UNIVERSITY OF CRAIOVA
FACULTY OF MECHANICS

PhD thesis summary:

Research concerning the analysis and synthesis of some mechanisms from farming machine

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The area of farming machine has become one form the most fascinate and old from technical history, having in mine that it is necessary to assure the food of a continuously grooving population.

An elemental role in the building of the machines and agricultural equipments it has these mechanic structure, the interface human – working environment, this performances causing the parameters of productivity. The large number and the evolution of constructive solutions are explained that it must satisfy the basic technology of the plants or agricultural operations.

The agricultural machines do part from the category of the work machines, to accomplish a diversity of works, according to the agrobiologic and technical economics requirements imposed to every work. The prime basic material are scheduled cultivated plants, but and the development environments of these. The diversity of live organisms and environments in which are in progress the biologic process, caused the realization of agricultural complex machines, some with major degrees of universality, some more specialized.

The classification of the machines and installations plant used in the mechanization of agricultural works is can done after more criteria:

After the actuation kind:
- With manual actuation;
- With animal actuation;
- With mechanic actuation.

After the way in which executes the work process;
- Mobile agricultural machines;
- Stationary agricultural machines and agricultural stationary plant;

After the way in which the active organs executes the work process;
- Machines of those active organs execute the process of work only by reason of translational motion on the direction of movement (ploughs, harrows, leveller, etc.);
- Machines whereat the active organs receive the supplementary motions (rotation, translation) in time that the machine is displaced (harvester-threshers of harvests cereals, agricultural mills etc.);
- Machines whereat a part from the active organs executes the process of work by reason of movement of the machine, and an another part from the works organs, receive the supplementary motions (sowers, planters etc.);
- Machines of which active organs executes the work process, receiving the supplementary motions, when machine stands (machines of diggings hollows).

Most frequently criterion of used-up classification to as and globally (ISO) is by the way of the work which is made by the agricultural machines:
- soil working machines;
- sowing and planting machines;
- machines to administrate fertilizers;
- harvesters machine;
- machine to condition and primary process of the agricultural products;

Trough this PhD thesis with title “Research concerning the analysis and synthesis of some mechanisms from farming machine” y proposed for study, analyse and achievement of the following objectives:

- stage to day in what looks the type of used-up mechanisms in the building of diversity of agricultural machines, such as: Machines for the works of the soil, seeders, machines of harvests and mowers machines:

- Elaborate of structural models for the illustrative mechanisms from the range of studied machines.

- Build of a selective database considering the existing types of mechanisms, used in the building of agricultural machines.

- Functionally study of a mechanisms from the agricultural machines, existing on global plane.

- Constructive and structural characteristics of some mechanisms from the agricultural machines.

- Systematization of the constructive solutions for a certain type of machine, from structural point of view;

- Optimizations of the chose constructive solution, for the kinematic, dynamic and experimental study, from kinematic and dynamic point of view;

- Systematization of the constructive solutions for a certain type of machine from structural point of view;

- Optimization of the chose constructive solution, for the kinematic, dynamic and experimental study, from kinematic and dynamic point of view;

- Researches concerning the dynamic answer on new models of mechanisms, optimal;

- Study of the computational model of the mechanical system.

- Mathematical modelling with the computer (with specialised software: Solid Works, MSC.visual.Nastran, MSC.Adams) of the mechanical systems assembly.

- Analyse with the finite elements method of the considered mechanical system, with consideration of the joint friction, and elements flexibility.

The PhD thesis is structured in IX chapters, in every of the chapter is obviously the expose of an existent constructive solution, and contributions to the analysis and optimal synthesis of the mechanisms from the studied type.

It is treated the problem of the mechanisms from the farming machine, elaborating for some of them kinematic and dynamic studies.

The PhD thesis has a rich bibliography (249 titles) and to day.

The main contributions from theoretic and applicative order are synthesized in the following.

In chapter I is presented a stage to day concerning the types of mechanisms from the agricultural machine structure. They are presented mechanisms from harvester machine and mowers machine (fig.1), mechanisms from the soil working machine, sowers.

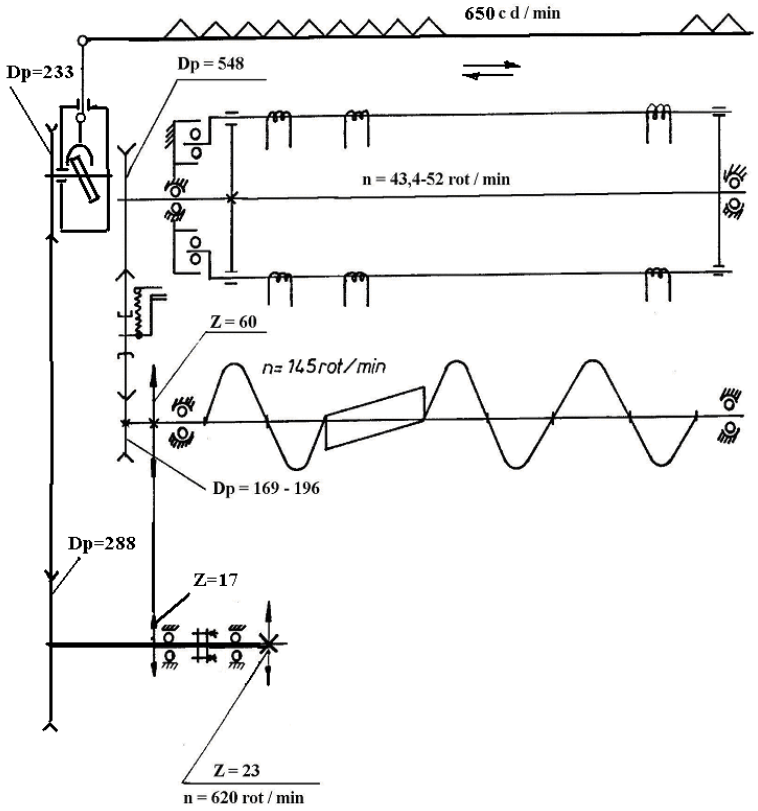

Fig.1. Kinematic scheme. Equipment to harvest plants

In chapter II are systematized from structurally point of view the existing mechanisms of the agricultural machine and in particularly those from the mower and harvester machine, every class of mechanisms being illustrated trough structural, constructive functional particularity.

The utmost majority of the mechanisms have the functional role for adjust and positioning, but are mechanisms, which work in dynamic regime: the cut-off system mechanisms, the harvester cleaning mechanism, etc. But, also the positioning and adjusting mechanisms can be considered to work in dynamic regime, upon them acting forces which vary in time (the height adjust mechanisms from the ploughs).

The systems for positioning and control are mechanisms with superior degree of mobility, imposed by the number of the parameters which define positional and kinematic the elements of execution. The degree of mobility, of the multi mobile mechanisms, for adjust, position and manipulation, are assured in the majority of cases by an equal number of active joints. At complex plane mechanisms, the geometric and kinematic parameters of the execution elements depend by the simple movements (absolute or relative) and by the elements geometric configuration and kinematic joints which can constitute modular groups.

The cutting mass from the harvesting is made from an assembly of mechanisms, the cut-off system is one of the basis mechanisms.

It is presented the structural and functional analysis of the mechanisms from the cut-off systems of the mowers and harvester machine (fig.2). They are analyzed the mechanisms for actuate of the knife, for the construction with fingers and plate, and with two knife.

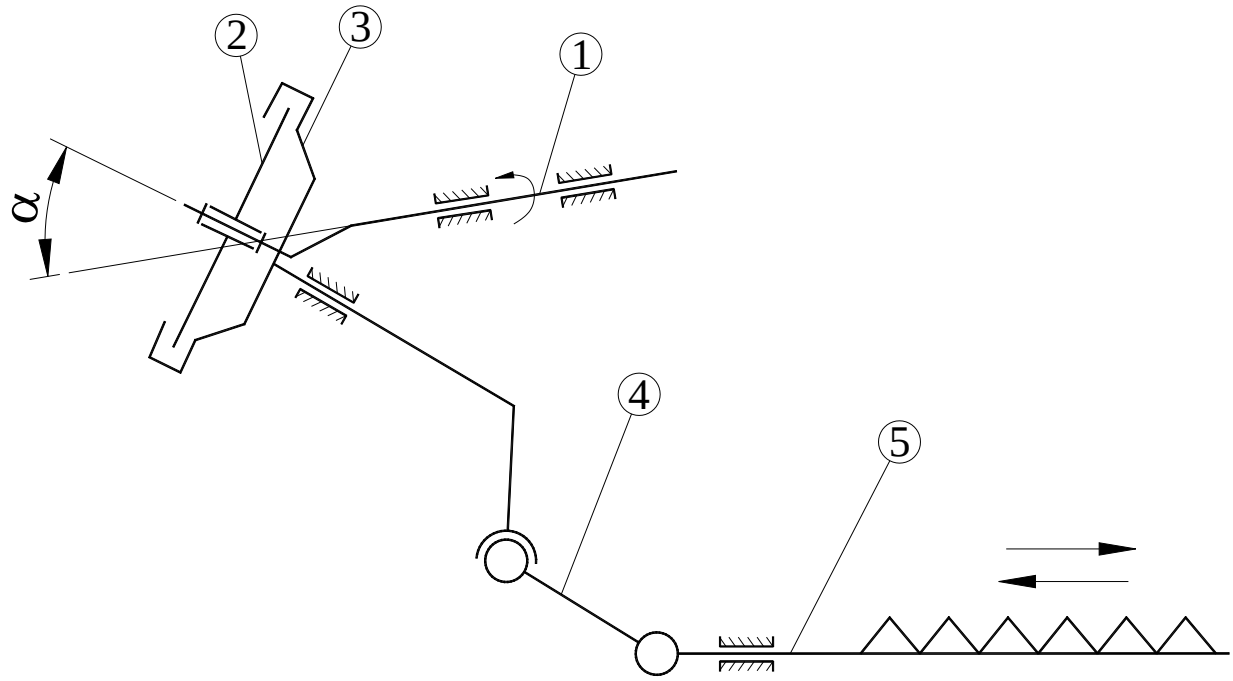

Fig.2. Oscilatory washer mechanism

In chapter III is presented a model of kinematic and dynamic optimization, based on the algorithm included in Adams software, which offer the possibility, trough the virtual model parameterization, of a series of studies, having as object to identify the design parameters which influence the kinematic and dynamic behaviour of the studied mechanisms from the agricultural machine.

In Adams, the optimization of a mechanical system consists from the next stages:

- Virtual model parameterization;
- Defining of the design variable;
- Defining of the objective function for optimization;
- Realize of the design study to identify the principals design variables, with significant influence upon the objective function;
- Optimization of the mechanical system upon the main variables.

The IV chapter is orientated to the kinematic analyze of mobile mechanical systems from the agricultural machine structure. The chapter contains kinematical analysis models, with complete computerised application, finalised trough numerical results, diagrams and simulation of the mechanical systems in two-dimensional and three-dimensional environment. They are performed kinematic simulation of diverse cut-of systems, based on the balancing mechanism, non axle crank slider mechanism, on oscillatory washer mechanisms, and the kinematic modelling of a work mechanism for agriculturally tractors.

The cut-off system of the harvesting and mowers machine, in different constructive variants, is made from two independents contours, one spatial ant other plane, connected in series. From the study of different cut-off systems has resulted that for the spatial contour are adopted two constructive variants, and namely: the spherical mechanism 4R and spatial mechanism 3RSR, and for the plane contour is preferred the RTRT solution. Is treated, trough the spatial mechanisms theory, the kinematic analysing, and we establish the kinematics characteristics of the studied mechanical systems.

For the balancing mechanism, for actuate the cut-off system of the C12 harvester-thresher, is made the kinematic modelling with the help of MSC.visualNastran software. The balancing mechanism is a spatial mechanism, is made from two contours: the first contour is RRSR type, and the second contour is RSRT. The aspect of diagram variation is influenced by step, the integration method used, and the damping coefficient used to the dynamic model of the joint. The theoretical displacement, performed by the knife is 75.2 mm. practically, the knife displacement, is bigger with 3-4 mm, to compensate the clearance from the joints, and for that the edges of the cutting blades to pass from the edges of the fingers.

Another studied mechanism is the oscillatory washer mechanism. The mechanism was designed to assure a knife displacement of 52 mm (the angle of the washer mounting angle is 10 degree) The kinematic model of the mechanism with oscillatory washer has been computer processed, with the help of a Maple computer program, presented in Addendum I. We have presented the variations laws of the displacement, speed and acceleration of the knife under 3D graphics, depending on time and the washer axle angle (fig. 3).

The washer axle angle is an important geometric characteristic, of this mechanism. From figure 3 we observe, we observe that the washer axle angle vary between 10 and 30 degree, corresponding with the type of existing mechanisms. As is represented in figure 3, we observe that at measure that the washer angle increase, the knife displacement increases to. The knife translation varies between 50 mm and 160 mm, displacements that usually are used to the existent types of mechanisms.

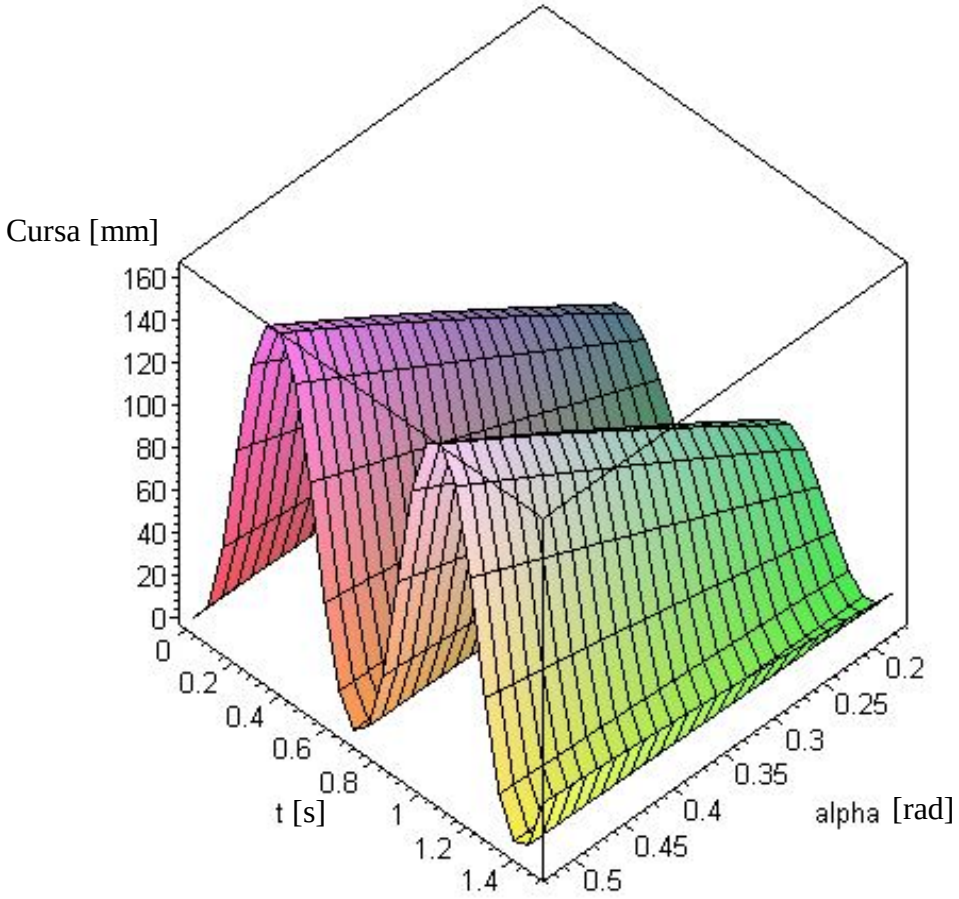

Fig.3. The graphic of variation of the knife translation displacement depending on the time and the washer axle angle

In this chapter we also studied a working mechanism to serve the agricultural tractors (fig. 4). We have proposed to perform the kinematic analyse when the mechanism works, in automatic mode, so the loads that acts upon the working machine are integrally transferred to the tractor, by means of this mechanism. Upon the experimentally researches made in chapter VII, we know the loads that act upon the mechanism.

To process on to computer the mechanism kinematic model we obtained the variations laws we elaborate a calculus program in Maple, to solve the equations that describe the kinematic parameters variation. The calculus program is presented in Addendum II.

Upon the computer process we obtain the time laws variation for the positions, speed and acceleration of the kinematic joints, and the angular positions, speed and acceleration of the elements.

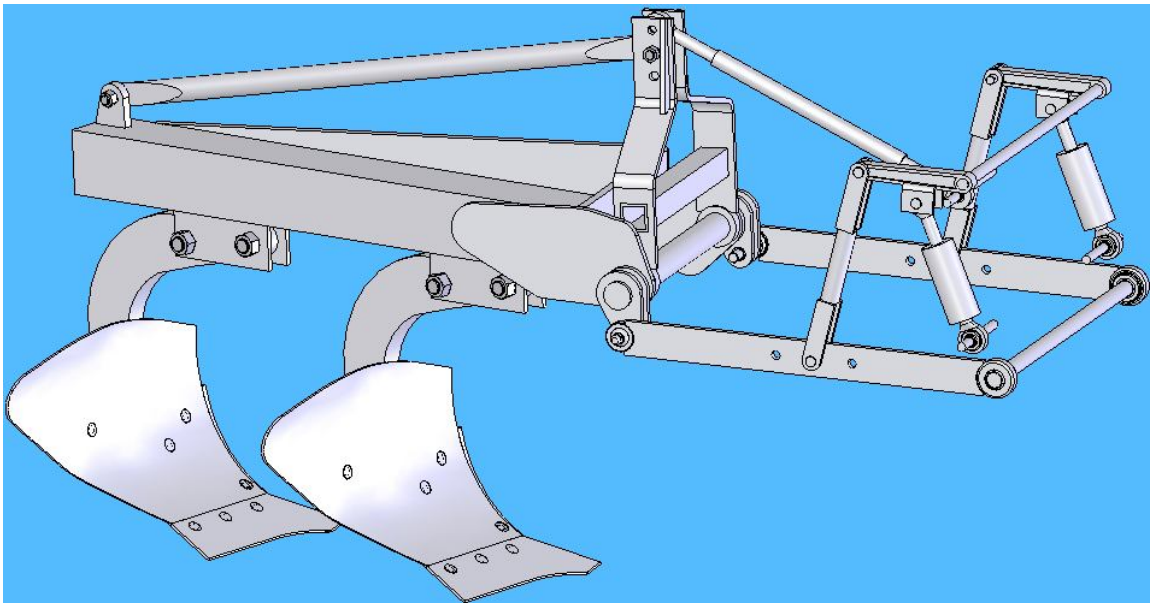

Fig. 4. Three-dimensional representation of the mechanism coupled with a plough (assembly view)

The chapter V, named „Researches upon the dynamic answer of the mechanisms from the agricultural machine" is structured in two parts: analyze of the dynamic answer of an experimental mechanism for the mowers machine, and the kinetic modelling of a working mechanism from the agriculturally tractors.

In this chapter is presented the modality to obtain the dynamic answer of the mechanism to actuate the cut-of system of a mower machine and this dynamic model is processed on to computer, with Maple software. The calculus program used to solve the dynamic model is presented in Addendum III. Upon the computer process of the model we obtained we obtained graphics of variation of the kinematic parameters in dynamic regime and for the bound forces for the mechanism kinematic joints (fig. 5). It is made the following observations and conclusions:

- The considered mechanism for the dynamic study, is a new mechanism, experimentally, designed to achieve a knife displacement by 52 mm. Structurally, the mechanism is formed from two plane contours: the first is RRTR type and the second is TRT type.

- the dynamic analyze of the considered mechanism is made with the dynamic models method, which is theoretically presented;

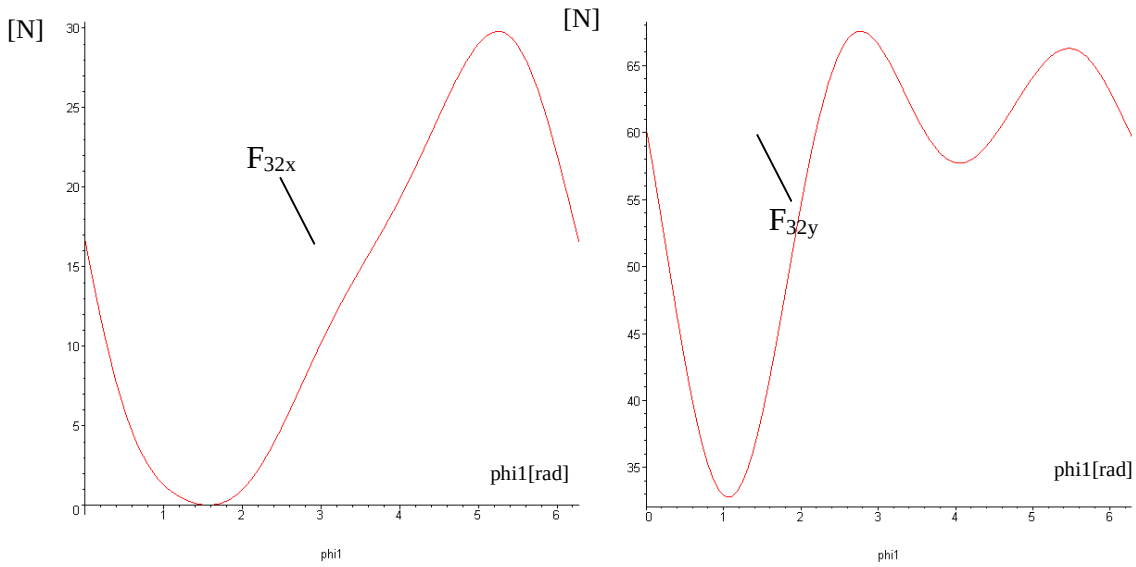

Fig.4. The graphic for the bound force F_{32}

In chapter VI is presented the modal dynamic analysis of a mechanism with MSC.Adams software.

The analysed mechanism works in dynamic regime, to an angular speed by 9 rad/sec of the motor element, so considering the flexibility of elements or the most flexible element is important.

We modelling the mechanism like a 3D structure, on which the cinematic elements are defined as shape, geometry and material property.

We define the kinematic joints with the corresponding constraints and mobility, we define the globally axis system and locally axis system upon are calculated the kinematic parameters. We define the motor element and the loads (force or moments which act upon the kinematic elements) after that we process the dynamic analysis.

We follow the procedure to transform the kinematic element into a flexible one. We chose the finite element type (spatial element by solid tetrahedral type). We define the medium and minimal value of the mesh.

We put the flexible body in the centres of the kinematic joints trough that connects to the mechanism.

We establish the number of the vibrations mode. We establish the interest nodes, and we select the mass centre of the element.

We process the modal dynamic analyse, considering the elements flexible, in a first stage the element 1 and after that the element 3.

The results of this analysis are confirmed and by the experimental research, being materialised trough diagrams, 2D and 3D graphical representation, and simulation of the mechanism functioning.

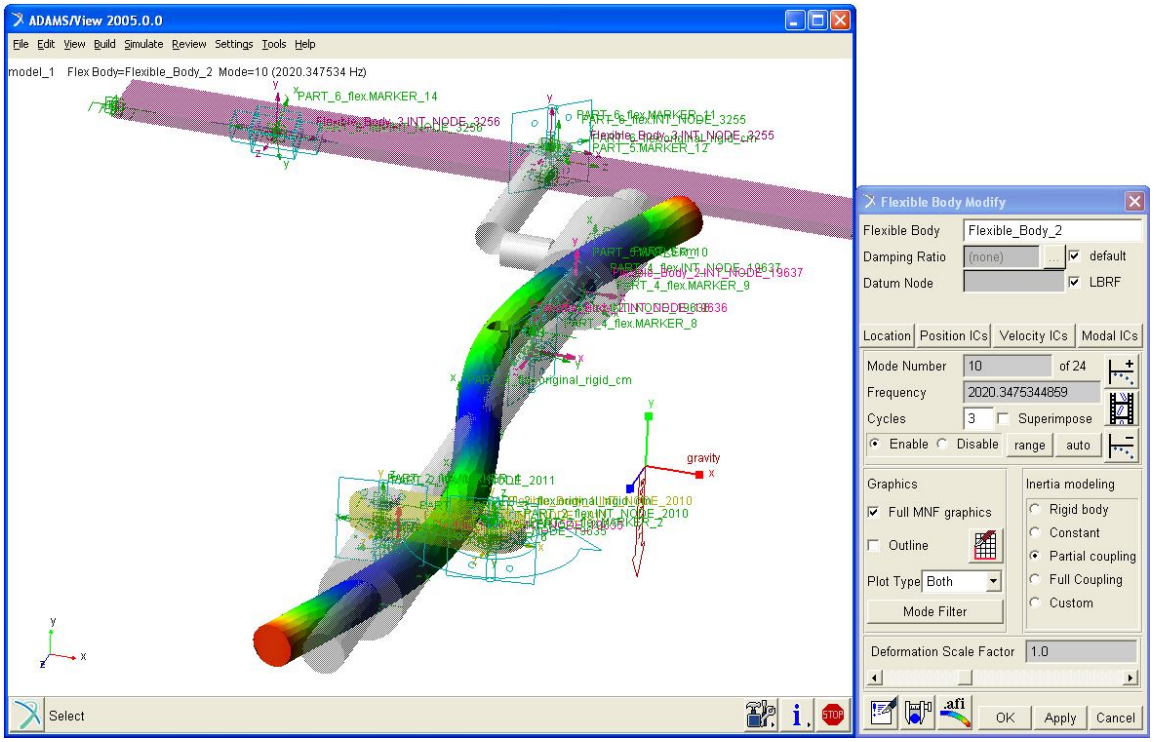

Fig.5. Representation of the mechanism deformed shape for the mode 10 of vibration

The chapter VII contains the experimental researches. They were made experimental researches for the determination of the kinematics and dynamics parameters of the auxiliary mechanism for serve the tractors, for an actuator mechanism of a mower machine knife and upon an experimental mechanism for the actuation of a knife of the mowers.

To achieve these experimental researches of the mechanics systems is necessary to follow the stages:

- Elaboration of methods and of the experimentally research system, to allow the determination, the processing and analyse of the parameters, which characterizes the dynamic behaviour and the power of the mechanic system studied;

- Choose of the apparatus and the experimental investigatory equipments in concordance with the objective established through the program of experimentally research;

- The acquisition, the process and the experimental results interpretation and elaboration of conclusion concerning the dynamic behaviour of the mechanical system.

The problems concern the mounting, mechanical dimensioning and sensors dimensioning and strain gage transducers, have been solved with the help of the specialist from the Department to test tractors, trail, and agricultural machine from I.N.M.A. Bucharest.

To measure in work the kinematic and dynamic parameters we use a modern equipment with acquisition system of type DAP 1200 MICROSTAR LABORATORIES, with 10 analogical entrance, 10 digitally outputs and frequency of acquisition of 20 KHz and the measured dates are store to a notebook 486. The amplifier module is Analog Devices 3B18/ 3B20. The power supply source is a 12 V battery. The existing software allows the signal filtering, and establish of the minimum, maximum and medium values of these.

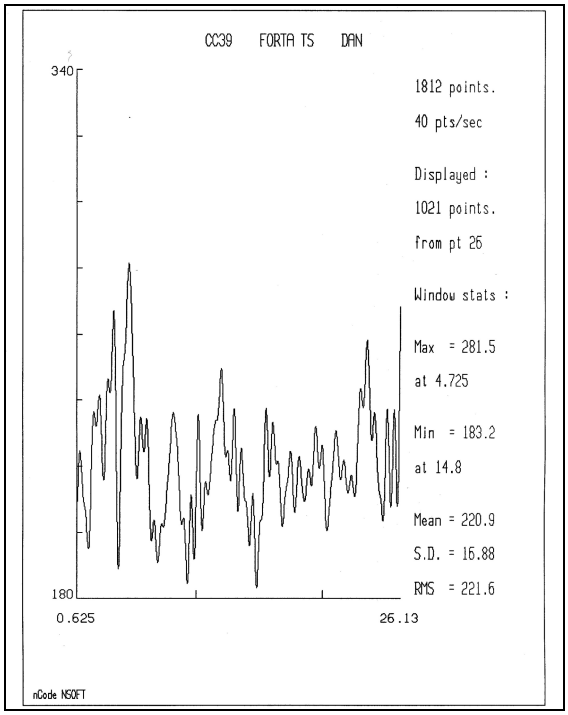

Fig.6. Graphic registered for the traction force variation in the left joint, in gear I_R

They are made experimental researches to establish the kinematic characteristics of the mechanism of a mower machine (fig.7).

The tests were made on a mower machine in dynamic conditions of start and cut-off from plants. There have been determined the following parameters:

- The knife linear translational displacement, Crs [cm],
- The knife vibration acceleration (in vertical plane, perpendicular on knife support), AccT [m/s^2],
- The rod acceleration of vibration (in horizontal plane), AccB [m/s^2],
- The guide bars acceleration of vibration (in horizontal plan), AccM [m/s^2].

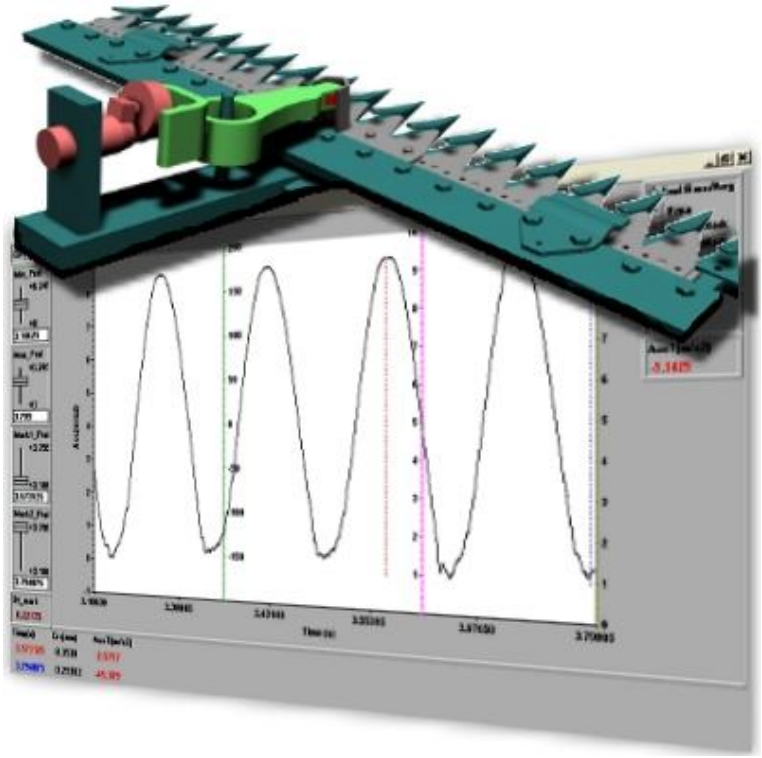

Fig.7. Mower machine mechanism

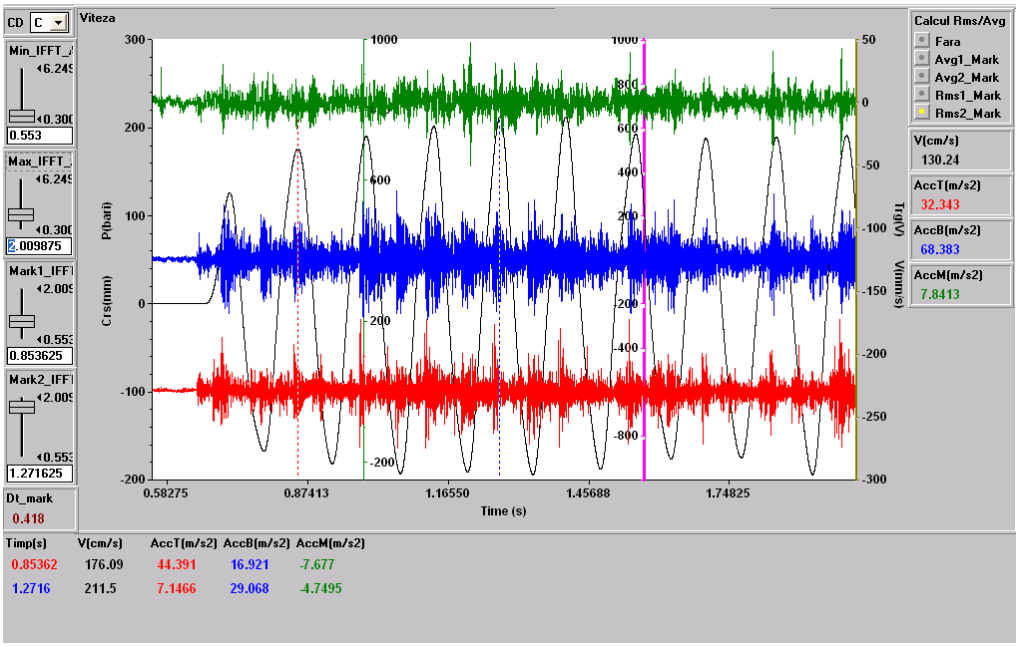

Fig.8. Graphic of time variation of the knife speed (detail) on which we also represented and the vibrations that appear in time of work

There have been made experiments to establish the kinematic and dynamic parameters of a mower machine mechanism. We made tests for 6 technological forces, which have been determined whit the force transducer. With the Spider 8 measuring system, have been determined the displacements S_1 – displacement of the slide 1, S_2 – displacement of the slide 2, and S_3 – displacement of the knife, the motor moment and the resistance force. In fig. 9 is presented the time variation of the slide displacement S_1, S_2 and S_3, for the first technological force, and the motor moment.

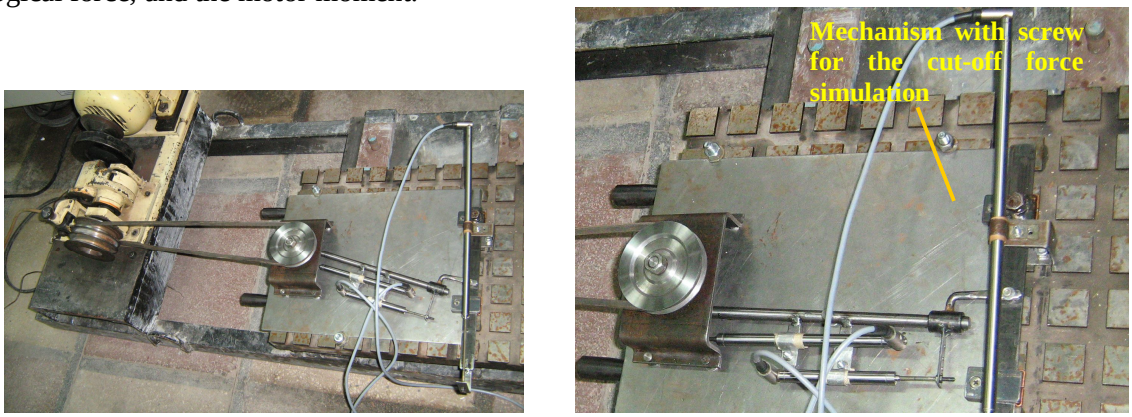

Fig.9. The mechanism mounted on the test stand

In chapter IX, we perform the computerised modelling and simulation of the mechanism. For the mower machine actuation mechanism, this has been experimentally researched; establish the motor element angular speed variation, and considering the cut-of force constant, we have been performed the finite element analysis. We use the MSC.visual.Nastran software, and we have considerate the elements like being rigid, considering the contact between elements. We present, in this chapter the stress, strain and displacement distribution for the mentioned mechanism.

We have performed the finite element analysis in dynamic regime, for the tractor work mechanism. We use to define the contour condition and of the loads the dates from the experimental research.

Another studied mechanism was the balance mechanism from the harvester machine.

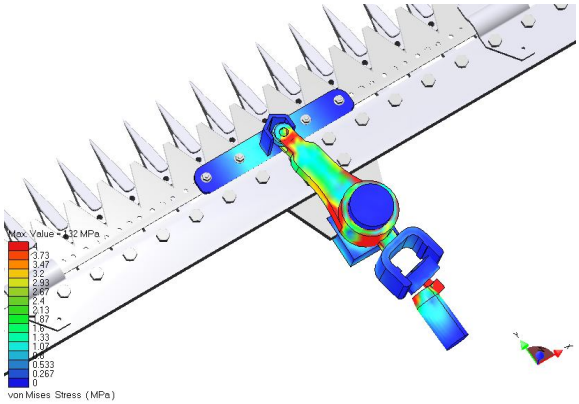

Fig.10. Stress distribution - frame 24

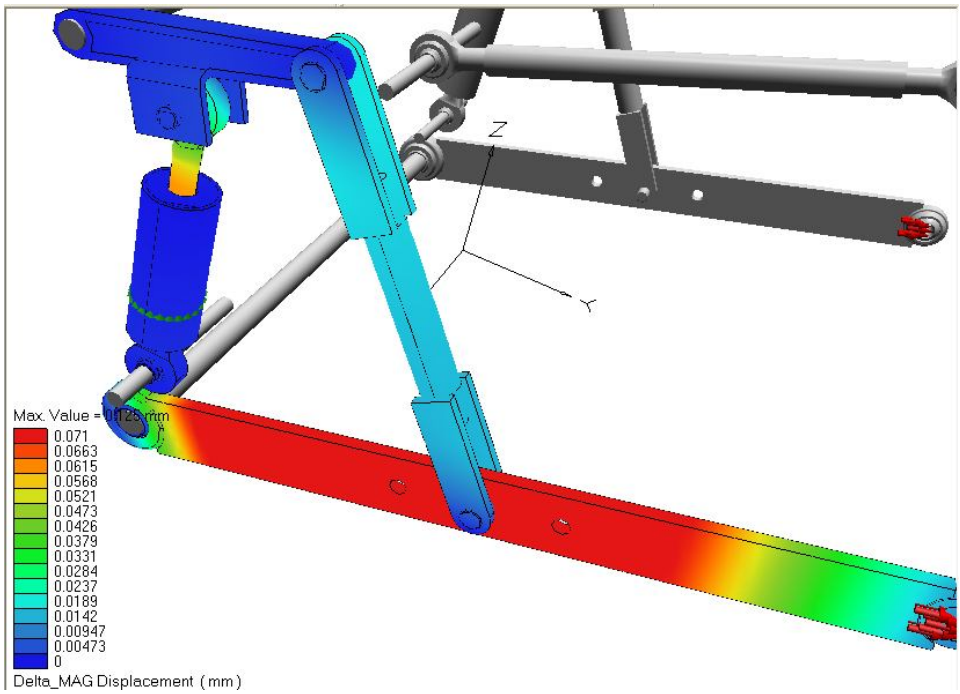

Fig.11. Displacement distribution

The chapter IX contains general conclusion and original contribution of the thesis.

On the doctoral thesis elaboration stage has been consulted a number of 249 bibliographic references, consisting in books, PhD thesis, scientific works, web pages and catalogues. ***Also the PhD thesis has been elaborated upon the financial support of CNCSIS, contract type TD, no.234/2007, with title „Research regarding the analysis and synthesis of mechanisms from farming machine”.***

They have been realised 3 calculus programs in maple, and a large number of virtual simulations on mechanical systems performed with **MSC.visualNastran** and **MSC.Adams** software.