TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 67, Issue II, June, 2024

CHAIN TRANSMISSION MECHANISM USED TO REDUCE THE REACTION MOMENT FOR MACHINERY THAT PERFORMS ROTATIONAL MOVEMENT AROUND ITS OWN

Elena Stela WISZNOVSZKY, Attila GEROCS, Lavinia Ioana CULDA, Andrei KOMJATY, Geza-Mihai ERDODI, Aurel Mihail TITU

Abstract: The paper wants to present an innovative device with a role in reducing the reaction moment, which occurs under normal working conditions in machines that perform rotational movement around their own axis. Starting from the third principle of dynamics, also called the principle of action and reaction, a device was designed to decrease the reaction moment. The device presented in the article consists of a mechanism with chain transmission made up of 12 identical chain wheels placed according to a certain geometric scheme. The chain is driven in translational motion with the help of an electric motor by means of a gear of two cylindrical gears with inclined teeth. One of these gears is mounted on the rotor axis of this motor, and the other gear is mounted on the axis of one of the 12 sprockets. The structure that supports the bearings of the chain wheels is rigidly connected to the stator of the motor, forming a common body with it so as to make it possible to rotate it also around the same axis of the rotor. During operation, the reaction moment produced by the entire system will be compensated and greatly reduced. To highlight the effect of the chain as best as possible, weights placed evenly on the chain are mounted along the entire length of the chain.

Key words: moment of inertia; dynamics; compensation, drive chain, mechanical processing.

1. INTRODUCTION

Often, during drilling or drilling operations, we were struck by the reaction moment produced by the entire system. Drilling is the most widely used machining operation, with applicability in vast fields. The moment of the force has an important role and expresses the ability of the force to rotate a rigid body around a line that passes through a point and is perpendicular to the plane formed by the supporting line of the force and that point. Cutting force is important and depends on thrust force and drilling torque. In addition, there is a reaction moment from the entire system that can slow down or make the drilling process more difficult. That's why we want to lessen this reaction by introducing an innovative device, fig 1.

Starting from the third principle of dynamics, also called the principle of action and reaction which was originally used in the context of linear forces, we found its validity also in the case of rotating systems.

For rotating systems, moment becomes the equivalent of force in linear systems. So, if a body acts on another body with a torque, then this second body acts with the same torque but of the opposite direction on the first body.

Thus, in order to operate without problems, motors or rotating systems must be tied to a foundation or must be fixed by means of a clamping system so that the reaction moment is transferred to the ground. Otherwise, the moment and power produced by the motor will be processed by its housing, which will rotate in the opposite direction.

The use of the invention is possible in any application involving rotational movement such as for example drilling or milling certain parts, milling tunnels, drilling wells, etc. In order to reduce the reaction moment, the mechanism called "Non-Reaction Torque Drive"[1] is

Received: 23.05.24; **Similarities**: 04.06.24: **Reviewed**: 19.06./19.06.24: **Accepted**:24.06.24.

known, which is composed of a rotor, a stator, two gyroscopes, two high-speed electric motors, which rotate the gyroscopes and four electromagnets of 24 V used as direct current drive elements and a co-control unit.

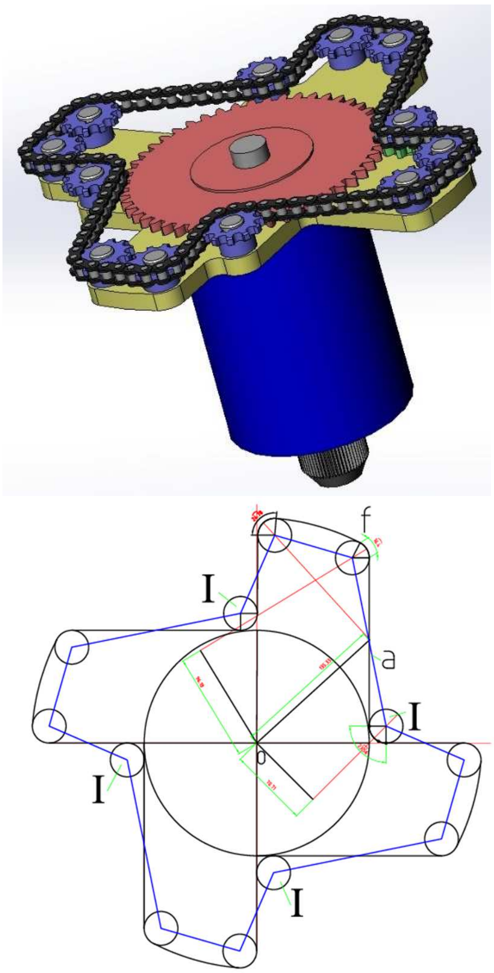

Fig. 1 The chain transmission mechanism

The non-reaction torque drive is actually a rotary drive, which like most drives converts some form of energy (such as electricity) into rotary mechanical work and creates a rotational torque.

In relation to the studied device, the mechanism presented above has 3 major disadvantages. First, the transmitted motor power is limited by the efficiency of the gyroscopes. Secondly, to rotate the gyroscopes, the two high-speed electric motors are required, so an additional energy consumption. And finally, the reaction moment is eliminated with the help of the mechanism in a percentage of 95%.

Also, for the same result, the device for counteracting the reaction moment in a load-bearing system of reversible actuation is also known [2]. The assembly, named "Mechanism for Counteracting Reaction Torque in a Powered Reversible", contains an internal mechanism to reduce the reaction moment, which would otherwise act directly on the assembly housing and therefore on the operator's hand. The device is bi-directional, reducing the reaction moment to the same extent that the system is operated in one direction or in the opposite direction. The assembly includes a differential planetary mechanism, having an input driven from a rotor, an output driving the drive shaft, and an additional output coupled to an offset shaft that is laterally offset from the axis of the drive rotor. A system of levers is used to prevent the offset shaft from rotating in any direction relative to the housing, thereby reducing the reaction moment that would act on the housing. This assembly also has 2 disadvantages related, on the one hand, to the lower percentage of reduction of the reaction moment and, on the other hand, to the power that can be transmitted by this system carried by the hand of a human operator, [3,4,5,6].

2. DESIGN AND DYNAMIC CALCULATION OF THE DEVICE

The technical problem that the device solves is that of reducing to a minimum the system of holding the engine or the drive assembly in rotational motion which must cancel the effect of the reaction moment.

As shown schematically in Figures 1 and 2, the system consists of a frame (a) to which 12 sprockets (f) are mounted which set the chain (g) in motion. The frame being anchored in the center (O). The chain is set in translational motion by means of the cylindrical spacer (d) which meshes with the cylindrical gear (h) which is coplanar with the sprockets corresponding to the positions (I) and of the same number of teeth as the sprockets (f). Spur gear (d).
The cylindrical gear (d) is driven in rotation by the rotor of the electric engine (ENGINE)

through its shaft (h), and the stator (i) counter-rotates the frame (a) as shown in figure 2.

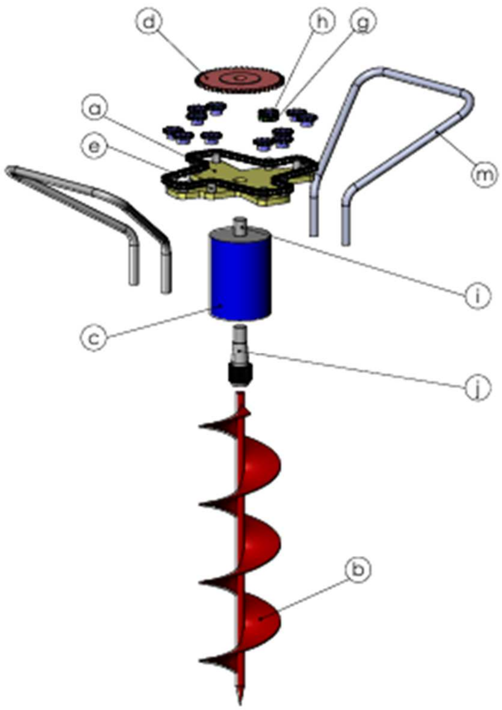

Fig. 2 The component parts of the device

The grips (m) are fixed to an outer housing that rotates freely on the motor axis.

Time intervals according to figure 3.

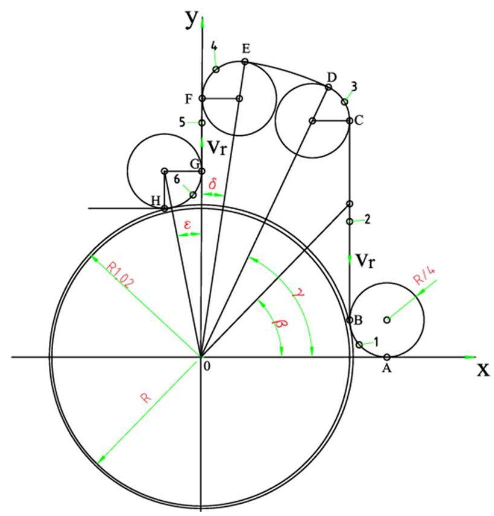

Fig. 3 Dispersion mode of accelerations on portions 1-6 of the chain

$$t_2 = 0, \frac{\pi}{18000} .. \frac{6.328}{200} [s] \tag{1}$$

$$t_3 = 0, \frac{\pi}{18000} .. \frac{1.128}{200} [s]. \tag{2}$$

$$t_4 = 0, \frac{\pi}{18000} .. \frac{1.696}{200} [s]. \tag{3}$$

$$t_5 = 0, \frac{\pi}{18000} .. \frac{1.976}{200} [s] \tag{4}$$

$$t_6 = \frac{1.369}{200}, \frac{1.369}{200} + \frac{\pi}{18000} .. \frac{\pi}{400} [s] \tag{5}$$

$$x_2(t_2) = -\left(R - \sqrt{\left(\sqrt{\frac{7}{4}} \cdot R \cdot \sin\left(\arccos\left(\frac{3}{7}\right)\right) - \frac{\omega_r \cdot R \cdot t_2}{2}\right)^2 + R^2} \cdot \cos\left(\frac{\omega_r \cdot t_2}{2} - \arctan\left(\frac{7}{4} \cdot \sin\left(\arccos\left(\frac{3}{7}\right)\right) - \frac{\omega_r \cdot t_2}{2}\right)\right)\right) \tag{6}$$

$$y_2(t_2) = \left(\sqrt{\left(\sqrt{\frac{7}{4}} \cdot R \cdot \sin\left(\arccos\left(\frac{3}{7}\right)\right) - \frac{\omega_r \cdot R \cdot t_2}{2}\right)^2 + R^2} \cdot \sin\left(\frac{\omega_r \cdot t_2}{2} - \arctan\left(\frac{7}{4} \cdot \sin\left(\arccos\left(\frac{3}{7}\right)\right) - \frac{\omega_r \cdot t_2}{2}\right)\right)\right) \tag{7}$$

$$x_3(t_3) = \left(R + \frac{R}{4}\right) \cdot \left(\frac{3}{7} - \cos\left(\arccos\left(\frac{3}{7}\right) + \frac{\omega_r \cdot t_3}{2}\right)\right) + \frac{R}{4} \cdot \cos\left(\arccos\left(\frac{3}{7}\right) + \frac{3 \cdot \omega_r \cdot t_3}{2}\right) \tag{8}$$

$$y_3(t_3) = \left(R - \frac{R}{4}\right) \cdot \left(\sin\left(\arccos\left(\frac{3}{7}\right) + \frac{\omega_r \cdot t_3}{2}\right) - \sin\left(\arccos\left(\frac{3}{7}\right)\right)\right) + \frac{R}{4} \cdot \cos\left(\arccos\left(\frac{3}{7}\right) + \frac{\omega_r \cdot t_3}{2}\right) - \frac{R}{4} \cdot \cos\left(\arccos\left(\frac{3}{7}\right) + 2 \cdot \omega_r \cdot t_3\right) \tag{9}$$

$$x_4(t_4) = \frac{7 \cdot R}{32} - \frac{R}{4}\left(1 - \cos\left(\frac{3 \cdot \omega_r \cdot t_4}{2}\right)\right) \tag{10}$$

$$y_4(t_4) = \frac{7 \cdot R}{4}\left(\cos\left(\arcsin\left(\frac{1}{8}\right)\right) - \cos\left(\arcsin\left(\frac{1}{8}\right) + \frac{\omega_r \cdot t_4}{2}\right)\right) + \frac{R}{4} \sin\left(\frac{3 \cdot \omega_r \cdot t_4}{2}\right) \tag{11}$$

$$x_5(t_5)=\left(\frac{5\cdot R}{4}\right)\cdot\left(\sin\left(\operatorname{arcos}\left(\frac{1}{5}\right)\right)-\sin\left(\operatorname{arcos}\left(\frac{1}{5}\right)+\frac{\omega_r\cdot t_5}{2}\right)\right)+\frac{R}{4}\cdot\left(1-\cos\left(\frac{5\cdot\omega_r\cdot t_5}{2}\right)\right) \tag{12}$$

$$y_5(t_5)=\left(\frac{5\cdot R}{4}\right)\cdot\left(\frac{1}{5}-\cos\left(\operatorname{arcos}\left(\frac{1}{5}\right)+\frac{\omega_r\cdot t_5}{2}\right)\right)+\frac{R}{4}\cdot\left(\sin\left(\frac{5\cdot\omega_r\cdot t_5}{2}\right)\right) \tag{13}$$

$$x_6(t_6)=\begin{pmatrix}\left(R+\frac{R}{4}\right)\cdot\left(\sin\left(\operatorname{arcos}\left(\frac{1}{5}\right)+\frac{\omega_r\cdot t_6}{2}\right)-\sin\left(\operatorname{arcos}\left(\frac{1}{5}\right)\right)\right)-\\ -\frac{R}{4}\left(\sin\left(\operatorname{arcos}\left(\frac{1}{5}\right)\right)-\sin\left(\operatorname{arcos}\left(\frac{1}{5}\right)+\frac{5\cdot\omega_r\cdot t_6}{2}\right)\right)\end{pmatrix} \tag{14}$$

$$y_6(t_6)=\left(\left(R+\frac{R}{4}\right)\cdot\left(\frac{1}{5}-\cos\left(\operatorname{arcos}\left(\frac{1}{5}\right)+\frac{\omega_r\cdot t_6}{2}\right)\right)+\frac{R}{4}\left(\frac{1}{5}-\cos\left(\operatorname{arcos}\left(\frac{1}{5}\right)+\frac{5\cdot\omega_r\cdot t_6}{2}\right)\right)\right) \tag{15}$$

By deriving the equations (6÷15) of the displacements, the velocities given by the equations (16÷25) are obtained $\frac{\omega}{2}$ for gear (d), respectively 2ω for the gear wheel (h).

$$vy2(t_2)=\frac{d}{dt_2}\sqrt{\left(\sqrt{\frac{7}{4}}\cdot R\cdot\sin\left(\operatorname{acos}\left(\frac{3}{7}\right)\right)-\frac{\omega_r\cdot R\cdot t_2}{2}\right)^2+R^2}\cdot\sin\left(\frac{\omega_r\cdot t_2}{2}-\operatorname{atan}\left(\frac{7}{4}\cdot\sin\left(\operatorname{acos}\left(\frac{3}{7}\right)\right)-\frac{\omega_r\cdot t_2}{2}\right)\right) \tag{16}$$

$$vx2(t_2)=\frac{d}{dt_2}-\left(R-\sqrt{\left(\sqrt{\frac{7}{4}}\cdot R\cdot\sin\left(\operatorname{acos}\left(\frac{3}{7}\right)\right)-\frac{\omega_r\cdot R\cdot t_2}{2}\right)^2+R^2}\cdot\cos\left(\frac{\omega_r\cdot t_2}{2}-\operatorname{atan}\left(\frac{7}{4}\cdot\sin\left(\operatorname{acos}\left(\frac{3}{7}\right)\right)-\frac{\omega_r\cdot t_2}{2}\right)\right)\right) \tag{17}$$

$$vy3(t_3)=\frac{3\cdot\omega_r\cdot R\cdot\cos\left(\operatorname{arcos}\left(\frac{3}{7}\right)+\frac{t_3\cdot\omega_r}{2}\right)}{8}+\left(\frac{R\cdot\cos\left(\frac{t_3\cdot\omega_r}{2}+\operatorname{arcos}\left(\frac{3}{7}\right)\right)}{4}-\frac{R\cdot\cos\left(\operatorname{arcos}\left(\frac{3}{7}\right)+2\cdot t_3\cdot\omega_r\right)}{4}\right) \tag{18}$$

$$vx3(t_3)=\frac{3\cdot\omega_r\cdot R\cdot\sin\left(\operatorname{arcos}\left(\frac{3}{7}\right)+\frac{t_3\cdot\omega_r}{2}\right)}{8}+\frac{R\cdot\cos\left(\frac{3\cdot t_3\cdot\omega_r}{2}+\operatorname{arcos}\left(\frac{3}{7}\right)\right)}{4} \tag{19}$$

$$vy4(t_4)=\frac{7\cdot\omega_r\cdot R\cdot\sin\left(\operatorname{arsin}\left(\frac{1}{8}\right)+\frac{t_4\cdot\omega_r}{2}\right)}{8}+\frac{3\cdot\omega_r\cdot R\cdot\cos\left(\frac{3\cdot t_4\cdot\omega_r}{2}\right)}{8} \tag{20}$$

$$vx4(t_4)=\frac{-\left(3\cdot\omega_r\cdot R\cdot\sin\left(\frac{3\cdot t_4\cdot\omega_r}{2}\right)\right)}{8} \tag{21}$$

$$vy5(t_5)=\frac{5\cdot\omega_r\cdot R\cdot\sin\left(\operatorname{arcos}\left(\frac{1}{5}\right)+\frac{t_5\cdot\omega_r}{2}\right)}{8}+\frac{5\cdot\omega_r\cdot R\cdot\cos\left(\frac{5\cdot t_5\cdot\omega_r}{2}\right)}{8} \tag{22}$$

$$vx5(t_5)=\frac{5\cdot\omega_r\cdot R\cdot\cos\left(\operatorname{arcos}\left(\frac{1}{5}\right)+\frac{t_5\cdot\omega_r}{2}\right)}{8}+\frac{5\cdot\omega_r\cdot R\cdot\sin\left(\frac{5\cdot t_5\cdot\omega_r}{2}\right)}{8} \tag{23}$$

$$vy6(t_6)=\frac{5\cdot\omega_r\cdot R\cdot\sin\left(\operatorname{arcos}\left(\frac{1}{5}\right)+\frac{5\cdot t_6\cdot\omega_r}{2}\right)}{8}+\frac{5\cdot\omega_r\cdot R\cdot\sin\left(\operatorname{arcos}\left(\frac{1}{5}\right)+\frac{t_6\cdot\omega_r}{2}\right)}{8} \tag{24}$$

$$vx6(t_6)=\frac{5\cdot\omega_r\cdot R\cdot\cos\left(\operatorname{arcos}\left(\frac{1}{5}\right)+\frac{5\cdot t_6\cdot\omega_r}{2}\right)}{8}+\frac{5\cdot\omega_r\cdot R\cdot\cos\left(\operatorname{arcos}\left(\frac{1}{5}\right)+\frac{t_6\cdot\omega_r}{2}\right)}{8} \tag{25}$$

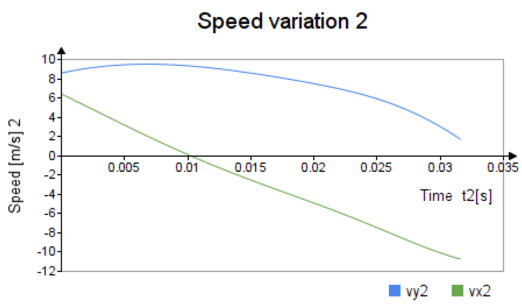

Fig.4 Variation of speed 2 equations (16, 17)

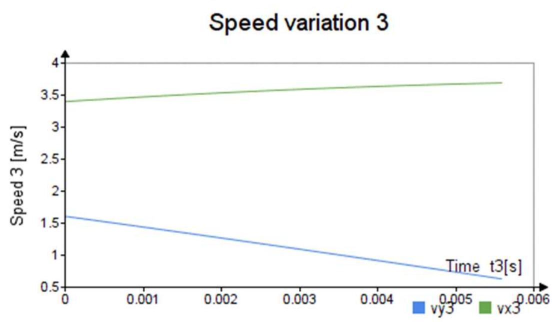

Fig.5 Variation of speed 2 equations (18, 19)

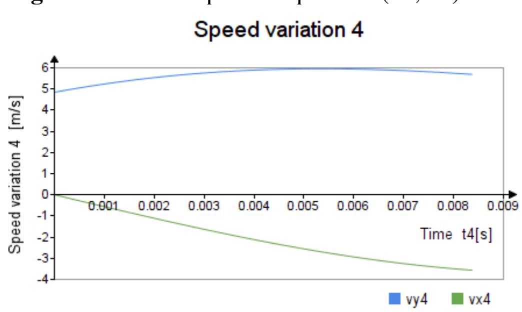

Fig.6 Variation of speed 2 equations (20, 21)

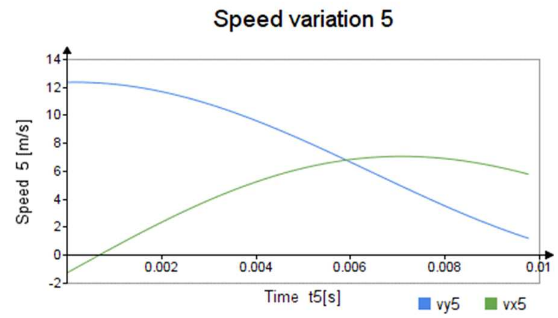

Fig.7 Variation of speed 2 equations (22, 23)

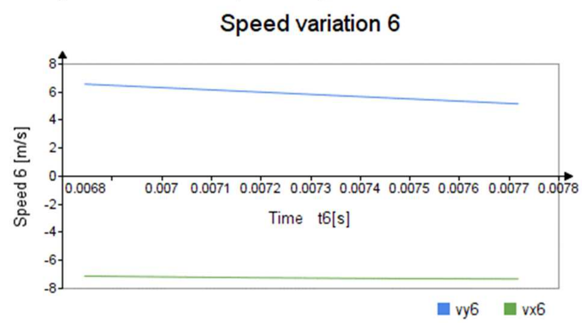

Fig.8 Variation of speed 2 equations (24, 25)

If we derive the velocity equations (16÷25) we get the acceleration equations (26÷34).

$$ay2(t_2)=\frac{d^2}{dt_2^2}\sqrt{\left(\sqrt{\frac{7}{4}}\cdot R\cdot\sin\left(\operatorname{acos}\left(\frac{3}{7}\right)\right)-\frac{\omega_r\cdot R\cdot t_2}{2}\right)^2+R^2}\cdot\sin\left(\frac{\omega_r\cdot t_2}{2}-\operatorname{atan}\left(\frac{7}{4}\cdot\sin\left(\operatorname{acos}\left(\frac{3}{7}\right)\right)-\frac{\omega_r\cdot t_2}{2}\right)\right) \tag{26}$$

$$ax2(t_2)=\frac{d^2}{dt_2^2}-\left(R-\left(\sqrt{\left(\sqrt{\frac{7}{4}}\cdot R\cdot\sin\left(\operatorname{acos}\left(\frac{3}{7}\right)\right)-\frac{\omega_r\cdot R\cdot t_2}{2}\right)^2+R^2}\right)\cdot\cos\left(\frac{\omega_r\cdot t_2}{2}-\operatorname{atan}\left(\frac{7}{4}\cdot\sin\left(\operatorname{acos}\left(\frac{3}{7}\right)\right)-\frac{\omega_r\cdot t_2}{2}\right)\right)\right) \tag{27}$$

$$ay3(t_3)=-\frac{3\cdot\omega_r^2\cdot R\cdot\sin\left(\operatorname{arcos}\left(\frac{3}{7}\right)+\frac{t_3\cdot\omega_r}{2}\right)}{16}+\left(\frac{R\cdot\cos\left(\frac{t_3\cdot\omega_r}{2}+\operatorname{arcos}\left(\frac{3}{7}\right)\right)}{4}-\frac{R\cdot\cos\left(\operatorname{arcos}\left(\frac{3}{7}\right)+2\cdot t_3\cdot\omega_r\right)}{4}\right) \tag{28}$$

$$ax3(t_3)=\frac{3\cdot\omega_r^2\cdot R\cdot\cos\left(\text{arcos}\left(\frac{3}{7}\right)+\frac{t_3\cdot\omega_r}{2}\right)}{16}+\frac{R\cdot\cos\left(\frac{3\cdot t_3\cdot\omega_r}{2}+\text{arcos}\left(\frac{3}{7}\right)\right)}{4} \quad (29)$$

$$ay4(t_4)=\frac{7\cdot\omega_r^2\cdot R\cdot\cos\left(\text{arsin}\left(\frac{1}{8}\right)+\frac{t_4\cdot\omega_r}{2}\right)}{16}-\frac{9\cdot\omega_r^2\cdot R\cdot\sin\left(\frac{3\cdot t_4\cdot\omega_r}{2}\right)}{16} \quad (30)$$

$$ax4(t_4)=\frac{-\left(9\cdot\omega_r^2\cdot R\cdot\cos\left(\frac{3\cdot t_4\cdot\omega_r}{2}\right)\right)}{16} \quad (31)$$

$$ay5(t_5)=\frac{5\cdot\omega_r^2\cdot R\cdot\cos\left(\text{arcos}\left(\frac{1}{5}\right)+\frac{t_5\cdot\omega_r}{2}\right)}{16}-\frac{25\cdot\omega_r^2\cdot R\cdot sin\left(\frac{5\cdot t_5\cdot\omega_r}{2}\right)}{16} \quad (32)$$

$$ax5(t_5)=\frac{5\cdot\omega_r^2\cdot R\cdot\cos\left(\text{arcos}\left(\frac{1}{5}\right)+\frac{t_5\cdot\omega_r}{2}\right)}{16}-\frac{25\cdot\omega_r^2\cdot R\cdot\sin\left(\frac{5\cdot t_5\cdot\omega_r}{2}\right)}{16} \quad (33)$$

$$ay6(t_6)=\frac{25\cdot\omega_r^2\cdot R\cdot\cos\left(\text{arcos}\left(\frac{1}{5}\right)+\frac{5\cdot t_6\cdot\omega_r}{2}\right)}{16}+\frac{5\cdot\omega_r^2\cdot R\cdot\cos\left(\text{arcos}\left(\frac{1}{5}\right)+\frac{t_6\cdot\omega_r}{2}\right)}{16} \quad (34)$$

$$ax6(t_6)=\frac{25\cdot\omega_r^2\cdot R\cdot\sin\left(\text{arcos}\left(\frac{1}{5}\right)+\frac{5\cdot t_6\cdot\omega_r}{2}\right)}{16}-\frac{5\cdot\omega_r^2\cdot R\cdot\sin\left(\text{arcos}\left(\frac{1}{5}\right)+\frac{t_6\cdot\omega_r}{2}\right)}{16} \quad (35)$$

To calculate the force required to move the chain, we must establish the components of each $axi(t_i)$ respectively $ayi(t_i)$ by the direction of chain travel at all times t_i. The formulas are given with the relations (36÷40).

$$a2(t_2)=ax2(t_2)\cdot\sin\left(\frac{\omega\cdot t_2}{2}\right)+ay2(t_2)\cdot\cos\left(\frac{\omega\cdot t_2}{2}\right) \quad (36)$$

$$a3(t_3)=ax3(t_3)\cdot\sin\left(\frac{\omega\cdot t_3}{2}\right)+ay3(t_3)\cdot\cos\left(\frac{\omega\cdot t_3}{2}\right) \quad (37)$$

$$a4(t_4)=ax4(t_4)\cdot\sin\left(\frac{\omega\cdot t_4}{2}\right)+ay4(t_4)\cdot\cos\left(\frac{\omega\cdot t_4}{2}\right) \quad (38)$$

$$a5(t_5)=ax5(t_5)\cdot\sin\left(\frac{\omega\cdot t_5}{2}\right)+ay5(t_5)\cdot\cos\left(\frac{\omega\cdot t_5}{2}\right) \quad (39)$$

$$a6(t_6)=ax6(t_6)\cdot\sin\left(\frac{\omega\cdot t_6}{2}\right)+ay6(t_6)\cdot\cos\left(\frac{\omega\cdot t_6}{2}\right) \quad (40)$$

By multiplying the accelerations on different portions by the mass unit m of the chain and integrating over the respective portions, the total force is obtained F_{TOTAL} necessary to set the chain in motion, shown in relation number (41).

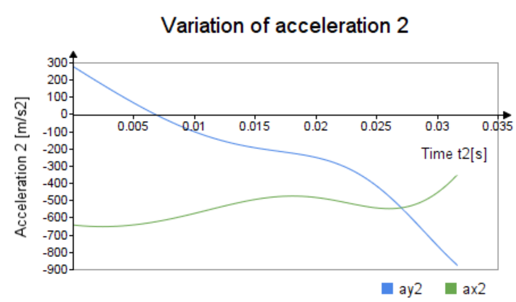

Fig.9 Variation of acceleration 2 equations (26, 27)

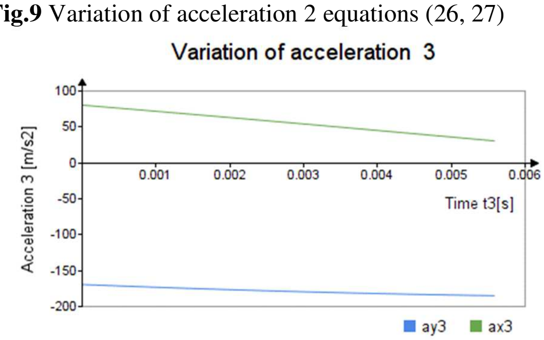

Fig.10 Variation of acceleration 3 equations (28, 29)

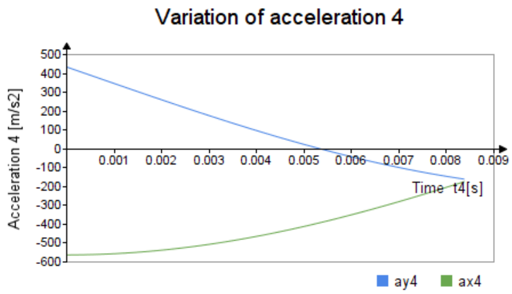

Fig.11 Variation of acceleration 4 equations (30, 31)

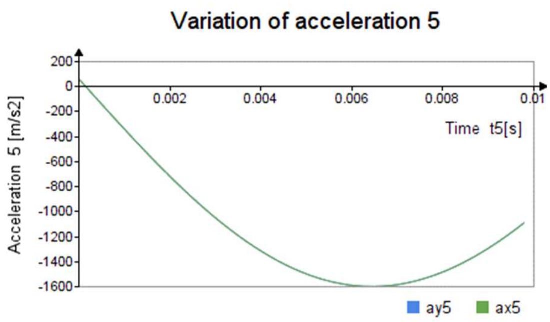

Fig.12 Variation of acceleration 5 equations (32, 33)

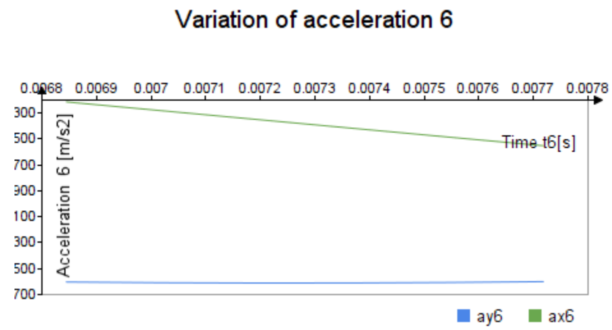

Fig.13 Variation of acceleration 6 equations (34, 35)

$$F_{TOTAL} = \int_0^{\frac{6.328}{200}} F2(t_2)dt_2 + \int_0^{\frac{1.128}{200}} F3(t_3)dt_3 + \int_0^{\frac{1.696}{200}} F4(t_4)dt_4 + \int_0^{\frac{1.976}{200}} F5(t_5)dt_5 + \int_{\frac{1.369}{200}}^{\frac{\pi}{400}} F6(t_6)dt_6 = -22.938[N] \quad (41)$$

And the moment needed to train the chain is:

$$M_{TOTAL} = F_{TOTAL} \cdot R \cdot 1.02 = -2.34[N] \quad (42)$$

The formulas (58÷61) are used to calculate the angles at different times t_i.

$$\beta(t_2) = \arctan\left(\frac{7}{4}\cdot\sin\left(\arccos\left(\frac{3}{7}\right)\right) - \frac{\omega_r \cdot t_2}{2}\right) \quad (43)$$

$$\gamma = \arccos\left(\frac{3}{7}\right) \quad (44)$$

$$\delta = \arcsin\left(\frac{1}{7}\right) \quad (45)$$

$$\varepsilon = \arccos\left(\frac{1}{5}\right) \quad (46)$$

For the calculation of the moment required to train the frame $M_{STRUCTURA}$ it is necessary to multiply the x- and y-direction components of the forces in the sprocket bearings with the arm of each relative to the point of rotation O,

$$My_2(t_2) = Fy2(t_2)\cdot\left(\frac{R}{\cos(\beta(t_2))}\right)\cdot\left(\cos\left(\beta(t_2) + \frac{\omega_r \cdot t_2}{2}\right)\right) \quad (47)$$

$$Mx_2(t_2) = Fx2(t_2)\cdot\left(\frac{R}{\cos(\beta(t_2))}\right)\cdot\left(\sin\left(\beta(t_2) + \frac{\omega_r \cdot t_2}{2}\right)\right) \quad (48)$$

$$My_3(t_3) = Fy3(t_3)\cdot\left(2\cdot R - \frac{R}{4}\right)\cdot\left(\sin\left(\gamma + \frac{\omega_r \cdot t_3}{2}\right)\right) \quad (49)$$

$$Mx_3(t_3) = Fx3(t_3)\cdot\left(2\cdot R - \frac{R}{4}\right)\cdot\left(\cos\left(\gamma + \frac{\omega_r \cdot t_3}{2}\right)\right) \quad (50)$$

$$My_4(t_4) = Fy4(t_4)\cdot\left(2R - \frac{R}{4}\right)\cdot\sin\left(\delta + \frac{\omega_r \cdot t_4}{2}\right) \quad (51)$$

$$Mx_4(t_4) = Fx4(t_4)\cdot\left(2R - \frac{R}{4}\right)\cdot\cos\left(\delta + \frac{\omega_r \cdot t_4}{2}\right) \quad (52)$$

$$My_5(t_5) = Fy5(t_5)\cdot\left(R + \frac{R}{4}\right)\cdot\left(\sin\left(\frac{\omega_r \cdot t_5}{2}\right)\right) \quad (53)$$

$$Mx_5(t_5) = Fx5(t_5)\cdot\left(R + \frac{R}{4}\right)\cdot\left(\cos\left(\frac{\omega_r \cdot t_5}{2}\right)\right) \quad (54)$$

$$My_6(t_6) = Fy6(t_6)\cdot\left(R + \frac{R}{4}\right)\cdot\left(\sin\left(\arccos\left(\frac{1}{5}\right) + \frac{\omega_r \cdot t_6}{2}\right)\right) \quad (55)$$

$$Mx_6(t_6) = Fx6(t_6)\cdot\left(R + \frac{R}{4}\right)\cdot\left(\cos\left(\arccos\left(\frac{1}{5}\right) + \frac{\omega_r \cdot t_6}{2}\right)\right) \quad (56)$$

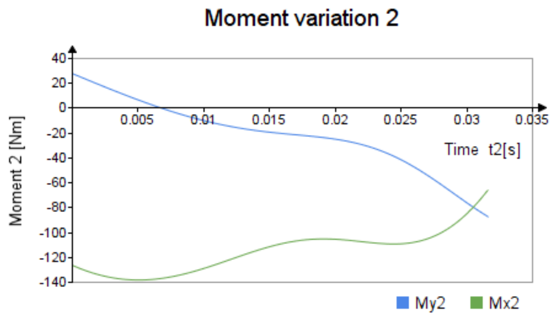

Fig.14 Moment variation 2 equations (47, 48)

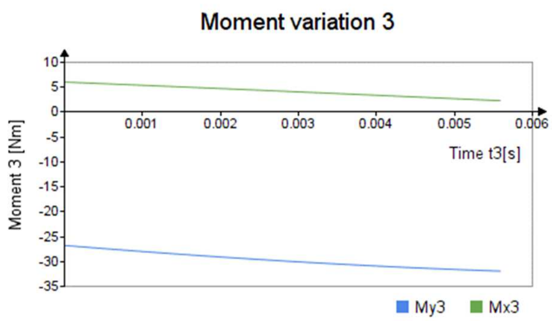

Fig.15 Moment variation 3 equation (49,50)

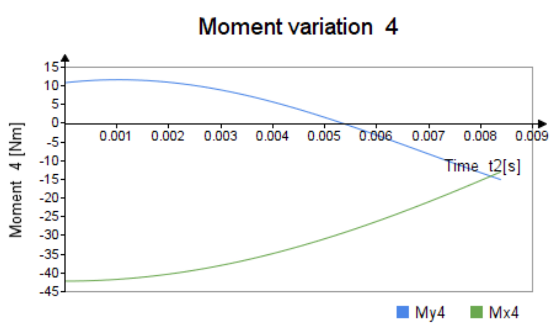

Fig.16 Moment variation 4 equation (51,52)

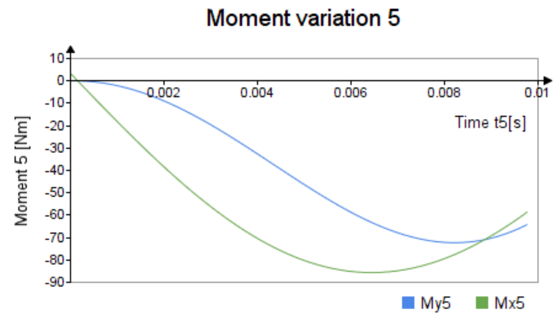

Fig.17 Moment variation 5 equation (53,54)

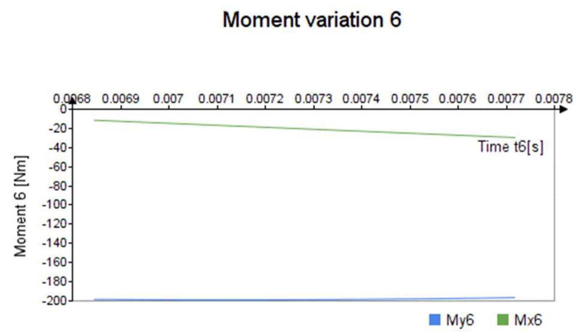

Fig.18 Moment variation 6 equation (55,56)

We note that all the calculation algorithm was made for the first dial of the mechanism. In the final phase, to make the calculation complete, I multiplied the respective moments by 4, to obtain their real value.

The final moment of motion of the structure will be given by relation (57).

$$M_{MS} = 4 \cdot M_{STRUCTURA} = -13.436[N \cdot m] \qquad (57)$$

The final moment of motion of the chain will be given by relation (58).

If we mount a tool at the axis of rotation of the stator, coaxial with it, then the moment for its rotation will be $M_{UNEALTA} = M_{MS} - M_{REACT}$, as a result the reaction moment produced by the entire system will be compensated and reach zero.

$$\begin{aligned} M_{STRUCTURA} = & \int_0^{\frac{2.712}{200}} Mx_2(t_2)dt_2 \int_0^{\frac{1.128}{200}} Mx_3(t_3)dt_3 + \int_0^{\frac{1.696}{200}} Mx_4(t_4)dt_4 + \int_0^{\frac{1.976}{200}} Mx_5(t_{_5})dt_5 + \int_{\frac{1.369}{200}}^{\frac{\pi}{400}} Mx_6(t_6)dt_6 + \\ & + \int_0^{\frac{2.712}{200}} My_2(t_2)dt_2 + \int_0^{\frac{1.128}{200}} My_3(t_3)dt_3 + \int_0^{\frac{1.696}{200}} My_4(t_4)dt_4 + \int_0^{\frac{1.976}{200}} My_5(t_{_5})dt_5 + \int_{\frac{1.369}{200}}^{\frac{\pi}{400}} My_6(t_6)dt_6 = -3.359[N \cdot m] \end{aligned} \qquad (58)$$

$$M_{TOTAL} = F_{TOTAL} \cdot R \cdot 1.02 \quad (59)$$

$$M_{ML} = 4 \cdot M_{TOTAL} = -9.36[N \cdot m] \quad (60)$$

To obtain this torque we use an electric drive motor, by means of its rotor axis according to figure 4, and as a result a reaction moment appears and as a result there is a moment of reaction M_{REACT} equal and opposite to M_{ML} mean $M_{REACT} = -M_{ML}$.

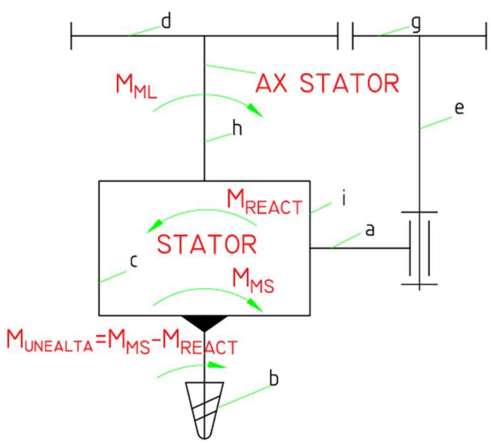

Fig. 19 Electric drive motor

If we connect the body of the stator of this motor to the frame structure of the sprockets, it means that the moment produced by the reactions in the bearings of the sprockets also acts on the stator, mean M_{MS}.

7. CONCLUSION

The element of originality is to cancel the reaction moment that appears in normal working conditions in an industrial machine equipped with a work tool that performs rotational movement around its own axis.

By applying the device, the following advantages are obtained:

The realization of a moment of rotation that is able to counteract the moment of reaction that occurs in all systems of rotation, which during operation use a working moment.

Manufacturing costs are relatively low, the system being mainly composed of some sprockets and weights mounted along the entire length of the chain used.

The mentioned torque is dependent on the angular speed of rotation of the system, for which the system can be used (within certain limits) of varied working moment.

The combination of mechanical chain transmission characterized by the fact that through the combined movement of the chain equipped with weights (over its entire length) a rotational moment is produced that serves to counteract the reaction moment that inevitably occurs when driving the working pin.

8. REFERENCES

[1] Damavandi Shacriar Yazdani: *Non-Reaction Torque Drive*, US 7554283 B2, Jun, 30, 2009 (https://www.google.com/ patents/US7554283)

[2] Gotman Alexander S.: *Mechanism for Conteracting Reaction Torque in a Powered, Reversible, Hand- Held Rotary Driver*, US5540629 A, Jul, 30, 1996 (https://www.google.tl/patents /US5540629)

[3] Timofte, S; Miclosina, CO; Cojocaru, V; Gerocs, A ; Korka, ZI , *Inertial Propulsion of a Mobile Platform Driven by Two Eccentric Bodies,* Volume 13 Issue 17, DOI10.3390/app13179511, Article Number 9511, Published SEP 2023, Indexed 2023-09-22,

[4] Plakhtienko, N. P., *Parametric indentification of chain systems under inertial excitation*, 1990/09/01, Soviet Applied Mechanics, 903- 908, Vol - 26, Issu - 9, ISSN - 1573-8582, https://doi.org/10.1007/BF00888778, DO - 10.1007/BF00888778, ID - Plakhtienko1990, JOUR.

[5] A E Shokhin, A N Nikiforov and K V Krestnikovskii, *On self-synchronization of inertial vibration exciters in a chain-type oscillatory system*, IOP Conference Series: Materials Science and Engineering, Volume 489, International Conference of Young Scientists and Students "Topical Problems of Mechanical Engineering 2018" 20–23 November 2018, Moscow, Russian Federation Citation A E Shokhin et al 2019 IOP Conf. Ser.: Mater. Sci. Eng. 489

012044, DOI 10.1088/1757-899X/489/1/012044.

[6] Korka, ZI, *Challenges of ethics in current research*, Romanian Journal of Acoustic and Vibration, Volume 17, Issue 2, Page 84, Published 2020, Indexed 2021-02-03

Mecanism de transmitere prin lanț utilizat la reducerea momentului de reacție pentru utilajele care efectuează mișcare de rotație în jurul propriei axe

Rezumat: Lucrarea face referire la un mecanism cu transmise prin lanț alcătuit din 12 roți de lanț identice așezate după o anumită schemă geometrică. Iar lanțul acestui este antrenat în mișcare de translație cu ajutorul unui motor electric prin intermediul unui angrenaj de două roți dințate cilindrice cu dinți înclinați, iar una din aceste roți este montată la axa rotorului acestui motor, iar cealaltă roată dințată este montată la axa uneia dintre cele 12 roți de lanț. Structura care susține lagărele roților de lanț este astfel montată încât să facă posibil învârtirea acesteia tot în jurul aceluiași ax al rotorul. Structură care este legată rigid cu statorul motorului, formând corp comun cu acesta. În timpul funcționării lanțul pe diferite porțiuni, respectiv în fiecare punct al acestuia apar niște accelerări pe care putem evidenția după două direcții perpendiculare x, respectiv y. Pentru obținerea acestor accelerații s consumă o forță de tracțiune a lațului, care este realizată prin intermediul momentului realizat de rotorul motorului. Realizând calculul cinematic al sistemului și considerând o sculă de lucru montată la axa statorului, coaxial cu axa acestuia și dacă această unealtă lucrează cu un moment egal cu rezultanta dintre momentele ce apare în stator, atunci putem trage concluzia reducerii la zero a rezultantei momentelor ce acționează asupra sistemului.

Elena MUNCUT (WISZNOVSZKY) [0000-0002-4097-8500], lecturer, “Aurel Vlaicu” University Arad, Fac Eng., Dept Automat Ind Eng. Text Prod & Transport, Romania, Arad, Email: muncutstela@yahoo.com, Phone: 0746491247, Home Address: str. Lungă, nr.21, Romania, jud. Arad, Șeitin.

Attila GERÖCS [0000-0001-9546-2096], lecturer, “Aurel Vlaicu” University Arad, Fac Eng., Dept Automat Ind Eng. Text Prod & Transport, Romania, Arad, and University of Szeged, Faculty of Engineering, Postal address: Mars tér 7, H-6724 Szeged, Hungary, Email: atti.gerocs@gmail.com, Phone: 0729649493, Home Address: str. Atim Ivireanul, nr. 43/F, Romania, Arad.

Lavinia Ioana CULDA [0000-0003-4230-5390], Ph.D. Lector, Aurel Vlaicu University, Faculty of Engineering, lavyy_99@yahoo.com, Phone: +40-257-250389, Address: B-dul Revoluţiei, nr. 77, 310130, Arad, Romania.

Andrei KOMJATY [0000-0003-2308-3964], lecturer, “Aurel Vlaicu” University Arad, Fac Eng., Dept Automat Ind Eng. Text Prod & Transport, Romania, Arad, Arad, str. Ștefan Luchian nr 23, Bl. B17, sc. B, ap.2, cod 310359, jud Arad, România, telefon: 0745-754418, komjatya@gmail.com

Geza-Mihai ERDODI, lecturer, “Aurel Vlaicu” University Arad, Fac Eng., Dept Automat Ind Eng. Text Prod & Transport, Romania, Arad, Email: komjatya@gmail.com, Home Address: str. Stefan Luchian, nr. 23, Bl B-17, Romania, Arad, v, Home Phone: 0357803486.

Aurel Mihail TITU, [0000-0002-0054-6535], Professor, Lucian Blaga University of Sibiu, Faculty of Engineering, mihai.titu@ulbsibiu.ro