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SIMULATION OF FUNCTION OF MECHANISMS CAM - BALANCE LEVER IN CONSTRUCTION OF THE VARIATOR WITH INTERMITTENT OPERATION

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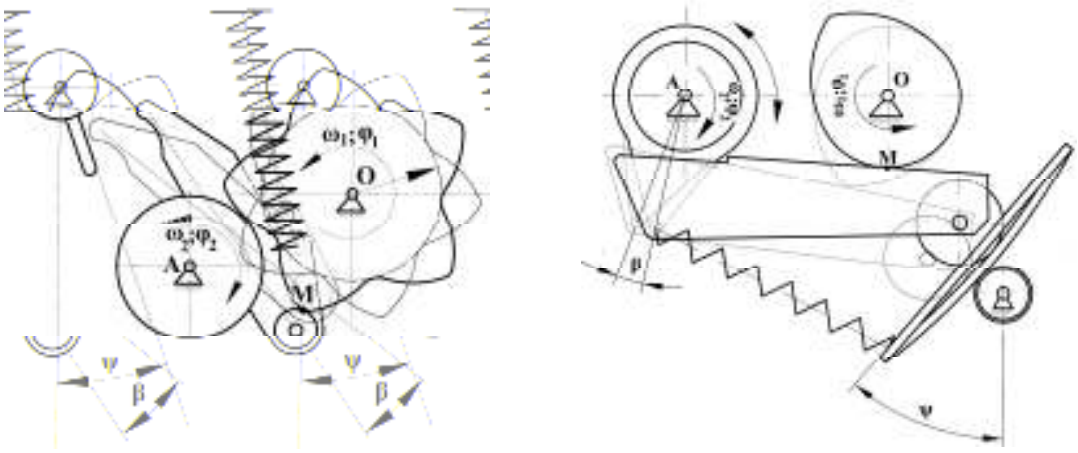
Abstract: *In this paper is presented the method of kinematics simulation of the mechanism cam-balance lever used in the transmissions of the seed drill for cereals. To realize virtual prototypes, some various constructive variants of mechanisms used in the variator with intermittent operation construction was utilized the software PROEngineer Wildfire 2.0. The results of research through simulation are presented in the likeness of diagrams which emphasize the functional peculiarities of the mechanism cam-balance lever and on which may optimize functional variator.*
Key words: *transmissions, simulation, seed drill.*

1. INTRODUCTION

The variator with cam-balance wheel transforms the constant motion of active wheels, in intermittent motion of active shaft of dosage machines. They have in their component variators which a determinated number mechanisms cam-balance wheel and mounted in-line and operating phase-shifted.

Implementation of variators mechanisms cam-balance lever in sowing machine transmission has led to: simplify the construction transmission and operations to regulate the dosage, reducing manufacturing costs, improve working conditions of operators and increase safety in operation [4].

Variators with intermittent operation allowing the regulation of transmission and implicitly the flow of seeds distributed by dosage machines manually, by positioning a lever to limit active race of balance-lever on a graduated sector, and through a command system electro hydraulic equipped with a sensor position. This system allows modification of the transmission from the tractor cabin [1].



a. b.

Figure 1: Constructive types of mechanisms with cam encountered in construction of variators construction with intermittent operation

In construction of variators with intermittent operation, there are two categories of cam-balance-lever mechanisms: mechanism which the contact (point M) between the leader and the led is through a role, and the active race is limit through a plate (figure 1, *a*); mechanisms which the contact (point M) between the leader (the cam) and the led (the balance-lever) is directly and the roll keep moving on a plate for limiting the active race (figure 1, *b*) [3].

2. DEVELOPMENT OF FUNCTIONAL MODELS AND SIMULATION OF FUNCTIONAL MECHANISMS CAM-BALANCE LEVER TYPE

Virtual - functional prototyping of mechanisms cam-balance lever allows the evaluation of their function from early stages of design and offers the possibility of multifunctional optimizations.

Virtual prototypes include representations of flexible and rigid parts, connected by geometric and kinematics constraints, and which may act forces - external and internal moments.

To realize virtual models was used PROEngineer software, and for simulation of kinematics mechanism was used the Mechanism-Animation of the same software that allows viewing of motion mechanisms and the graphical representation of the laws of motion both in terms of time and depending on a parameter of movement input (angle of rotation of the shaft with cams).

Software PROEngineer consider mechanisms as assemblies of rigid bodies, interconnected by mechanical links (geometrical restrictions), elastic elements (eg springs) and disipative (eg dampers), acting on the mechanical system of external forces (weight, engines, resistant) and internal forces (generated by the elastic and damping). Mechanisms cam-balance lever are mechanical systems of bodies for transmission and transformation of movement of the constant motion of the active wheel in intermittent motion of the drive shaft of dosage elements. They have in their structure elements which require laws of movement.

To elaborate the functional models, in a first stage was accomplished the structural models (figures 2 and 3). Elaboration of a structural model consisted in representation of all pieces and modules which compose the mechanism, where after were put the restrictions advert to assemblage manner, where through was attain corrected position of all the component elements of the ensemble. For the representation of component elements of the gearbox were utilized the drawings of execution of these [2].

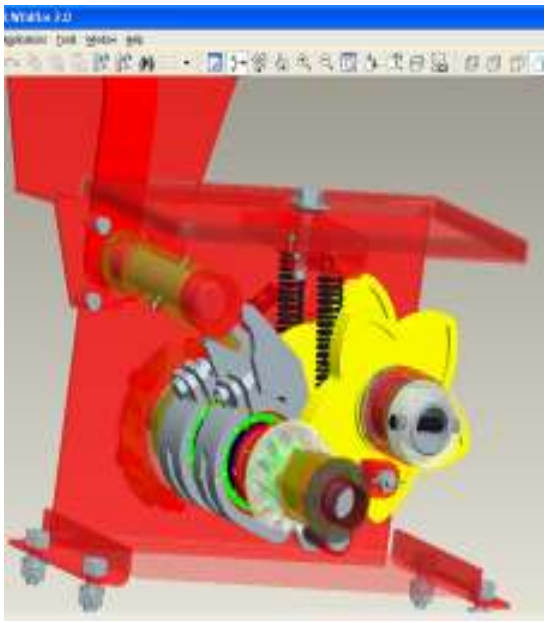


Figure 2: Structural model of a variator with intermittent motion which include two mechanisms cam-balance lever, having a cam with five lobes.

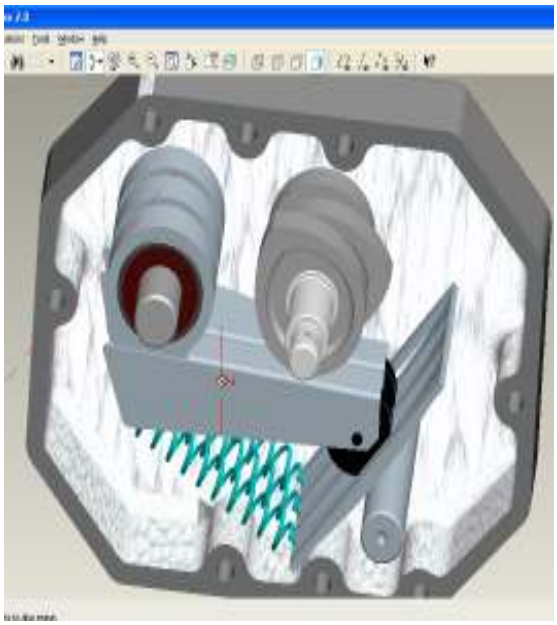


Figure 3: Structural model of a variator with intermittent motion which include two mechanisms cam-balance lever, having a cam with one lobe.

For the application of assemblage restrictions was necessary the cognition of the next questions: position of the piece in report with the bindery pieces and the category of specific restriction, for several of them. To assure the correct operation of the mechanism, for the fixed pieces, which don't assist to conduction motion, were put.

Place type restrictions and for the mobile pieces, between is transmitted the motion, were put Connect type restrictions.

Before elaborate the kinematics models, in order for Animation-Mechanism module can operate in optimum conditions, was applied a simplified model of a variator, neglecting the two one-way couplings of one-way traffics, where through the balance wheels are kinematics binded of exit shaft. Also is renouncing to the parts that do not move forward (fixed parts), as: simerings, washers spacers, wedges, bushings, rolling bearings, screws, nuts.

This simplification is motivated through the next:

- the simulation is realized only for the analysis of motion laws of balance-levers and determination of angles pressure from kinematics conditions, depending on the type of mechanism, the profile and of cams dimensions of balance-levers.
- the couplings contain a big number of elements, which requires, on their ensemble, a very big number of restrictions, which PROEngineer software cannot to generate them [5].

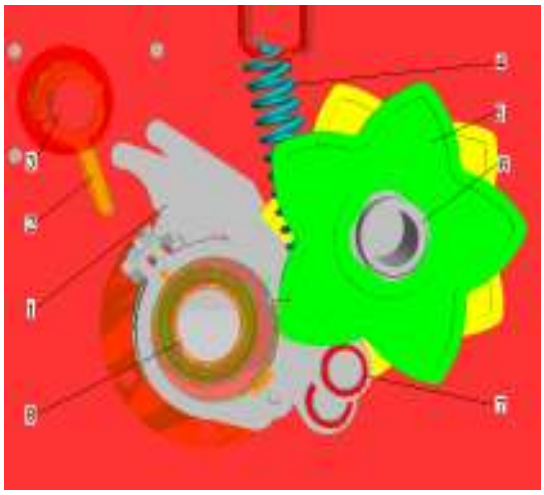


Figure 5: Reduced structural model of mechanism with two cam with five lobes:
1 – balance-lever; 2 - limiter plate; 3 - axle limiter plate; 4 - helical springs; 5 – cam; 6 - input shaft; 7 - roll of balance-lever; 8. - output shaft.

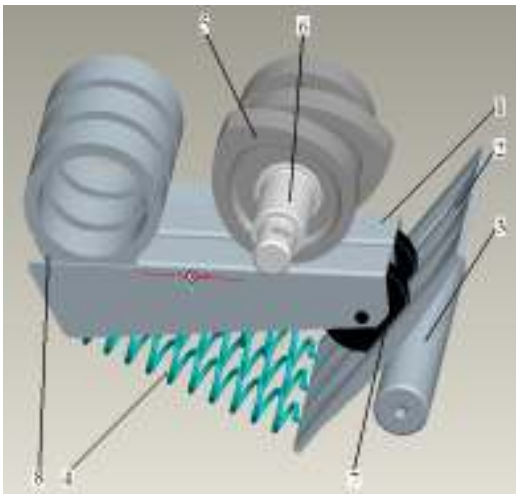


Figure 6: Reduced structural model of mechanism with three cam with one lobe: 1 – balance-lever; 2 - limiter plate; 3 - axle limiter plate; 4. - helical springs; 5 – cam; 6 – input shaft; 7 - roll of balance-lever; 8 – support welded to the outer ring couplings.

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The second stage in simulation realization was adverted to application of restrictions of kinematics order, which are compulsions which generates the motion of leading elements of mechanism, depending on time, and the application of input motion to the leading element.

First restriction of kinematics order is related to the fact that during of active race the reels 6 of the balance wheels *1* are displaced on the cam profile and have the possibility of detachments from this, at the end of passive race (figure 5). For this compulsion is utilized command Cam - Follower Connections, with the property Enable Liftoff.

In the case of mechanism with three cams, the first restriction is that the cam *5* must remain in permanent contact with balance-lever *1* (figure 6).

In the case of mechanism with three cams, Litoff Enable property is not used, on the reason that this type of mechanism the cams remains always keep in contact with the balance-lever.

The second restriction of kinematics order is related to the possibility limitation of the race of the return of balance wheels, there for being used the command Cam - Follower Connections, with the propriety Enable Liftoff, and property Enable Friction.

The third restriction of kinematics order is related to the fact that on an area of return race, up to the contact with the limiter plate, is necessary the sustentation of balance wheels reels in contacts with the cam profile. There for using the command Springs, where through is generated helical bows mounted in pre-tension state. To adopt the value of tensions from the helical bows, exists the possibility of modification values of elastic constant *K* or diameter of wrap up the whorls.

For generation the motion of camshaft was used Motors command, this permitting modification of the rev and sense of rotation.

To properly present the influence of geometric cam configuration, on motion laws of balance-lever and pressure angle, were taken into account the distinct positions of cam-balance-lever aggregate. For mechanism

which the contact between the cam and balance-lever it through a role, these positions are: entry into contact of balance-lever with a lobe of the came, the sprint of active race of balance-lever and detachment of cam from the lobe, the three positions being characteristic of mechanism kinematics.

After developing kinematics model in order to run simulations, are introduced a number of parameters related only to each operating system that is intended to be simulated. These parameters are: the type of analysis, speed of entry, position of race plate which limited the return of balance-lever, which is achieved by changing the transmission rapport; duration of simulation; the frames number (number of values recorded per second).

Based on the model described above, *the stage of processing* (rolling model) was performed automatically by the application and consisted of the following:

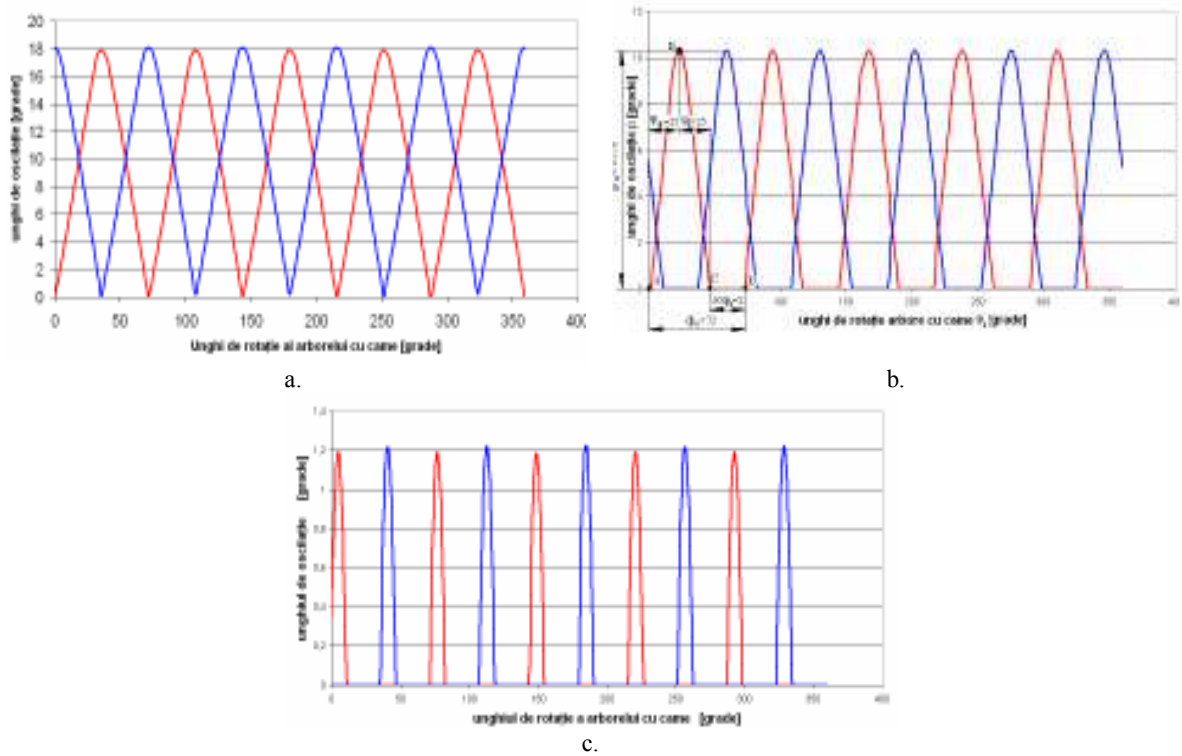
- system assembling through restrictions introduced by the movement of components;
- identifying and removing redundant connections (over-constraints) from system;
- generation of successive positions of the mechanism elements.

3. SIMULATION RESULTS

After the analysis (process model) is continued with post-processing phase, which consisted in processing the results obtained by: drawing diagrams of variation of motion laws, according to independent kinematics parameter (implicit parameter – the time) or another parameter specific to model (the angle of rotation of camshaft); graphic animation (simulation) of model in various projections (representation plans) and tabular representing the interest measures (for further processing in specific applications spreadsheet, like Excel).

To represent the variation laws of space, velocity and angular acceleration of balance-levers was used Measure Results command, which allows graphic representation of motion laws according to movement of camshaft and also depending on the implicit parameter - the time.

Figure no. 7 shows graphs of variation of fluctuation angle of balance-lever for variators with two mechanisms cam-balance lever mounted in parallel and in-shift having the cam with five lobes and following operating parameters: speed shaft which the cam is mounted, n_1=35 [rot/min]; limiter plate of balance-lever race being set by turn in one of three positions characteristic of kinematics mechanism $\psi=24^o;44^o;62^o$; simulation period (time of operation of the mechanism) *t = 2,5 [s]*, the frame number 200.



a. b.

c.

Figure 7: Diagram of variation of oscillation angles of balance-levers depending on rotation angle of the camshaft for two mechanisms mounted in parallel and in-shift :
a. - for the maximum race; b. - for an intermediate race; c. – for the minimum race.

It is noted that when the balance-lever is running maximum race, the roll is remains during the cycle in contact with the cam, motion law contains only two phases:

- ascending stage, which balance-lever roll amounts range from a minimum radius of lobe to maximum radius, characterized by an rotation angle of cam $\varphi_u=36^o$ (considered the active race);
- descendent phase, which balance-lever roll goes down from the maximum radius of cam to minimum radius, characterized by an angle rotation of cam $\varphi_c=36^o$.

When the limiter plate is in an intermediate position, the motion law of balance-levers comprises three phases:

- ascending phase, characterized by an angle of cam rotation $\varphi_u=25^o$ (considered the race active);
- descent phase, characterized by an angle of cam rotation $\varphi_c=25^o$.
- stationary phase (angleφ_s) characterized by an angle of cam rotation $\varphi_s=22^o$.

The point B of the diagram characterized the end of active race and the beginning of withdrawal, the roll of balance-lever being positioned on top of cam lobe; the point C characterizes the moment which the balance-lever comes in contact with limiter plate, which is the end of passive race; the point D characterizes the moment which the balance-lever comes in contact with the profile cam lobe and start the active race; the point A is characterizing the beginning of active race.

Because the functioning basis of variators with intermittent motion, stand the principle of summarization of rotation impulses, generated by cam – balance lever – one-way coupling ansamble, variation diagram of angular space covered by output shaft from variator will be in form of impulses whose amplitude is the amplitude of oscillations of the two mechanisms mounted in parallel (figure 8).

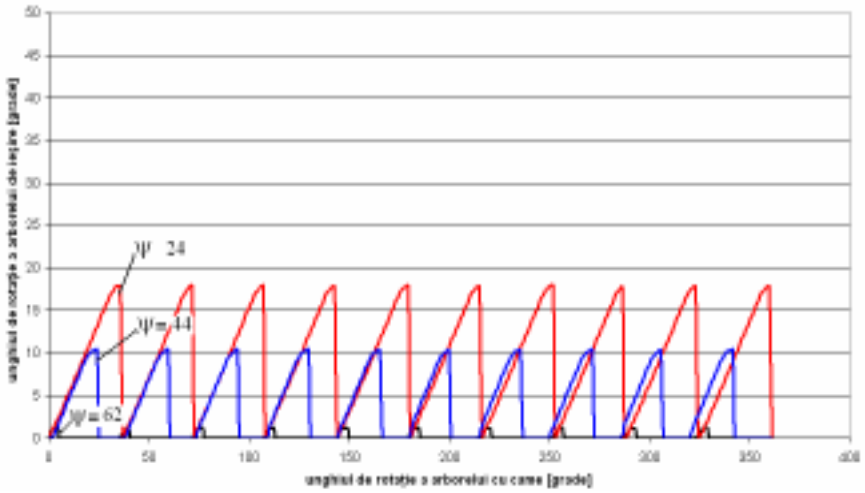


Figure 8: Diagram of variation of rotation angle of output shaft depending on the angle of rotation of the camshaft for the positions of limiter plate corresponding to minimum, maximum and intermediate race.

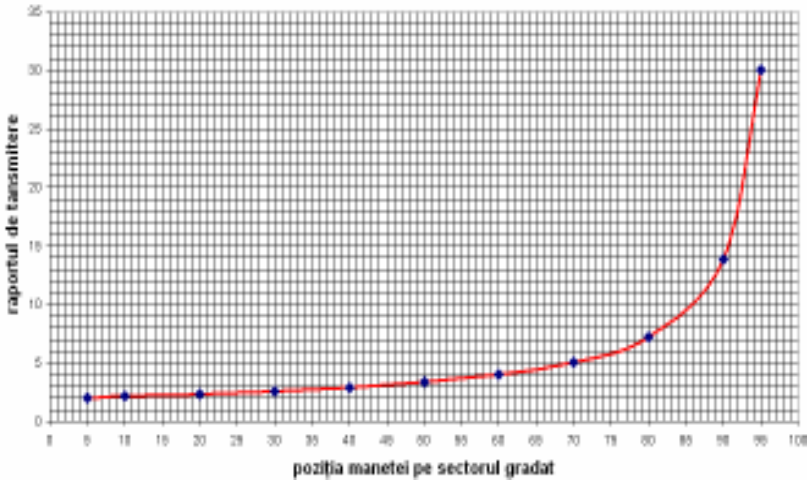


Figure 9: The curve of variation of transmission report according to the position of lever on the gradual sector.

To determine the theoretical transmission reports, was left by the reason that the one-way couplings are locks instantaneously and the components of mechanisms are not used, considering 10 positions of lever on the gradual sector. It notes that for the first positions of limiter plate (from 0 to 50) the value of transmission reports increases slightly after which is recording a pronounced increase.

Figure no. 9 shows the curve of variation of transmission report according to the position of lever on the gradual sector.

4. CONCLUSIONS

Analysis of cam mechanisms consist in establishing laws of operation, properties and structural defects in the check items in terms of resistance and wear and how to preserve the laws of operation after a certain period of operation.

Virtual prototypes of variators with cam-balance-lever mechanisms can be created from the concepts of new products, but also from existing products on the market.

In variators operation with intermittent operating stays the principle of sumarization the impulses generated by each of cams lobes and transforming the oscillating movement of balance-lever in intermittent moving rotation of output shaft of variator through the one-way couplings.

Mechanisms used in the variators construction with intermittent operation, the law of variation of the balance-lever is in form of impulses and includes three phases of operation: lifting phase, which the balance-lever is growing by the minimum radius to maximum radius of lobe, being considerated the active race; the descent phase, which the balance-lever down form the maximum radius to minimum radius; the stationary phase, which no longer keep moving.

Angle of rotation of the output shaft of the variator and the default report of transmission are dependent on the amplitude oscillations balance-levers β_a, which is limited by changing the angle of limiter plate ψ. Therefore, the adjusting of report transmission at cam mechanisms is realized by adjusting the angle of oscillation of balance-levers ("impulse amplitude").

Adoption of motion laws for the phases lifting of descent, at the mechanisms cam-balance lever type, is determined by two things: by limiting the movement of oscillation of balance-lever should ensure a range of reports sufficient to enable the used of machine to a large number of agricultural cultures; the mechanisms must have a good dynamic behavior.

The simulation realized in Mechanism Animation module, of the mechanisms cam-balance-lever, allows relatively easy determination of the adjustment interval of report transmission and also allows mechanisms optimization to achieve a range of adjustment.

If mounting two mechanisms of cam-balance lever mechanisms, having a cam with five lobes, the amplitude of oscillations varies between 18 ° and 1,2 °, and transmission report can be adjusted in the range 2 ... 30.

REFERENCES

[1]. Loghin, Fl., Hodîrnău, M. : The cinematic analyze computer - assisted of the gearbox with intermittent function used to the seed drill, Proceeding of BIOATLAS, vol. 2, 2008.

[2]. Loghin, Fl., Cutie de viteze cu impulsuri pentru reglarea debitului de semințe la apratele de distribuție ale semănătorii de cereale, Mecanizarea Agriculturii, Nr. 1-2, 2007.

[3]. Marin, E., Mecanisme cu came pentru transmisia distribuției maşinilor de semănat cereale păioase, Ed. Terra Nostra, Iaşi, 2007.

[4]. Rus, Fl., Masini agricole pentru lucrarile solului, semanat si intretinerea culturilor, Universitatea "Transilvania" din Brasov, 1987.

[5]. *** Creating Flexible Components in Pro/ENGINEER Wildfire - a tutorial to create part flexibility and assembly variation, 2006.