

$$M_{in} = (M_{stat} \cdot \dot{\mathfrak{x}} + \Theta \cdot \ddot{\mathfrak{x}} \cdot \dot{\mathfrak{x}}) / \dot{\varphi} = 0 \qquad (2)$$

(M_{stat} - statical moment and Θ - moment of inertia at the driven shaft).

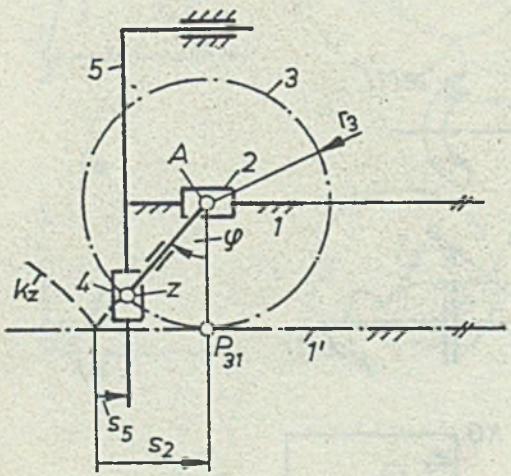

Fig. 6

At a pure inertia-loading also the torque at the driven shaft is zero. In this positio the driven shaft can be disenga ded "free of torque" and engaged again after k periods (coupling K in Fig. 5b).

A motion according to Fig. 1c is obtained with a continuously rotating drive $\varphi(t)$. A known application of this principle is in textile machin building. In the so-called "Rotary-Dobbies" different sto times $k.\varphi_S$ are required in dependence on the cross-weavin textile fabrics.

Instead of the coupling K (Fig. 5b) also the driving motor can be stopped and started in the position R. Since the driving torque is zero, the driving motot starts without a load-moment. Also, at the end of the intermittent motion there is not necessary a braking torque. The moved masses are "softly" started or stopped.

For the practice also the arrangement according to Fig. 5a is important Here, the intermittent mechanism SG gets an oscillating input-motion $\varphi(t)$, e.g. a pneumatic swivel-motor. If the start-stop positions of the swivel-drive coincide with the instantaneous dwell position of the intermittend mechanismen, a motion according to Fig. 1d with an arbitrary dwell-duratio ($x.\varphi_S$) results.

In this start-stop position R there holds again:

$$\ddot{\varkappa} = \varkappa'' \cdot \dot{\varphi}^2 + \varkappa' \cdot \ddot{\varphi} = 0 \qquad (3)$$

with

$$\varkappa' = d\varkappa/d\varphi; \qquad \varkappa'' = d^2\varkappa/d\varphi^2$$

and

$$\dot{\varphi} = d\varphi/dt; \qquad \ddot{\varphi} = d^2\varphi/dt^2.$$

Start-stop accelerations $\ddot{\varphi}$ of the input which are possibly given are not transferred to the output-motion of the dwell-mechanism, since at the same time $\varkappa' = \varkappa'' = 0$ (for any $\dot{\varphi}$ and $\ddot{\varphi}$).

3. Summary

The generation of intermittent motions with dwells of different quality and possibly a duration which can be set according to patterns is an important task in automation. Very suitable for this are intermittent geared-linkages with at least three-pointed instantaneous dwells and motions without jerk or shock. Five-bar geared-linkages meet these demands and are easy to produce.

Generally valid synthesis specifications and various kinematic and kinetostatic characteristics have been worked out for the various structures of these mechanism [1].

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OGNIWA PRZEKŁADNI ZĘBATEJ Z KOŁAMI O NIEPEŁNYM UZĘBIENIU W AUTOMATYZACJI

S t r e s z c z e n i e

Ogniwa przekładni zębatej z kołami o niepełnym uzębieniu to mechanizmy generujące ruchy wyjściowe z chwilowymi przerwami. W przerwach prędkość kątowa i przyspieszenie kątowe wynoszą 0 i wyjściowy moment obrotowy również 0. Funkcje przenoszenia tych mechanizmów pozbawione są wstrząsów czy szarpnięć. Z powodu tych zalet ogniwa przekładni zębatej z kołami o niepełnym uzębieniu są odpowiednie w różnych dziedzinach projektowania automatycznych urządzeń. W pracy tej przedstawione są niektóre 5-członowe połączenia zębate.

ЗВЕНЬЯ ЗУБЧАТОЙ ПЕРЕДАЧИ С НЕПОЛНОЗУБЫМИ КОЛЁСАМИ В АВТОМАТИЗАЦИИ

Р е з ю м е

Звенья зубчатой передачи с неполнозубыми колёсами это механизмы генерирующие выходные движения с мгновенными перерывами. В перерывах угловая скорость и ускорение составляют 0 и выходной вращающий момент также 0. Передаточные функции этих механизмов лишены толчков или зарядки. Благодаря этим преимуществам звенья зубчатой передачи с неполнозубыми колёсами пригодны в разных областях проектирования автоматических устройств. В настоящей работе представлены некоторые пятизвенные зубчатые соединения.

Recenzent: Prof. dr hab. inż. Józef Wojnarowski

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