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UNEVEN GROUND COUPLED SYSTEMS INFLUENCE ON AGRICULTURAL TRACTORS

Ion BARBU[1]

Abstract: *Scale development of new technologies in agriculture, introducing new types of machinery and equipment as well as the global trend of widespread use of tractors, both in agriculture and in other economic sectors, this has led to a great diversity types of tractors. The expansion of agriculture in all geographic areas (mountains, hills) and as fierce need for mechanization, made it impossible to use power sources (tractors) because the boundary conditions of access and stability.*

Key words: *tractor, forces, moments, stability, vibration.*

1. Introduction

According to RE 3 ECE-UN "tractor agricultural and forestry" means "any vehicle with wheels or tracks, having at least two axles, whose function is essentially linked to its tractive power and which is conceived especially to tow, push, carry or lead certain tools, machinery or trailers intended for use in agriculture or forestry economy. It may be equipped to carry a load and passengers.

This definition was issued by international regulatory basis for the construction of road vehicles it has an official character and is the same as that considered by the Framework Directive 74/150/EEC relating to uniform legal prescriptions of the Member States concerning the approval type of wheeled agricultural or forestry tractors.

However the definition of agricultural or forestry tractor issued Resolution overall UN ECE RE-3 was taken over by the International tractors OECD test, but under a simplified form. Under the Framework Directive 74/150/EEC as amended by Directive 97/54/EEC as regards the maximum design speed of wheeled agricultural or forestry tractors, they speed from 6 km/h and a maximum of 40 km/h.

The first formal classification International tractor was made in 2001 with the issuing of Directive 2001/3/EC that agricultural and forestry tractors shall be divided into four distinct categories whichever wheel track, the mass of the tractor empty of ground clearance and speed [4].

2. Aspects of Dynamic Modeling Tractor Unit - Agricultural Machine

The study looked at the dynamics of agricultural unit as a whole consisting of agricultural tractor and agricultural machine it is considered a dynamic system in which both the inputs and outputs are the system status and time functions.

[1] Centre "Advanced Research on Mechatronics", *Transilvania* University of Braşov.

Operation tractor unit - agricultural machine is conditioned by external factors actions with random variation: micro-profile tread, grip, rolling resistance and cut resistance of the soil, the driver steering action etc.

Changes mentioned factors is complex since both the interaction of working bodies of the agricultural machine and ground and running gear interaction between the unit and the ground are influenced to a considerable extent on the speed of the unit [4].

To study the operational behavior of the unit to be used farm tractor - The dynamic models built by simulating essential aspect of the process of the real thing. The general dynamic of an aggregate consisting of articulated tractor and trailer or semi-mounted agricultural machine shown in Figure 1.

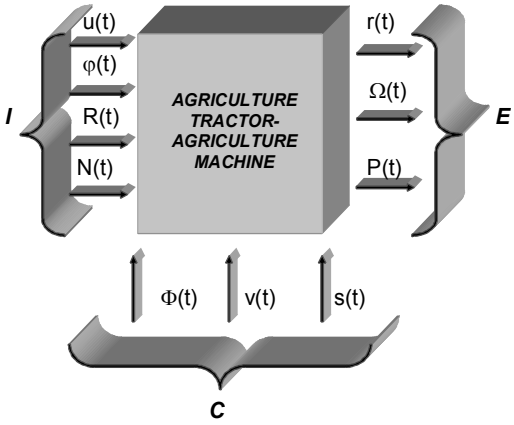

Fig. 1. *The general dynamic of tractor unit - agriculture machine*

At the entrance, the position vector I work conditions (noise outside of the unit - Tractor agricultural machine) includes micro-profile way $u(t)$, adherence $\varphi(t)$ resistors environment $R(t)$ and soil reaction wheels supporting the unit $N(t)$. C is the control of sizes vector include tractor steering wheel rotation angle $\Phi(t)$, speed $v(t)$ and subassemblies influences unit $s(t)$.

The output vector function's parameters that describe the behavior of the unit in real working unit include position in space $r(t)$ spins unit components $\Omega(t)$ power consumption $P(t)$ [5].

3. The Virtual Prototypes of Tractor Unit - Agriculture Machine

One of the most important for virtual prototyping concept is to test as it simulates. Physical testing of the hardware prototypes in classical (traditional) laboratory tests in various configurations involves high costs and time. The virtual prototyping concept it's used to reproduce the test procedures and operating conditions of the product at much lower cost and time. Virtual prototyping allows building models that simulate the actual operation of the product, for example facilities (stands) for testing any type of dynamic system. Testing is an important component of virtual prototyping during the design cycle. Virtual testing is performed continuously while the physical testing is introduced only in certain stages to model virtual revalidated after a finishing significant.

To simulate the dynamics of tractor unit - agriculture machine system was used specialized software MBS (multi-body systems) and this software involve going through three stages:

- pre-processing (system modelling);
- processing (model run);
- post-processing (processing results).

In mechanical systems using dynamic simulation are frequently addressed three working models:

- structural model, containing only the elements and links between them (joints) and which is fixed transmission provided laws of movement (mobility system);
- kinematic model, which, in addition to the structural and geometric parameters includes defining the system and to

establish laws of motion (position, speed and acceleration) of elements in the movement of time (known/required) element leader; dynamic model, which, in addition to the kinematic model, and contains the mass of elements (mass, moments and products of inertia) and the forces (external and internal) acting on the system, this model determines the movement elements under the action of forces [1-3], [6]..[xx]

4. The Study of the Dynamic Forces That Occur in the Axle of the Tractor

Using specialized software, simulate moving tractor agricultural machine unit worn on a track position virtual obstacle (tractor passing over obstacles with the amplitude of 30 cm, irregularly).

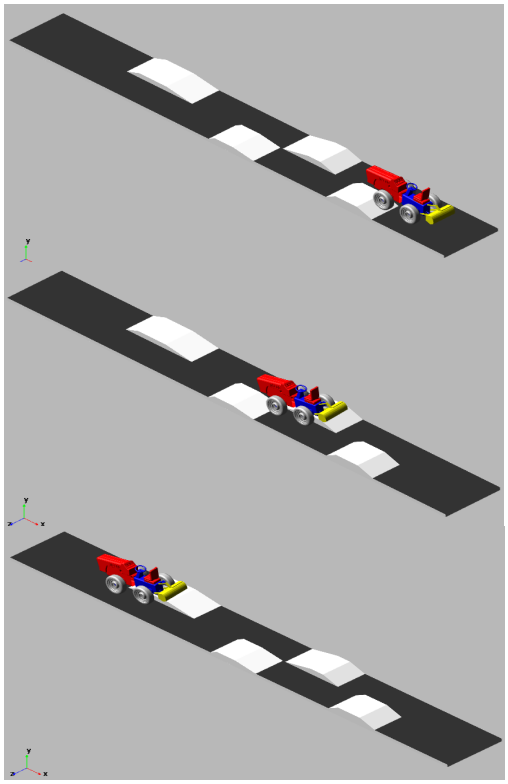

Fig. 2. *The three different stages of simulation tractor unit - agriculture machine movement on uneven ground*

By modeling this type of dynamic stand were followed requests that occur on the bridges due to uneven distribution of weight tractor unit, changing the center of gravity height and amplitude unevenness, Figure 2.

The tread modeling to highlight desired limit as possible situations that may arise during an operation conducted by aggregate in real case.

Unevenness heights vary, but the maximum amount of a side tread such a body give the possibility to swing left or right tractor to the maximum.

There was studied the stability in the case where the travel speed can be excessive, and shocks that occur in the wobble body to bring the unit from tipping over.

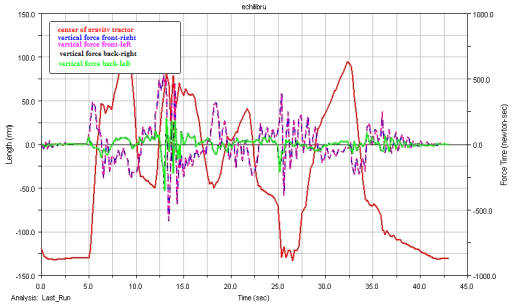

Fig. 3. *The vertical forces that occur in the axles during the movement of the unit - agriculture machine on uneven ground*

To capture and simulation of dynamic movement on a runway obstacle to determine transverse loads that occur in the axles tractor. The runway with obstacle was provided with obstacles so as to oblige the tractor to swing beyond the maximum permissible joint (angle of rotation of more than 150^0 a side) to simulate loss of stability due to the kinetic energy of the mass of the tractor imprinted to the mechanical limitations(stops) makes for to limit the maximum oscillation 150^0. Dynamic simulation model retains stability of the tractors and agriculture machine at

speeds up stage IV from the tractor gearbox. At higher speeds the dynamic model loses its stability. During these simulation processes were sought changes and position the tractor axle load dynamic (moving) center of gravity of the tractor, Figure 3.

5. Measuring the Forces on the Rear of the Tractor Axles

To measure the forces they are subjected to when driving axles of the tractor while working with an agricultural machine was needed to install sensors that are designed to measure the deformation of the structure required in dynamic axes [7].

So, was measure vertical and horizontal forces on the tractor wheels were mounted resistive sensors on the rear axle of the tractor axles, as shown in Figure 4, and the model of mounting the wires for capture the signal from the sensors to the acquisition system, Figures 5 and 6.

Fig. 4. *Tractor axle view with installing the sensors*

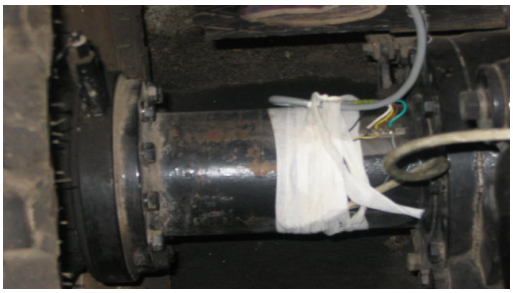

Fig. 5. *Mounting the capture signal wires from sensors*

Fig. 6. *Complete assembly of sensors on the back axle of the tractor*

6. Measuring the Vibrations of the Tractor

To determine experimental shocks and vibrations applying to the agricultural tractor was mounted two accelerometers on the tractor seat, to measure shocks and vibrations in two directions, vertical and horizontal.

Fig. 7. *Two accelerometers mounted to the tractor seat*

It is known that tractor and agricultural machine working in difficult conditions where they are subject to dynamic forces due to mechanical phenomena occurring during work. To measure their effects on the tractor was necessary to use two sensors then using these measurements to find solutions to reduce the effects of forces on the tractor, Figures 7 and 8.

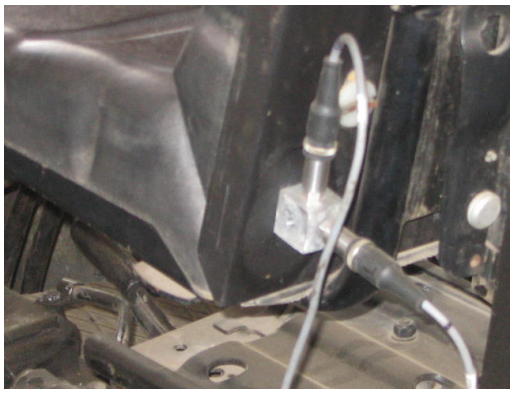

Fig. 8. *Zoom view with accelerometers which measure on two directions, vertical and horizontal*

7. The Results of the Tests

Hills, forests and mountains where the works using agriculture have their features. Tractors must be of medium or large but as small gauge, with the best possible throughput capacity, especially with a high stability as possible.

When talking about the weight of the tractor operating primarily take into account the weight distribution on the tractor axles. If you know this can optimize tractor unit - agricultural machine in terms of the work itself, but rather in terms of stability.

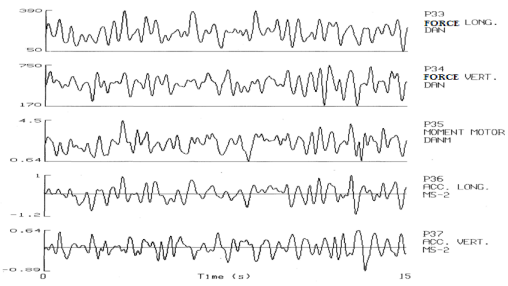

Fig. 9. *The results of forces and vibrations to the tractor unit - agriculture machine*

An aggregate stability not only refers to the existence overturn during transport or driving on rough roads. It accepts that stability during operation is equally important. A good stability means an aggregate optimal technics terms of the requirements demanded by the type of work performed and fuel.

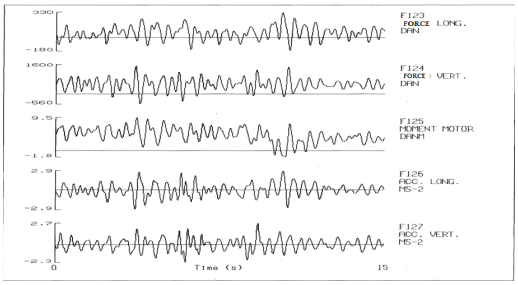

Fig. 10. *The results of forces and vibrations to the tractor unit - agriculture machine*

8. Conclusions

An important phenomenon was observed in the obtained results in the unit tractor with agriculture machine consists of rough terrain of the tractor and agriculture machine in transport position. Because the position to the center of gravity of the tractor unit (tractor with agriculture machine) is placed closer to the axis of the rear axle than the center of gravity of the agriculture machine, when the machine is in transport position makes the vertical and longitudinal forces to be negative and this negative forces reduces the load on the axle tractor, Figure 9.

Forces arising during a working process of an aggregate reflect on the tractor body, which is required, both in terms of reserve power and resistance components.

All these things are closely related to the most important phenomenon that appears when composing an aggregate namely the phenomenon of weight distribution on the axles of the tractor, Figure 10.

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