Bulletin of the *Transilvania* University of Braşov
Series II: Forestry • Wood Industry • Agricultural Food Engineering • Vol. 5 (54) No. 1 - 2012

DYNAMIC MODELING OF TECHNICAL SYSTEM TRACTOR - SEED DRILL

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Abstract: *The paper presents the study method by dynamic modeling of the technical system tractor - sowing machine, using the specialized software Inventor. The achievement of the dynamic system model assumed in advance the design and the simulation of three different models namely: the dynamic model of working sections of the sowing machine, dynamic model of mechanical transmission of the sowing machine and the tractor's dynamic model. After the simulation process: the moments and the forces from the joints of the technical system, the variation of forces and the lengths of the elastic elements of pressure on the ground of working sections and of transmission wheel drive were graphically represented.*

Key words: *tractor - sowing machine, simulation of the dynamic model, model optimization.*

1. Introduction

The dynamics study of an agricultural aggregate research as a whole consists of the agricultural tractor and agricultural machine being considered a dynamic system in which both input and output, status and output parameters are functions of time [1].

The dynamic model developed in this paper consists of: tractor - oversowing machine MSPD 2.5 - soil.

The operating of tractor aggregate - seed drills is conditioned by the external actions of some random variation factors: the microprofile of soil surface, adhesion, rolling resistance, soil resistance to cutting etc.

The variation of these factors is complex because the interaction between working bodies and the soil agricultural machine and running gear and also the interaction between the aggregate and soil are influenced to a considerable extent by the speed of the unit.

The oversowing machine for degraded grasslands MSPD-2.5 is a farming equipment carried on a rear 3 point hitch of I/II category of tractors and is composed of 17 independent sowing sections, situated on two rows (8 sections in front and 9 sections in the back) articulately tied to the machine's body through some deformable parallelogram type mechanisms [3]. The parallelogram mechanism 1 of sowing sections (Figure 1) allows constant maintaining, during work, of the furrow's attack angle, and on the other hand it allows copying the soil's unevenness by the wheel's rigid rim 2, that thus ensures the constant maintaining of the depth at which the seeds are introduced in the soil. The elicoid pretensioned spring 6 (with adjustable tension) realizes the press force on the soil of the disc wheel with rim 2 and furrow 4 (Figure 1). The disc set on the rim wheel's circumference 2 allows cutting

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(splitting) in a longitudinal - vertical plan, of the soil (fallowed), making it easier for opening and realizing the drain by furrow 4, in order to introduce the seeds in the soil. After introducing the seeds in the soil, these are covered by the press wheel 5 [5].

To develop a complete dynamic model, in order to allow the analysis of behavior during tractor aggregate - agricultural machine exploitation, dynamic models built to simulate essential aspect of the real working process must be used. For this reason, for the dynamic development of the model a prior experimental research on dynamic behavior of aggregate agricultural tractor - over sowing machine MSPD - 2.5 was performed [2].

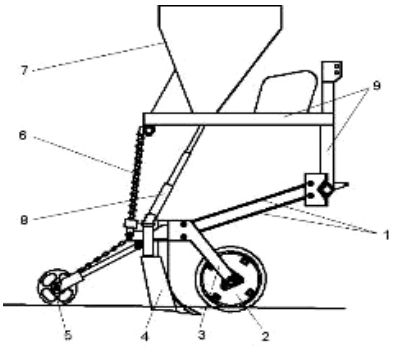


Fig. 1. *Constructive scheme of grassland oversowing machine* [2]: *1 - deformable parallelogram mechanisms; 2 - disc with rim; 3 - body of the section; 4 - furrow; 5 - press wheel; 6 - springs; 7 - seed box; 8 - tube for the leader ship; 9 - frame of machine*

2. Modeling and Dynamic Simulation of the Tractor System - Agricultural Machine

The dynamic simulation method of the tractor system - agricultural machine, using the Inventor 2010 soft, supposes going through three main stages: preprocessing (virtual modeling of the technical system tractor - sowing machine); processing (rolling the dynamic analysis); post-processing (working the results) [4], [5].

The preprocessing stage assumed the following work stages:

• developing the virtual model at real dimensions, defining the kinematic components that are involved in transmitting motion (position, orientation, mass-inertial characteristics), defining the relations, the restrictions regarding motion and introducing motion to the conducting element, defining the generating elements of the internal forces (elastic elements), defining the external forces and the application points;

• specification of the information regarding the following aspects: the type of analysis that must be done, the measure unit system used, the coordinate system used for modeling the system, the gravitational accelerating vector, the time interval in which the analysis is made, the entrance measures (motion, force etc.).

The elaboration of the dynamic system was achieved in three distinct stages:

a) In the first stage the dynamic model of a working section was accomplished (Figure 2).

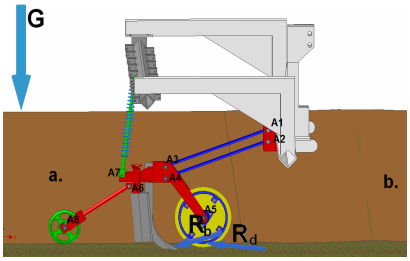


Fig. 2. *Dynamic model of the working section of the grassland oversowing machine: a) soil with smooth surface (linear microprofile); b) soil with surface with unevenness*

This stage consists of:

- representing in 3D form all the pieces and subassemblies composing the work section;

- Afterwards, restrictions were imposed regarding the assembly mode, restrictions by means of which the correct positioning of all the composing elements of the station was accomplished;

- The introduction of kinematic restrictions, these represent constraints that generate the motion of section elements, which canceled certain mobility degrees;

- Defining the elements generators of internal forces (elastic elements) and the external forces and the application points. For this, the spring was generated for pushing the section on the soil, having the following characteristics: The spring's stiffness (experimentally determined) 16,6 N/mm, the initial length of the spring (pretensioned) 387 mm, the winding diameter of the whirl 20 mm and the whirl's diameter 3 mm. Then the soil's reaction on the cutter was introduced, $R_{b,}$ being considered a concentrated force whose value, point of application and direction, were experimentally determined (the value of this force is about 200 N and the angle formed with the horizontal is of about 30 degrees). Reaction R_d, of the soil over the rim wheel's disc was considered a concentrated force applied in the contact point between the disc and the surface of the soil's microprofile, it's value, experimentally determined, is of about 100 N;

- The friction coefficients between the soil and the rim wheel, the compaction wheel of the section were also introduced into the system. Also, it was considered that the frictions of the two wheel joints (mounted on the trees by some bearings) are neglectable [4].

b) The realization of the kinematic and dynamic model of transmission of the grassland oversowing machine MSPD - 2.5. This step was performed similarly, indicating that generation and transmission gears, chain gears should use the Inventor Design Accelerator software module. It allows rapid design of gears and chain transmissions and also performs the necessary resistance calculations. Finally we obtained the dynamic model of transmission shown in Figure 3.

c) The achievement of the dynamic model of the tractor system - oversowing machine. This stage assumed the achievement of the dynamic model of oversowing machine and its coupling on rear 3 point hitch of II category of the tractor. At this stage, the dynamic model of transmission was introduced: the 17 working sections with the machine body strain gauge which is connected to the tractor and was made into a virtual model of the tractor.

Figure 4 presents the final model of tractor system - oversowing machine - soil.

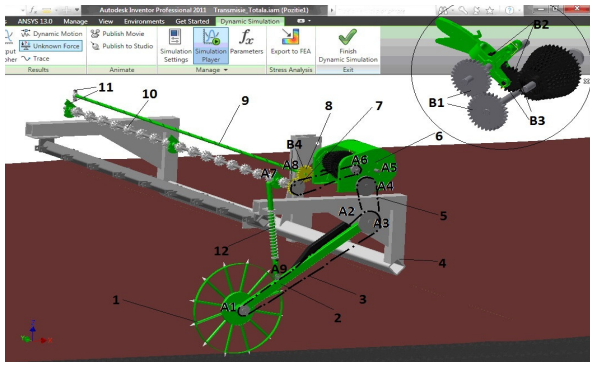


Fig. 3. *The dynamic model of transmission:*
1 - copying wheel (*with rim and spurs*)*; 2 - copying wheel's bolster; 3 - chain transmission; 4 - the machine's body; 5 - chain transmission; 6 - Northon gearbox; 7 - chain transmission; 8 - gearing with spur wheels; 9 - the seed stirrer; 10 - driving axle of metering equipment; 11 - bearing units; 12 - elastic element* (*spring*) *for pressing the copying wheel* [4]

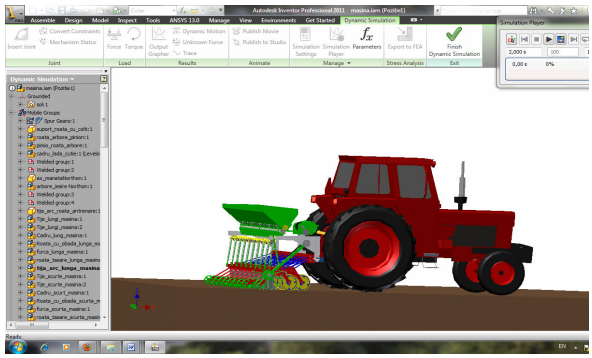


Fig. 4. *The final dynamic model of the tractor aggregate - oversowing machine*

After elaborating the dynamic model, the functional parameters which characterize exclusively each functioning mode that is to be simulated are introduced: analysis type (dynamic); displacement speed of the tractor aggregate - oversowing machine (2.7 m/s); the initial position of the aggregate; the duration of the simulation (1...10 s); the number of values registered per second (100 frame/s).

3. Experimental Research of the Dynamics of the Agricultural Aggregate Tractor - Oversowing Machine

The experimental research was conducted on the system formed of the oversowing machine for degraded grasslands MSPD-2.5 and the four wheel drive tractor New Holland TL100.

To achieve this objective it was necessary to measure, acquire and process the following main parameters: the traction forces from coupling bars of the sowing sections (to determine the traction forces of sections), forces acting on disc wheel with rim, forces acting on the furrow, load forces on section body performed by load tensioned springs, the resistance force to traction of the oversowing machine transmitted by the tractor through the suspension mechanism of the rear three points hitch of the tractor, working speed of machine and working depth of furrow opener. To carry out the experimental research of the above-mentioned parameters, a series of transducers and sensors were placed on both the tractor and the machine, as shown in Figure 5: optical transducers for measuring space and speed of machine 1; frame with tensometric transducers for measuring the forces in the three points hitch of the tractor 2; tensometric transducers for measuring forces in parallelogram mechanisms 3; tensometric transducers for forces measurement from disc with rim 4; tensometric transducers for forces measurement from opening gutter furrow 5; tensometric transducers for forces measurement from springs of sowing section 6; inductive transducers for measurement of vertical displacements against body of machine 7.

The development of a more complex model involved the introduction of parameters that had been determined in the laboratory: spring stiffness of the press sowing section on the ground, spring stiffness of the wheel drive elements dosing and drive torque of dosing devices (Figure 5).

Constructive solutions for the achievement of transducers and their location in the system it was taken into account the constructive and functional parameters of grasslands oversowing machine so that it's constructive and functional parameters are not modified or influenced during experimental research.

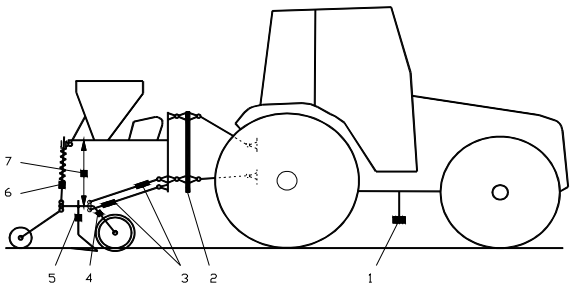


Fig. 5. *Location scheme of transducers and sensors on the tractor-oversowing machine system* [2]

Figure 6 shows the aggregate during experimental research.

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Fig. 6. *Agricultural tractor aggregate - oversowing machine: 1 - tractor New Holland TL100; 2 - oversowing machine MSPD-2,5; 3 - optical transducers of speed* [2], [6]

4. Results and Discussions

During the *postprocessing stage* of the dynamic model the following were obtained: the processing of results obtained from the temporal variation diagrams of motion laws (speeds and acceleration), of the forces of the elastic elements of the work section and their length), graphic simulation (animation) of the model in different projections (representation plans) and the tabular representation of interest measures, later processed in the specific *Excel* tabular calculation application.

Regarding the results of experimental research, by data processing, graphics for time variation of directly measured or processed parameters were obtained, based upon some established algorithms for time variation of traction forces of a section and of a vehicle as a whole (Figures 7 and 8).

By comparing the results, an assessment of the dynamic model developed for validation and use for making constructive improvements - functional oversowing was performed. For example in Figures 7 and 8 present comparative graphics of variation parameters of the unit studied.

Analysing the two graphics we found that between the results obtained through experiments and those obtained after the simulation of the dynamic model, there is a correlation, which determines the validation of the model.

5. Conclusions

Regarding the virtual models developed for studying the dynamics of tractor aggregate - oversowing machine the following issues were developed:

- by analysing the results obtained by theoretical (virtual modelling) and experi-

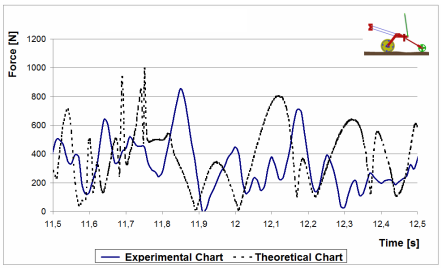


Fig. 7. *The variation diagram of traction force of the working section*

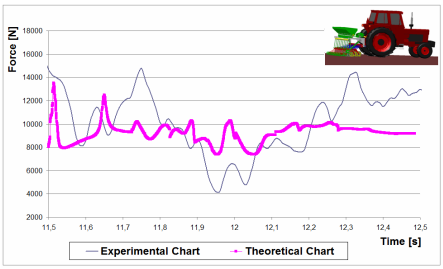


Fig. 8. *The variation diagram of tractor total force*

mental research, the validation of the three models developed was achieved;

- the three dynamic models that underline the achievement of the final dynamic model outputs can be used independently for making constructive - functional improvements of the oversowing machine components;

- the most conclusive results were obtained for the virtual model of the working section;

Data and conclusions of this type of study constitute a very useful instrument both in the design and development of new constructive solutions, and also in comparing these solutions with the performance of the existing ones in order to improve their functional construction.

Acknowledgement

This paper is supported by the Sectoral Operational Programme Human Resources Development (SOP HRD), financed from the European Social Fund and by the Romanian Government under the project number ID59323.

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