FEATURES OF EXPERIMENTS BASED ON PROCESS 3D-MODEL OF THE STATION

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ABSTRACT

A 3D-model can become an isomorphic one if there are no significant differences between the actual image and its likeness (the prototype). Theoretical evaluation of the results of observation of real technological processes at the railway station and imitating them in the course of experiments of model analogues, recreating the dynamics of all operations based on calculation and three-dimensional reproduction with correct physical phenomena of gravitation, resistance, inertia and the presence of other accompanying reactions. Model physics confirms the possibility of reconstructing multiple effects of controlled actions within the time quantum of the forces being calculated.

Keywords: railway station, design, process approach, experiment, 3D-model, information technologies.

Background. *The development of an adequate dynamic model of a railway station, reconstructing physical and technological operations for servicing train- and car flows with visualization of achievable states in three-dimensional images, makes it possible to obtain a powerful tool for simulating real processes. The structural and functional similarity of the 3D-model to the prototype objects of the stations (railway tracks, cars, locomotives) approximates the model interpretation in form and content to the originating procedures in the process of train formation, delivery, unloading, loading of cars at cargo points, etc. The model of the railway station, the objects of which function in accordance with the physical laws of motion of bodies and the requirements of technology, can be applied to various experiments, replacing the use of resources of a real station.*

Objective. *The objective of the author is to consider features of experiments on the process 3D-model of a railway station.*

Methods. *The author uses general scientific and engineering methods, statistical analysis, comparative method, mathematical apparatus, 3D-modeling.*

Results.

Possibilities of full-scale and model experimentation

The transfer of the functions of the full-scale experiment of model reconstruction is related to fulfillment of the condition of equal reliability of the representative real statistics and the sample obtained as a result of the data collection from the virtual sensors installed on the model objects. In this case, one should take into account the fact that the results of the experiments on the model will not be identical, but are close to the outcomes at similar prototype objects. Process reconstruction of complex technological operations with car flows as a dynamic deployment of events, taking into account physical interactions between bodies, can be sufficient to bring about the functioning of a real station.

If it is necessary to obtain reliable analytical material on the state of objects in the process of operation, to identify the causes of occurrence of significant stresses and deformations in complex structural elements of the track and rolling stock, the most reliable method is to carry out the full-scale experiment [1]. However, it should be noted that it is also conducted on a kind of model stand (physical), in a certain way prepared for retrieval of the given information.

Of all station objects, a certain track section is selected, on which information reading devices are installed in full accordance with the planned experiment. The fencing of the territory is carried out, all external influences that could violate the purity of the experiment are minimized. In this respect, full-scale experimentation can be considered as a somewhat repetitive experiment with preservation of the initial positions in its conduct. However, all the initial conditions of the full-scale experiment are conditioned by the action of a set of random factors and become somewhat different from the previous ones. For a number of reasons of objective nature (the inconsistency of the readout equipment, stochastic nature of the manifestation of influencing factors, the correlated action of forces, etc.), the results of such experiments carry a certain stochastic error. More advanced techniques and methods of information retrieval, of course, will lead to more accurate conclusions.

The second reason for the impossibility of an identical reproduction of the results of the full-scale experiment is errors in the measurement recording procedure. For example, we measure the wind speed V and the strength of the wind load f acting on the uncoupling during the dissolution from the hump at time t_0, which are distributed during looping in the intervals $[V_0–\Delta V_1, V_0+\Delta V_2]$ and $[f_0–\Delta f_1, f_0+\Delta f_2]$. All measurements pass for some time interval $[t_0–\Delta t_1, t_0+\Delta t_2]$. At the output, some averaged values V_0 and f_0, recorded at the time $t_0+\varepsilon_1$, are fixed. During some next act of the experiment, the effect can be exerted by factors that have been absent until now or are of little significance for the given experiment, but in the aggregate of their combined action, they can lead to a different result, which, in fact, occurs in real conditions. Under these conditions, the sensor will operate at time $t_0+\varepsilon_2$, processing a slightly different wind load graph in the range $[t_0–\Delta t_3, t_0+\Delta t_4]$. Statistical processing neutralizes such deviations, which by their chance have, as a rule, symmetrical distributions.

The use of the model instead of natural samples changes the general picture in a definite way, which is formed under the action of simplified model rules, the absence of random factors and the multiple correlation of their influence, etc. It can be quite easy to repeat the model experiment with the given initial conditions with a high probability of obtaining a result that coincides with the previous experiment. Therefore, with constant input data in the model, there is no need to conduct multiple observations – their results will be almost identical.

Fluctuations in the outcomes of full-scale experiments and the constancy of model reconstructions should theoretically be related in the sense that the result of the model experiment tends to the mathematical expectation of a significant statistical sample of full-scale data. A simple model of a relatively complex real technical system is considered as its some kind of substrate conglomerate, a «dry residue» from all complex, multilevel influences of various factors, in which there are only permanent, time-stable basic actions that are essential for correct performance of a technological operation in the range of tolerable deviations.

Naturally, the simplicity of the model is relative. For its use, the structure of objects must in some way reproduce physical and technological effects within the given limits of the values of real parameters, correctly imitate objective nonlinear processes (for example, with an arithmetic progression of the growth of the value of the parameter X_i, the geometric progression of the growth of the effect E_j, registered in reality).

The validity of the model experiment should be confirmed by comparative outcomes on natural *objects. However, in addition to correctly reproducing the results of real experiments, the model is called upon to possess predictive capabilities. Otherwise, the utility of such a complex model with the reconstruction of physical effects is doubtful, since it is possible to carry out a full-scale experiment without it and to use the obtained results with guaranteed reliability for solving the necessary applied problem.*

The engineering (process) model of the station must have a high similarity in its functional to the real prototype on the railway. The point is that the state of model objects changes according to mathematical calculations in the same direction as the change in the states of real station objects under the action of certain loads (gravitational force when rolling off the slides from the hump, the inertia force when the cars collide in sorting yard, resistance forces when braking the composition on hold devices, etc.). In this case, the quantitative effects observed on the model (speed of cars, length of the stopping distance) must correspond to the actually recorded phenomena arising under equal conditions. Some deviations of the desired values of the model parameters from prototyped processes are possible. More detailed structural and functional simulations narrow the domain of pre-emptive errors, allowing to form adequate models. «Inclusion» into the results of actions of special factors that dissipate the determined deterministic values of parameters in full compliance with real processes, further approximates the model to the outcomes of the full-scale experiment.

Advantages of experiment on 3D-models

Experiments on the visual model allow to concentrate on significant structural elements and technological operations, expertly evaluate the real process, ranking significant factors of mutual influence in the dynamics of phenomena. The 3D-model of the station should be considered as a visual reconstructive image, creating a comfortable environment for the researcher to study unknown patterns of interaction in wheel-rail systems, cargo car, locomotive-wagon, etc. Observation of the functioning of a pseudophysical model, adequate to a railway station, is perceived as an experiment on real objects, conducted in a safe environment, less labor-intensive, not requiring significant expenses for preparation for work that does not affect the activities of other units of the station [2, 3].

Such a reconstructive analog of a real station is represented as an isomorphic 3D-model of a station, seen on the display screen as a sequence of frames of changing objects. Visually, it is perceived as a video recording of a certain technological process performed on a real station. A high degree of detailing of external forms of original objects that are indistinguishable from the type of the corresponding prototypes is filled with a structural and functional similarity when the computer products of cars and tracks change their position under the influence of certain model calculated in full accordance with the parameters of real devices Loads. In this case, experiments on such isomorphic models after conducting verifying procedures can provide experimental studies with high confidence in the results obtained.

On isomorphic 3D-models of the station, it is possible to successfully study the states of objects in borderline and critical situations, when setting and carrying out similar tests in real conditions cannot be performed for safety reasons (for example, determining the zone of chemical damage in the event of an accident of railway rolling stock with hazardous loads of oxidizing, poisonous, infectious and other substances, modeling of the derailment of cars from the track in the curve before a complex intersection with motor roads and railways; determination of a limit speed of the train with the specific circuit arrangement of empty and loaded cars in the train, universal and special cars during the passage of complex curves in the plan and profile).

Model physics will allow to reconstruct multiple direct and indirect effects of the action of mutually correlated conditions and factors, calculate and visualize the states of objects that are sufficiently remote in time from the positions of collision of objects. In this case, not only individual frames are recorded in detail, as in real filming, but the state of each point of the digital object is recorded, from which it is possible to take data at any time within the time scale of the calculated forces, stresses, and deformations. Since all critical situations occur for a very small period of time (seconds and fractions of seconds), the subsequent study of computer animation of an isomorphic model of the station with a time scale extension of 20 or more will allow a detailed analysis, identify particularly dangerous points and surfaces Interacting objects, time intervals that require structural reinforcement of elements, speed limits for certain combinations of physical quantities and so on.

The cost of developing an isomorphic 3D-model of the station is expected to be significant, the efforts of many specialists in the field of algorithmization, programming, computational mathematics, physics, system analysis, and experienced transport technologists are needed. However, the possibilities of such a model as a system environment are commensurable with the potential of a real technical system that provides studies of the laws governing the operation of objective connections by full-scale and statistical material. Model reproduction of technological processes will become an adequate substitute for full-scale experimentation with associated high costs, a complex mechanism for planning and controlling all phases of the experiment.

Conclusions. *The engineering model of the station in form and content can be approximated to its prototype so that it can become a full-fledged substitute for obtaining certain statistical data on various problem aspects of the functioning of the transport system, studying complex phenomena arising from the action of unexplored factors (ultrahigh speeds, severe radioactive radiation, anomalous pressures and temperatures, etc.).*

The dynamical 3D-model of a station becomes isomorphic in the absence of significant differences between simulating technological operations and real physical processes that generate these technological operations. At the same time, the possibilities of such a reproducing environment are greatly expanded, especially in the modeling of dangerous situations, which bring with high probability to crashes and accidents.

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