THE PROBLEM OF MODELLING THE WORK TOOLS’ SURFACES OF AGRICULTURAL MACHINERY INDUSTRY

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Abstract. The present review has been based upon resolution of the issues that usually emerge while modelling the work tools of agricultural soil processing machines. The recommendations on modelling the surfaces of the work tools of soil processing machines used in an agricultural branch are given. The task of modelling new types of the work tools of agricultural soil processing machines has been resolved and as a consequence – Ukraine’s patent for the useful model.

Keywords: machine manufacturing, work tools, modelling, soil, agricultural machines, model, technological requirements, agrotechnical requirements.

The problem

In the practice of agriculture-related machine manufacturing a large number of variously-shaped work tools design methods is used.

In order to specify a design method for non-rectilinear-shaped work tools of such machines which is directly based on geometrical constraint between surface parameters and the requirements specified towards the operation of the latter the possibilities of geometric modelling of such complicated process as a textural change of the soil which is processed with due regard to specific package of agrotechnical and technological requirements.

The contemporary design techniques suggest the following requirements in solving the given issue:

1) disaggregation of existing phenomena into component parts;
2) mathematical modelling of phenomena and processes;
3) diminishment of advantages of external view in search of the solutions to the goals set.

The simplicity of the model compared to the actual modelled system makes it possible to overpass complexity information barrier and conduct necessary experiments on the model. The purpose of the scheduled experiments is to determine the model’s properties, which in its turn allows to determine the properties of the entire system.

Simplification of the model in comparison to the modelled system is one of the crucial requirements of the modelling. But this requirement should be followed in combination with the others: universalism, adequacy, precision, cost effectiveness.

Analysis of the recent research

On construction of agricultural machines work tool models the below pattern may be followed:

- selecting sources of information;
- crop’s property analysis;
- processed area analysis;
- performance test of the machines to be used in the this process;
- model’s parameters determination;
- model’s synthesis.

Motion of soil particles and layers under corresponding laws is considered to be the constructive principle of basic technological and agrotechnical requirements that exist towards the operation of agricultural tillers. Motion pattern of such particles along the work plane depends on soil’s physical properties, its structure and current state.

The main part

Mathematical modelling is based on such general principles as informativity, feasibility, plurality, but during the construction of complex system models, it is necessary to consider some additional aspects (Boldyrieva, Volokha 2014). The authors proposed to consider the following principles of modelling of complex processes.
1. The expediency of modelling – a fundamental principle of building of any model. Modelling as a process of representation of the object, process or phenomenon must be focused, economically sound and the result (the model) should not increase the complexity.

2. Having enough information – a principle of availability of information means that to construct a model you need a priori information that allows you to build an adequate model. Completeness and uncertainty of information available determines appropriateness, adequacy and effectiveness of the simulation.

3. The multiplicity of modelling – a principle of representation of a real object or set of process models that reflect different aspects of its functioning. Selection of the type of modelling, detailed description of the process, the complexity of the model – all this must be consistent with the purposes and objectives of the modelling.

4. Agregativity of the model – a principle of modelling of complex systems as a combination of simpler components that are combined by the model of a higher level – a unit. Hierarchical representation of the process allows you to simplify a complex object model, focus on key aspects, delatization of which is studied on the lower level of abstraction.

5. Coordination – a principle of modelling of complex system through decomposition and taking into account the mutual influence of autonomous subsystems. Any technological process consists of a specific set of operations, which makes quite a natural decomposition and modelling of individual stages as autonomous subsystems that interact with each other. Consistency of parameters, information and material flows between individual subsystems and between levels of aggregation of the model can effectively solve complex management tasks.

The system’s mathematical model while modelling the work surfaces of agricultural machines with corresponding value \( F \) may be expressed in the following functional form (Volokha 2014):

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Y = F(X, Z),
\]

where \( X \) – is internal parameters vector (displays the properties of components of required system); \( Y \) – output parameters vector (properties of the required system in relation to other systems and outside environment); \( Z \) – external parameters vector (displays properties of outside environment).

Search of new forms of effect on soil (Fig. 1) necessary to implement a complex of agrobiological conditions that are not fully accomplished by contemporary tillers (Boldyrieva et al. 2011).

Modelling analysis is conducted after processing of modelling statistics by means of analysis. Modelling analysis includes the tasks of analysis of model’s sensitivity to its parameters fluctuations, in particular the resistance of external parameters to their possible changes in the system or in outside environment.

Since soil is a multiparameter environment therefore it is now impossible to develop a model which would fully meet all tillage-related agrotechnical and technological requirements.

Fig. 1. Scheme of modelling of work tools’ surfaces

From point of view of reduction of secondary tillage depth and provision of technological process reliability in high humidity and pollution conditions in order to raise effectiveness of the work tool being modelled it is reasonable to consider passive rotary work tools where the work tool itself has a wheel spider shape to be future-oriented (Fig. 2) (Boldyrieva et al. 2013).

Spider wheel-shaped work tool is a constructive element which while running progressively under the influence of pulling force provides work tool’s revolution around its axis as well as recurrent contact of spider wheel’s blade tip with soil (one per revolution) which in its turn results in pricking and displacement (crushing) of soil’s upper layer. Installation of several spider wheel-shaped work tools specifically oriented in relation to the axis upon a single roller makes it possible to mill the soil producing the structure in its upper layer necessary for agricultural needs.

Within the system of intensive technology procedures it is common to frequently combine early spring soil loosening and smoothing as a single complex procedure. For such type of work an ARV-8.1-0.1 unit (city of Kharkiv) aggregated with 20–30 kN class tractors and capable of 8.1 m operating width is used (Fig. 3). Apart from a set of successively mounted passive-type work tools designed for loosening and smoothing soil’s upper layer the above unit is also equipped with synchronous herbicide distributor.

In order to illustrate effectiveness of the proposed ways of modelling the existing surface of a work tool of the given type has been modelled as follows: the shape has changed thus the machine’s work tool much more effectively deepens into soil inasmuch as rolling of its previous rib strengthens effect of “piercing” of soil’s superficial layer with the following rib. A radial rib with trapezoidal transverse cutter allows to stretch soil layer in process longitudinally and at the same time compress it transversally (Fig. 4) (Volokha et al. 2014).
This type of facility matches the standards of a serial USMK-5.4 cultivator as far as its agrotechnical performance is concerned, and at 1.2–1.3 g/cm³ soil consistency and low humidity (16–18.5 %) considerably surpasses it (4–6 % on average by number of soil clods with diameter of up to 25 mm within a loosened soil layer) which provides greater field sprouting.

Conclusions

In the suggested review it is recommended to specify the basic principles of soil processing agricultural machines work tools modelling as follows:

a) practicability of modelling;

b) availability of sufficient information;

c) multiplicity;

d) aggregativeness;

e) coordinatedness.

The above modelling recommendations may be applied in practice for effective and comprehensive search of new forms.

Literature


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