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Modeling of Technological Process In Rotary Tiller

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A B S T R A C T

To identify the specifics of the interaction of the soil and the rotary working equipment, the issues of modeling the technological process of the rotary tiller and its interaction with the soil has been investigated. Comparison of soil strain and deformation values through the application of the ANSYS WORKBENCH software enabled to conclude that the highest strain value in the soil is observed during the soil cutting. The issues of modeling the technological processes of the rotary tiller and its interaction with the soil has been investigated throughout the research. From this perspective it is important to measure the sizes of the slices cut from the soil and to identify the cutting form. The latter are related to both the structure of the rotary tiller and the moving velocity/forward speed/ of the soil cultivating machine, as well as to the rotating numbers of the operating equipment. At the same time during the planning of the working equipment it is possible to get functional relations between various parameters studying the specifics of these relations and improving the structure of the working equipment.

Keywords: Rotary tiller, Rotary hoe, Modeling, Soil, Strain, Deformation.

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Introduction

Soil cultivating machine with rotating equipment like rotary tiller (or rotary hoe) cuts the soil slices, turns over the soil and enables to mix the soil proportionally or to mix the fertilizer with the soil [1,2] The soil cultivation with rotary hoe enables to provide the sufficient soil looseness, which creates favorable conditions for the growth and development dynamics of the ferments vital for plants growth at the 10-12 cm depth of the soil plowing horizons. Thus, the soil reclamation with the rotary hoe has a significantly positive influence on the biological conditions of the crops growth and development process. With this regard a number of researchers [3, 4] have mentioned that the soil cultivation with the rotary hoe has a positive effect on the soil physical properties and on the improvement of water and nutritional regime conditions in crops.

Application of rotary tillers promotes the reduction of traction resistance. That is why these tillers are used in such conditions, where no other alternative is left. When cultivating the soil with rotary hoes the soil looseness holds well for a long time. Sometimes the depth of rotary tillage amounts to 15-20 cm, then the soil density decreases at the depth of 30 cm. This is accounted for the vibration impact [5] of the rotary tiller's blades.

In order to study the work of the rotary tiller it is recommended to design it through software and to model its process.

It is relevant to implement the design works of the rotary tiller by means of SOILDWORKS software development kit, which has an opportunity of making diverse geometrical modifications and the finished design is possible to further integrate in the ANSYS Workbench software package, which creates a vast platform for automated design and analyses with finite elements [6][7].

The design of the rotary tiller is a stage process and it should be implemented through the design of its individual parts. First, it is necessary to design its disc and axis planning the latter's sizes according to the fastening device of the power unit. Two types of blades were designed: straight and staple, which were installed on the disc of the rotary tiller by two items intermittently.

The soil is also designed separately as a solid substance, so as it would be further possible to get the characteristics of working equipment-soil interactions/ratio through its modeling and attributing elastic properties to the soil [8]. Later on, in order to model the soil inhomogeneity it will be possible to design several parts of the unit modeling the soil structure and to observe the characteristics of the rotary tiller and soil interaction when the latter passes along the connecting junctures of those parts.

As it is known the rotary tiller implements two types of movements: forward/linear and rotating. During the modeling process forward/linear movement velocity is conveyed to the soil cultivating machine, while the working equipment is provided with rotational movement velocity. During the study of this stage it is possible to carry out numerous measurements, which can serve as a base for the further improvement of the working equipment.

By applying the method of finite elements analysis the solid unit conventionally is divided into finite elements, which come forth as finite-constituent particles of the solid unit to which the parameters of the unit is attributed. Thus, the interaction of the solid units is observed via finite particles. During the analysis of the problem, depending on the tasks and the required precision it is possible to decrease or increase the divisibility rate of the finite elements, whereupon receiving the needed precision rate of calculations.

The aim of research

The aim of the current research is to simulate the interaction of the rotary tiller with soil.

The object of research

The object of the current research is the interaction of soil – working equipment in the simulation environment.

For this purpose rotary tiller designed through the software of Solidworks has been introduced into the software environment of ANSYS Workbench, the sizes of which have got an experimental nature. Cutting of the soil through rotary tiller is introduced in Fig. 1.

When studying the simulation results we notice that as a result of cutting with the rotary tiller the soil deformation is higher than the geometrical sizes of the blade sticking. This phenomenon is accounted for soil adhesion/coherence and the vibratory character of the rotary tiller. The longitudinal deformation is higher than the sum of the longitudinal sizes of oppositely arranged longitudinal blades, while the vertical deformation is higher than the length of blade.

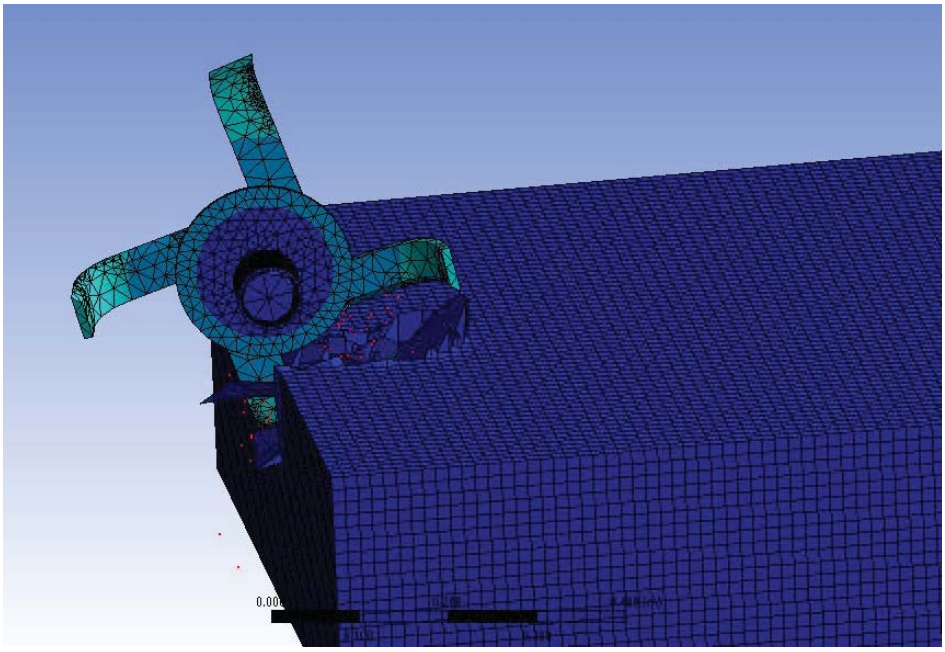

Fig. 1. *Soil cutting scheme through rotary tiller*

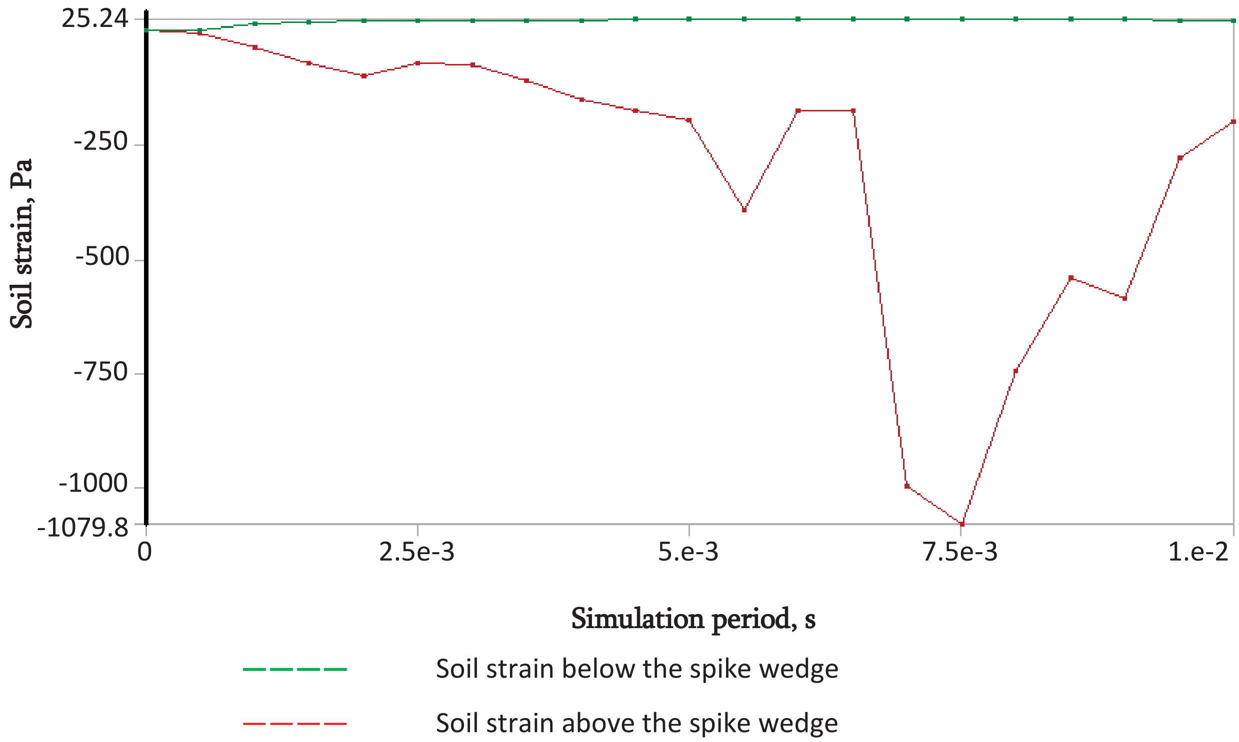

Fig. 2. *Soil strain values during the cutting with rotary tiller*

While considering the soil– working equipment interrelation the soil strain was investigated as well, the diagram of which is introduced below Fig. 2

Strain is the relation/ratio of deformation with the initial length of the unit or it is the relation of the unit affecting power (with regular direction) with the affected surface [9,10].

The diagram shows that at the moment when the blade of the rotary tiller is stuck into the soil the strain increases abruptly, later during the cutting it is getting lower. This means that at the accessing moment of the working equipment the soil demonstrates maximum resistance, after which the resistance decreases until the access of the next blade. So the diagram of the regular strain indicates that in order to improve the structure of working equipment in the rotary tiller it is vital to pay attention to such factors, which influence the decrease of resistance at the cutting moment. They are, for instance, the attack angle, blade sharpness, sharpening angle, the blade form, etc.

Conclusion

1. During the design of the working equipment it is possible to obtain functional relations between various parameters and through disclosing their nature to improve the structure of the working equipment.
2. The simulation results show that the maximum strain of the soil is manifested at the sticking moment of the blade, which should serve as the main indicator for the improvement of the structure in rotary tiller.

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