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DEVELOPMENT OF A METHODOLOGY FOR DESIGNING A SIMULATION MODEL OF A GRAIN COLLECTION AND TRANSPORTATION COMPLEX

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Abstract. *The relevance of the topic of the work is determined by the fact that the use of simulation modeling allows you to assess the efficiency of the collection and transport complex, identify its bottlenecks, reduce costs and increase productivity [1]. In agricultural production, the most widespread are systems of mass service with waiting. These are systems in which the request received at a given time (all service channels are busy) is queued and waits until the channel is free. Thus, a combine with a full hopper does not leave the system and waits for the next vehicle to unload grain. If a request received in the system (stopping a combine with a full hopper), finds all the vehicles busy loading other combines, it is forced to wait its turn until one of the vehicles is free. After servicing (unloading the hopper), the combines are again serviced after some time.*

Keywords: *grain harvesting and transport complex, work flow chart, GPSS, simulation model, design.*

Introduction. Simulation modeling is a method of studying complex systems by creating a digital or mathematical model of them and conducting experiments to analyze the behavior of the system under different conditions [3].

Let us consider the main features of simulation modeling: dynamic reproduction of processes (the model allows us to estimate the change in parameters over time); discrete-event or continuous approach (models can be based on sequential events or continuous processes); analysis of options (you can change input parameters and work scenarios to optimize processes); use of software tools (models are implemented in specialized environments, such as AnyLogic, Arena, Simulink, Python, MATLAB, GPSS, etc.).

In the agricultural sector, simulation modeling helps to predict the efficiency of equipment, optimize transportation routes, and reduce harvesting costs, etc. [2]. Or, for example, to develop a simulation model of the operation of a grain harvesting and transport complex, which is currently very relevant for our country. The relevance is also determined by the fact that the use of simulation modeling allows

you to assess the efficiency of such a complex, identify bottlenecks, reduce costs, and increase productivity.

Basic material. Designing a simulation model of a grain harvesting and transportation complex is an important stage in optimizing the process of grain harvesting and transportation [4]. Here is a detailed methodology for designing a simulation model of a grain harvesting and transportation complex:

Stage 1: System description. Such a complex usually consists of the following main components: combine harvesters; loading bunkers; vehicles for transporting grain (trucks, tractors with trailers); grain reception and storage points

Stage 2: Problem statement (Main tasks of designing a simulation model: determining the operating parameters of combines and transport; analyzing the impact of the number of units of equipment on productivity; determining optimal transportation routes; minimizing equipment downtime.

Stage 3: Methodology. A discrete-event modeling approach is used to create a simulation model. The main tools for implementing the model are: software (AnyLogic, Arena, Simulink, Python, GPSS); data on the productivity of combines and vehicles; geospatial data of fields and routes.

Stage 4: Model development. The model includes the following stages: collection of initial data (machine characteristics, field maps); construction of process logic (combine movement, bunker loading, transportation); setting parameters and work scenarios; conducting simulation experiments.

Stage 5: Analysis of results. After running the simulation scenarios, the following are analyzed: execution time of main operations; workload and idle equipment; optimal operating parameters of the complex; fuel consumption and economic efficiency.

Preliminary conclusions. Simulation modeling allows you to make informed decisions about the organization of the work of a grain harvesting and transport complex. Analysis of the results helps to increase the efficiency of harvesting, optimize the use of equipment and reduce operating costs.

Let us describe in detail the principle of operation of the simulation model we developed. The block diagram of the developed modeling program is shown in Figure 1.

The simulation begins when the harvester (combine) starts harvesting. The service channels are vehicles. The system is a closed multi-channel mass service system. The flow of service requests (applications) in it is characterized by the intensity - λ, and the throughput of the application service channels is characterized by the service intensity - μ.

A combine harvester filled with grain is queued (CHER) to wait for a free vehicle.

When entering the TRAN service device, it places a unit in the BUNKER (memory cell) and is delayed until this cell is equal to zero (Fig. 1).

Having detected an empty BUNKER, the combine immediately leaves the device and frees up space for the next one. Statistics of transport waiting for combines are collected using the CHER block. Then, after a delay for unloading, the transact returns to the beginning of the cycle. After the end of the shift, the transacts are removed from the model (simulation of the end of work).

Using the SAVEVALUE Tp(QT$CHER+1/Mu) and SAVEVALUE Lch QA$CHER blocks, the waiting time of combines in the queue and the average queue length, i.e. the number of combines waiting for a vehicle, are determined, respectively (Fig. 1).

Note. In this model, we do not take into account the transportation of grain by vehicles to the receiving point and their unloading, although for the completeness of the experiment it is necessary to take into account all factors. We will limit ourselves only to the distribution of combines by vehicles.

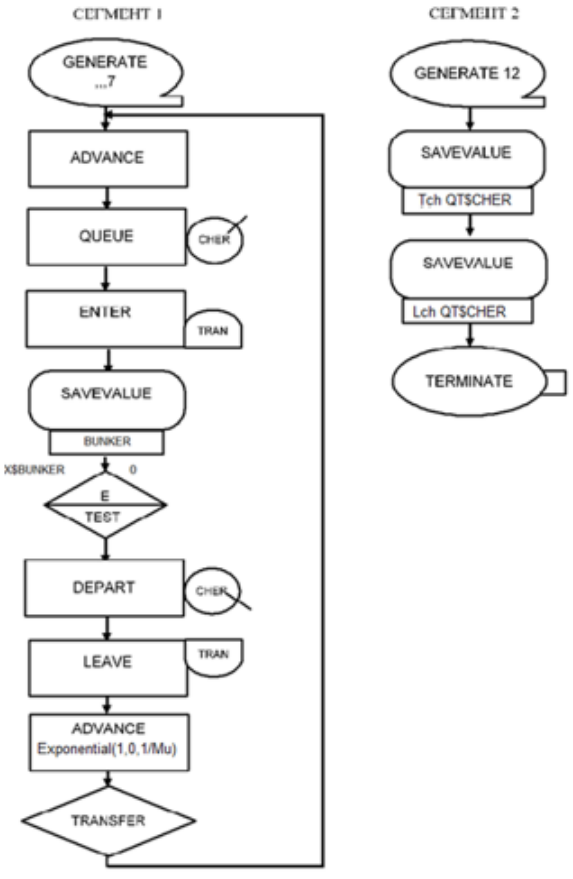

Figure 1 - Structural diagram of the simulation model

According to this flowchart, you can then implement the program code in the GPSS package.

Conclusions. A methodology for designing a simulation model of a grain harvesting and transport complex has been developed.

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РОЗРОБКА МЕТОДОЛОГІЇ ПРОЕКТУВАННЯ ІМІТАЦІЙНОЇ МОДЕЛІ ЗЕРНОВОГО ЗБИРАЛЬНО-ТРАНСПОРТНОГО КОМПЛЕКСУ

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Анотація. *Актуальність теми роботи визначається тим, що використання імітаційного моделювання дозволяє оцінити ефективність роботи збирально-транспортного комплексу, визначити вузькі його місця, зменшити витрати та підвищити продуктивність. У сільськогосподарському виробництві найбільшого поширення набули системи масового обслуговування з очікуванням. Це такі системи, в яких заявка, що надійшла в момент часу (всі канали обслуговування зайняті), стає в чергу і чекає, поки не звільниться канал. Так, комбайн з наповненим бункером не залишає систему і чекає на черговий автомобіль для вивантаження зерна. Вимога, що надійшла в систему (зупинка комбайна з повним бункером), якщо застає все автомобілі зайнятими завантаженням інших комбайнів, змушене чекати своєї черги до тих пір, поки не звільниться один з автомобілів. Після обслуговування (розвантаження бункера) комбайни через деякий час знову стають на обслуговування.*

Ключові слова: *зерновий збирально-транспортний комплекс, блок-схема роботи, GPSS, імітаційна модель, проектування.*

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