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RESEARCH ARTICLE

OPTIMIZATION OF TECHNOLOGICAL TRANSPORT SETS USING ANYLOGIC SIMULATION ENVIRONMENT

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ABSTRACT

The article presents a solution to the problem of finding the optimal number of standard sets for technological transport for the Trunk Pipeline Management Department in Western Siberia. The main task of the Department is to maintain the efficiency of the oil trunk pipeline system. Related business units with the same functionality may have significant differences in the length of pipelines, their reliability, natural and climatic conditions, infrastructure and road network. The existing regulations for equipping the units with technological transport do not take into account these factors completely. A simulation model for transport servicing of the oil pipeline system has been developed by the method of agent modeling in Anylogic environment, which allows using GIS maps with transport bases and pipelines. Based on modeling it is proposed to generate corrections of existing normative documents on the need for technology.

KEYWORDS

Simulation modeling, technological transport, main oil pipelines, the need for equipment, park structure.

1. INTRODUCTION

At present, in the organizations for the hydrocarbons transportation, the issue of optimizing the need for equipment for the Trunk Pipeline Management Department (TPMD) is quite relevant [1]. The existing regulatory documents of JSC "Transneft" regulate the need for equipment for structural divisions, not taking into account the differences in natural, climatic, road and other conditions.

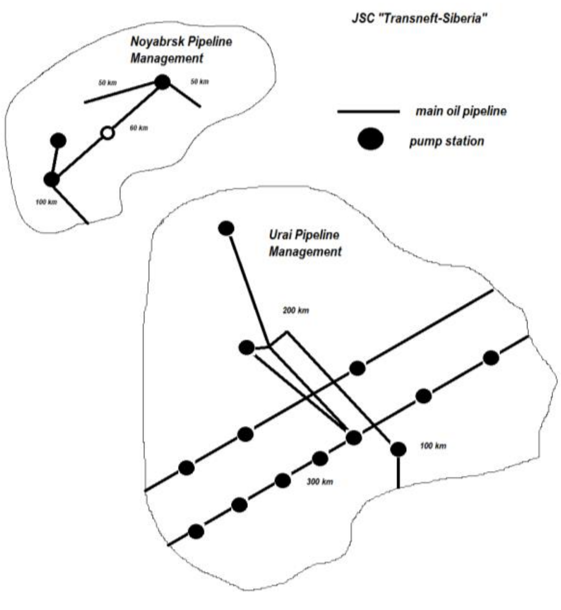

Figure 1: Comparison of two TPMDs that are parts of PJSC "Transneft-Siberia": Urai TPMD and Noyabrsk TPMD

The regional structure of the main oil pipelines includes several Trunk Pipeline Management Departments, each of which has the same list of tasks to ensure the continuous operation of the pipeline section. One of the main methods of maintaining pipeline operability is a planned repair by replacement of a pipeline section (spool replacement), installation of a repair clutch, grinding or surfacing of a pipeline section. To carry out these works, vehicle sets of units are used: on-board car, dump truck, truck tractor, crew cargo-passenger bus, mobile car repair shop, stalk truck, tank lorry, welding unit, mobile pumping unit, truck crane, pipe layer, and fire truck. It should be noted that for different methods of selective repairs of the pipeline, different vehicle sets are used. A preliminary analysis of the two TPMDs that are part of "Transneft-Siberia" PJSC revealed considerable differences between them, which significantly affects the processes of transport and technological services of the main production (Figure 1).

The total area occupied by the Noyabrsk TPDM is smaller than the Urai TPDM area, through which a branched network of three different main oil pipelines with a total length of more than 1500 km goes, while in the Noyabrsk TPDM there is one 800-km pipeline. Moreover, the Departments differ in the level of development of the road network and the presence of difficult-to-reach areas.

2. MATERIALS AND METHODS

In order to take into account the above features, an imitation model of the operation of the oil pipeline system was developed with reference to the geographic location of the Trunk Pipeline Management Departments. Currently, there are several approaches to simulation modeling: system dynamics, discrete-event modeling, dynamic systems, agent modeling, integrated approach [2-9].

In the framework of this study, an agent approach was used, implemented in the Anylogic software environment. The main essence of the approach is that the model is represented as a set of separate active objects (agents), each of which interacts with other agents that form an external environment for it. This approach is a powerful tool that can give the researcher an opportunity to take into account a large variety of factors [10,11].

The model simulates the work of the Trunk Pipeline Management Department. An operating network of oil pipelines can pass from an operating to a failure condition with a given intensity. The intensity of the need for repair was determined in the works [12]. It should be noted that the number of selective pipeline repairs in the Urai TPMD is larger than in the Noyabrsk TPMD. At the same time, the process of creating a need for selective repair by the method of a spool cutting, the method of clutch installation, the method of grinding or surfacing (modeled as one method due to the similarity of technologies) is modeled (Figure 2).

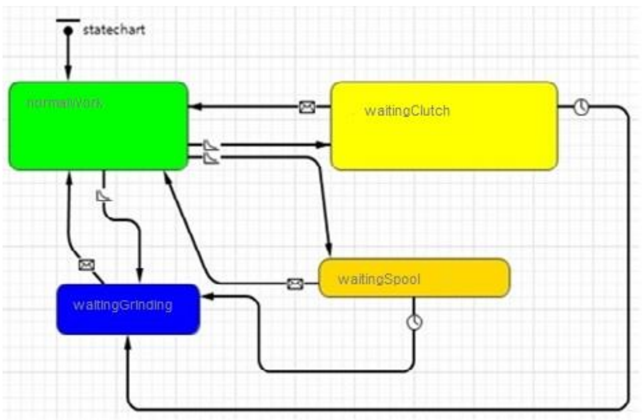

Figure 2: Logical algorithm for the operation of the trunk pipeline in the model

When the technical condition of the pipeline is changed, a request is made for this or that vehicle set of technological transport, which must leave the transport base located in the Department, make repairs and then return. After that, the pipeline returns to its operational condition.

3. RESULTS AND DISCUSSIONS

The logic of the transport operation (Figure 3) is a repeating algorithm in which, at the beginning of the simulation, the transport is on the base (at center), After receiving the application, its analysis and classification are carried out by one of three types: Servicing – repair by clutch installation, Servicing1 – repair by spool cutting, Servicing2 – repair by grinding. According to the type of application, a free vehicle set is selected, which is sent to the pipeline section (MovingToPipeline) in the next transition. At the same time, the average time for performing repair work is fixed, taking into account the expectation of the arrival of equipment at the destination. In the absence of a free brigade, the waiting time for the release of equipment is determined. The work of the model also took into account factors affecting the technical operation of transport-technological machines, considered in detail in the studies [13-16].

The main feature of this model is the reference to production well logging maps of the TPMDs under study. The locations of pipelines in the model were marked with geotags, each of which is the source of applications for equipment. This approach allows taking into account the development of the road transport network of the region, the time required for the movement of equipment to the locations of pipeline repairs. The movement of traffic occurs either on public roads or on travel routes (Figure 4).

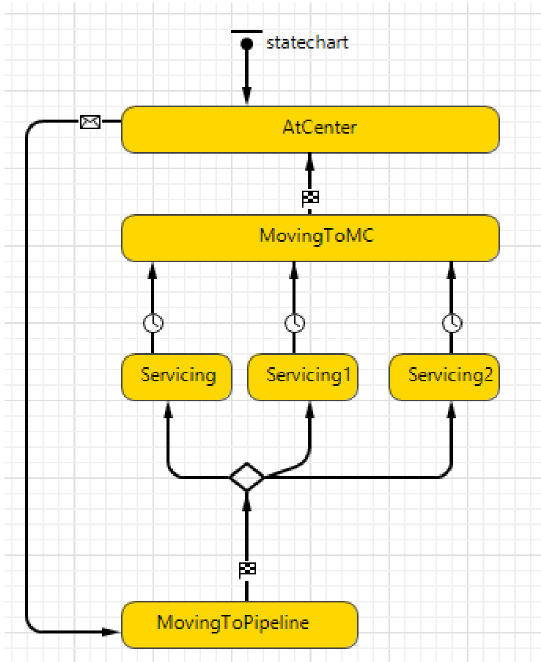

Figure 3: The logical algorithm of transport operation in the model

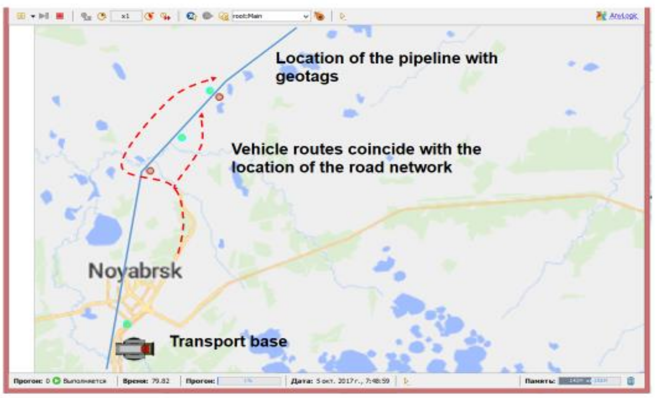

Figure 4: Simulation of the movement of equipment to the place of oil pipeline repair on the existing road network

The model also contained the average values of the number of pipeline repairs for the TPMDs under consideration and the average technical traffic speeds for the road network. The initial modeling data is presented in Table 1.

Table 1: The initial modeling data

Value	Noyabrsk TPMD	Urai TPMD
Repair by the method of cutting	50	70
Repair by the clutch method	221	581
Repair by the grinding method	115	257
The average operating speed	45	60

The implementation of the simulation model with given conditions for two TPMDs with different number of vehicle sets of technological transport allowed to generate statistics on the change in the average time for performing repair work taking into account waiting for machines. With an increase in the number of vehicle sets, the average time decreases to certain values corresponding to the complexity of the pipeline repair. The technologically necessary number of vehicle sets corresponds to the point at which the intensity of the decrease in the average repair time is slowed down to stable indicators. The results of the experiment on the determination of the vehicle sets of technological transport for the repair of the oil pipeline by the method of coupling installation are shown in Figure 5.

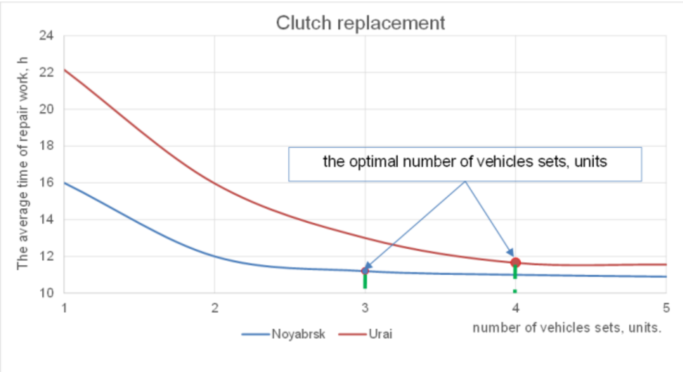

Figure 5: Graph of the dependence of the average waiting time of the section on the number of sets of equipment for replacing the coupling

It can be concluded that for the Noyabrsk TPMD in the given conditions, the technologically required number of sets of equipment is three, and for Uray is four. Therefore, based on the difference in the length of the TPMD, in the types of roads and climatic conditions, the hypothesis can be confirmed that for different departments it is necessary to select different equipment with technological transport.

4. CONCLUSIONS

The results obtained can be useful for the management of the structural divisions of the company "Transneft" in the formation of regulatory documents for the equipment with technological transport, in making decisions on updating the machinery park, as well as in determining the volume of transport units financing. The experimental model showed the need for a differentiated approach to equipping the structural units with equipment. This is a prerequisite for the classification of the Trunk Pipeline Management Departments, which will allow forming a more flexible system of equipment distribution, which allows minimizing the costs for transport and technological service of the oil pipeline industry.

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