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THE ADAPTING OF A MANUAL TOOL FOR WORKING THE SOIL TO A MECHANIZED WORK PROCESS

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Abstract: *The soil processing process is the basis of most agricultural technologies in agriculture. Sustainable development is the concept underlying the maintenance of resources and land conservation. Ensuring a healthy and harmonious environment, i.e. the quality of soil, water, air, vegetation and food, are fundamental human rights. In order to achieve these conditions, in the peasant households manual tools are still widely used for working the soil, especially in gardens and on small areas of land near the farm. In these places you can also use a relatively new hand tool successfully used by Russian gardeners, namely "chudo-shovel" or "shovel - wonder".This tool simultaneously plays the role of fork, shovel and rake by digging, harrowing, loosening and smoothing the soil. Unlike the ordinary shovel that requires a great effort on the part of the user, with a "miracle-shovel" which is based on the principle of "the breakdown effect", the soil can be worked on small areas of land by elderly people or even people with spinal disorders. However, the mechanization of agricultural works is a basic activity in agriculture and acts in close dependence with biological factors, with the potential of the soil executing a favorable influence on the growth of agricultural production.*
For this we have adapted such a tool to a mechanized production process being operated by a digger with engine by a double chain transmission from the support and displacement wheels. The functional optimization of the equipment was achieved through a dynamic analysis and a simulation of the movement of the working organs when entering the ground. Thus, the work presents a dynamic modeling, by using software, of the manual tool for working the soil (miracle-shovel), adapted to mechanical actuation with the help of a digger with engine. The dynamic model was realized by using the following elements: tool components, kinematic couplings between components, the characteristics of the materials from which the components are executed, the system of forces and the moments of action. Following the dynamic simulation process, there were represented: the forces and moments in the joints, the forces in the working organs, and the speeds in the system.

Key words: *manual tool, dynamic model, software, dynamic simulation, double quadrilateral mechanism.*

INTRODUCTION

A basic condition for getting a good harvest is the care for land. That's why the soil must be chopped, harvested and loosened to saturate it with oxygen. (BARBU,I., LUCULESCU, M., BARBU, D.M., 2005) These operations can be carried out simultaneously in gardens, protected areas and on small field surfaces with the help of a new type of tool, namely "chudo-shovel" or "shovel-wonder"(BUZATU, I.,s.a., 1984). With all its advantages, it cannot be used on virgin lands, rocky or hard soils, because they can significantly reduce productivity and damage the tool (FIELKE, J.M., 1996).

This tool can be used simultaneously as a fork, shovel and rake. (GODWIN, R.J., 2007) As a result, it performs simultaneously digging, bruising, weeding, barking, and smoothing the soil. Its ingenious, simple, reliable and easy-to-use design consists of a tiller fork articulated (1) and a fixed frame with a counterfeit (2). The collars are the active organs of the tool in the form of sharp bayonets at the ends.(LOGHIN, FL., 2010)

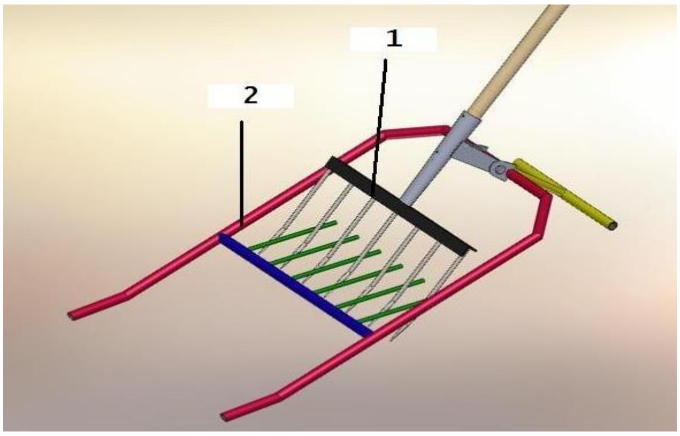

Fig 1 - The constructive scheme of "the chudo-shovel"
1 - the fork with articulated tilts, 2 - the fixed counterfeit

The usual bucket (the dumbbell, the spade) used to dig a land requires a great effort. The classic shovel raises tons of earth during work and can affect your health. With the help of this type of tool based on the "upside-down effect", soil digging can also be done by elderly people, children or even people suffering from spine diseases.(LI G., CHEN J., XIE H.J., & WANG S.M., 2016)

To increase productivity and minimize the physical effort, we have adapted such a tool to a cultivator, and we have acted on it through a double chain drive from the tiller'swheels. (SARACIN I., IORDACHE V., 2015)

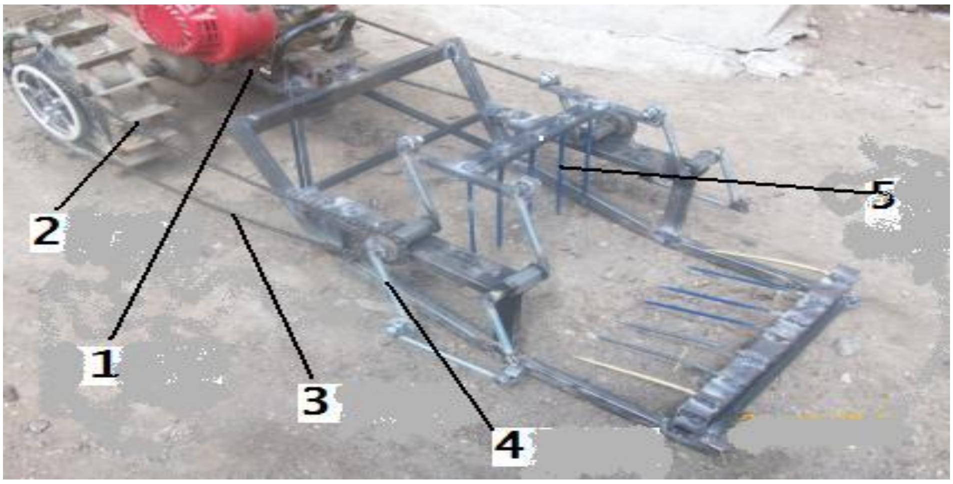

Fig 2 - Driving the gear from the tiller
1 - the mower cultivator, 2 - the travel wheels, 3 - chain transmissions,
4 - double quadrilateral mechanism, 5 - work organs

The tool is fixed by its frame or by the frame (1) of the tiller. From the supporting and displacement wheels (2) of the tiller, through a double chain transmission (3), the movement is transmitted to a double quadrilateral actuating mechanism (4) which acts further on the work organs (5). (SONG Y.M., ZHANG J.T., LIAN B., ET. AL., 2016)

Functional optimization of the tool can be accomplished by a dynamic analysis, which consists in studying the working organs under the action of forces and moments that occur when the work organs penetrate into the soil. The input sizes are: tool configuration, travel speed. Output sizes are: the parameters of the actual movement of the component elements and in particular of the working organs: forces, moments, speeds, energy, etc.

To perform the dynamic analysis and visualization of the virtual model movement, the Algodoo v.2.1.0 simulation program was used which allowed the dynamic analysis of the tool based on the geometric model and the existing restrictions.

MATERIAL AND METHOD

The tool modeling and simulation process using Algodoo v.2.1.0 involves several steps: virtual tool modeling, dynamic analysis, and result processing.

The virtual modeling of the tool involves the following phases:

- designing the real-world model, specifying the kinematic components in the transmission, defining the links, moving restrictions, introducing the movement of the leading element, defining the forces and moments in the joints;
- specification of the aspect regarding the type of analysis to be performed, the system of units of measurement used, the input sizes (motion, forces, moments, etc.).

For the development of the dynamic model, the component parts and subassemblies were represented, the restrictions regarding the assembly were imposed, the correct position of all the components was established.

The structural model consists of 7 movable elements (2 wheels, 2 chain transmissions, 2 double quadrilateral mechanisms, work bodies), a fixed element (the soil) and 7 cylindrical joints (A1, A2, ... A7).

To ensure proper operation, 2 kinematic restrictions were introduced. The first restriction refers to the fact that the feet of the frame must copy the ground and maintain the working depth constant. The second restriction relates to the fact that the tool has a solidarized frame with that of the tiller.

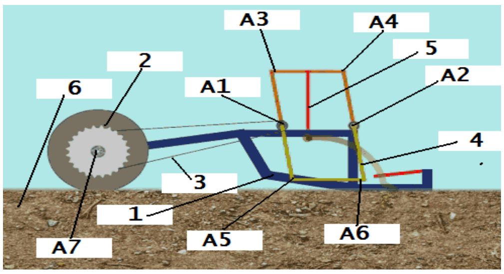

Fig 3 -The kinematic model of the earthwork tool

1 - frame, 2 - support and drive wheel, 3 - chain transmission, 4 - double quadrilateral mechanism, 5 - working organs, 6 – soil

For simulation of the model, the input movement was introduced, which consists in choosing a speed of movement of the tool frame relative to the ground. Also, for the elaboration of the dynamic model were defined the external forces and their points of application. Friction forces in the joints were considered negligible.Pentru simularea modelului s-a introdus mișcarea de intrare care constăîn alegerea unei viteze de deplasare a cadrului uneltei în raport cu solul. De asemenea, pentru elaborarea modelului dinamic au fost definite forțele exterioare și punctele lor de aplicație. S-a considerat că forțele de frecare din articulații sunt neglijabile.

After the kinematic model was developed, parameters of the operating regime were set: type of analysis, movement regime, working position. Based on the described model, automated application processing is performed.

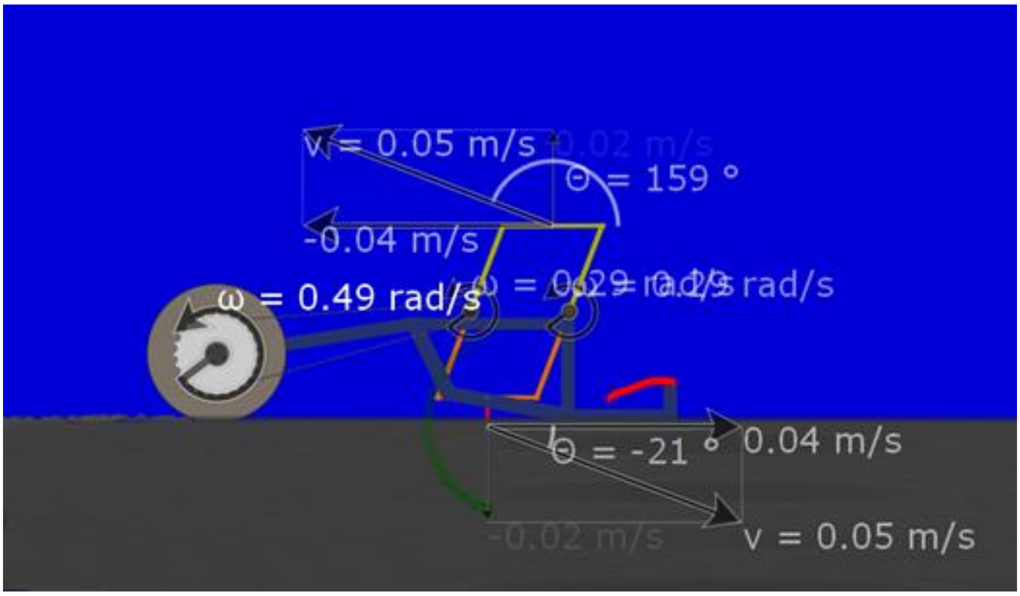

Fig 4 - The dynamic model of the earth-working tool

RESULTS AND DISCUSSIONS

After the analysis was carried out, it was realized the post-processing stage consisting of:

- processing of the results obtained from the time variation diagrams of the magnitudes of interest (force, speed, acceleration, moment, energy);
- graphic simulation of the model in various projections.

For example, figures 5, 6, 7, 8 and 9 represent the graphs of time variation of magnitudes of force, velocity, acceleration, moment and energy of the working organs during the working process.

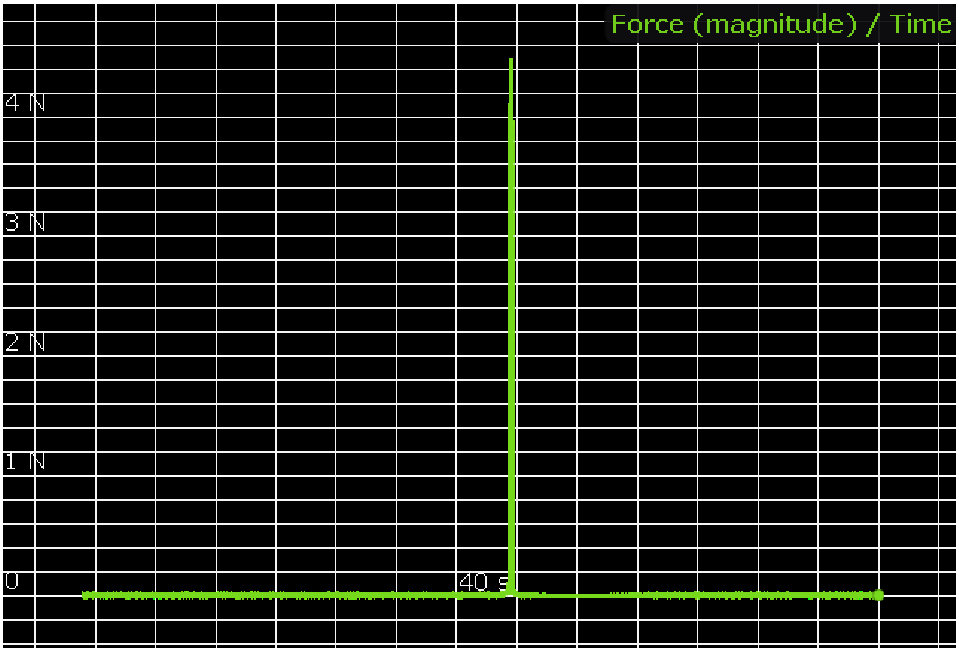

Fig.5 - Diagram of time variation of forces in the working organs

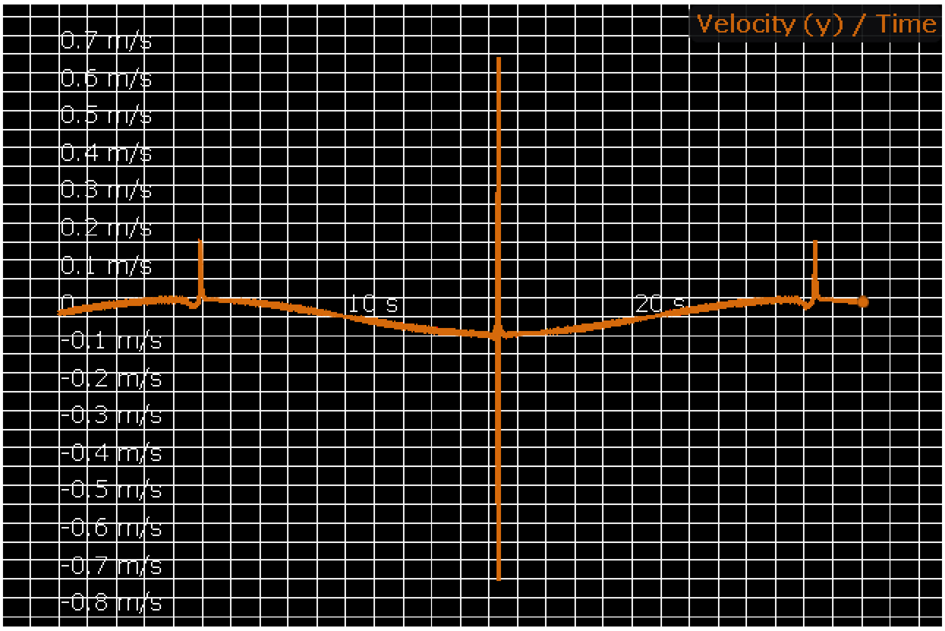

Fig 6- Diagram of time variation of speeds in the working organs

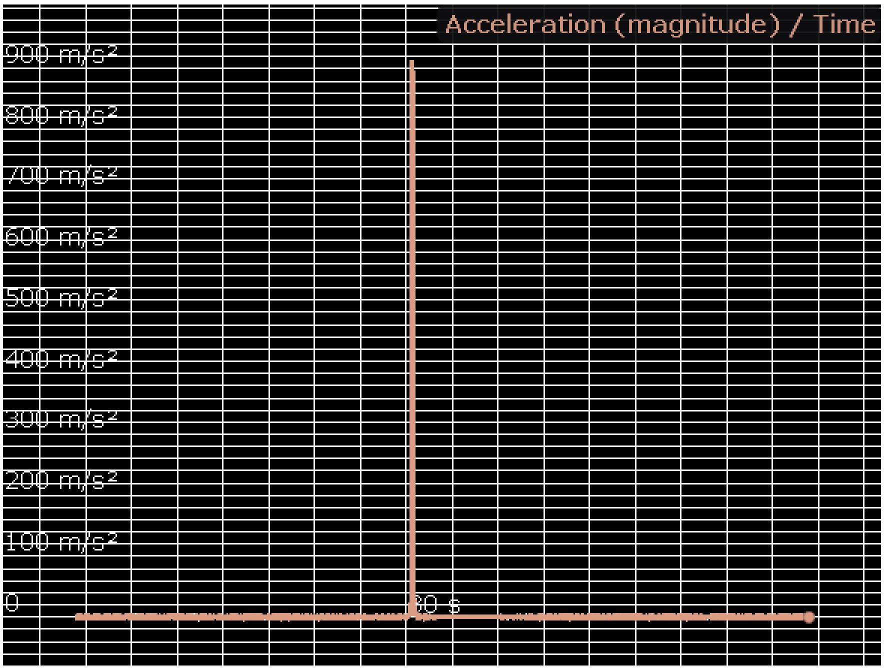

Fig.7 - Diagram of time variation of accelerations in the working organs

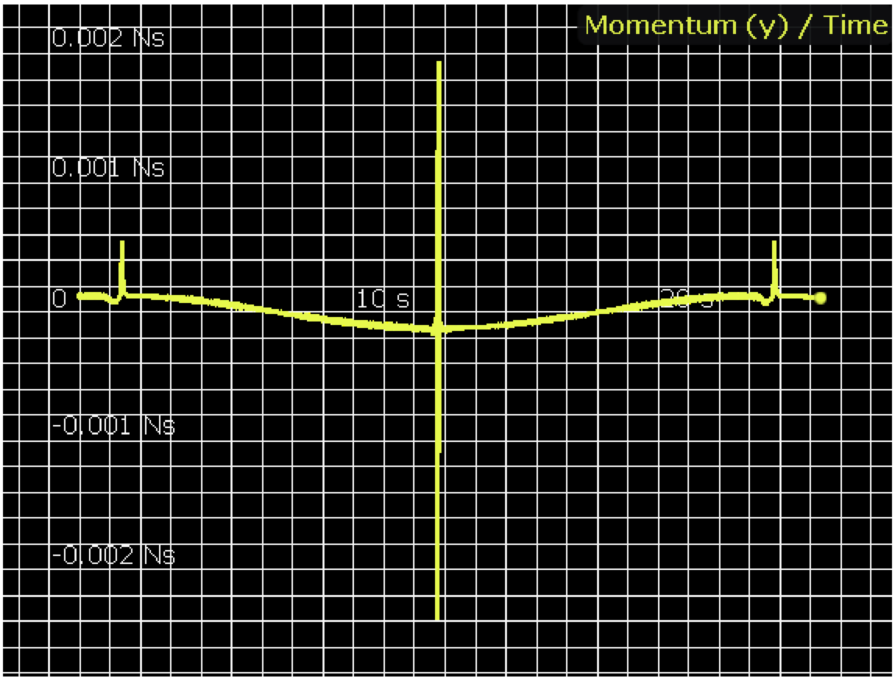

Fig.8 - Diagram of time variation of moments in the working organs

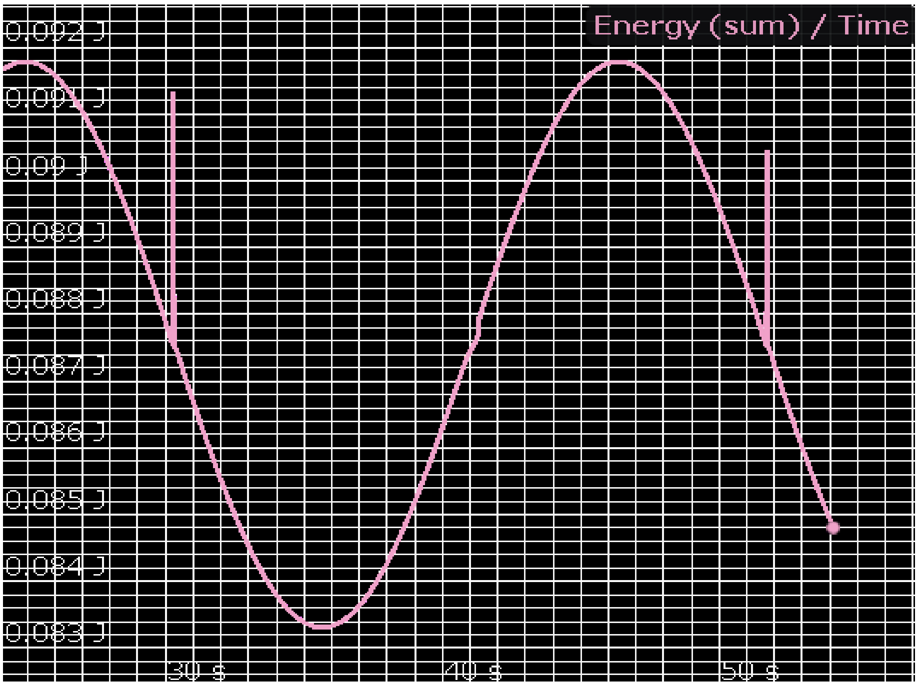

Fig 9- Diagram of time variation of total energy in the working organs

CONCLUSIONS

The virtual theoretical modeling of the tool allows the evaluation of its operation.

Dynamic analysis materializes by plotting time variation diagrams of the magnitude of basic physical magnitudes: forces, speeds, accelerations, moments, and total energy in the working organs. The data and conclusions of this study are a basic instrument in designing and building such a tool.

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