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ALGORITHM FOR SIMULATING THE NUMBER AND ORDER OF CARS IN THE TRAIN ARRIVING AT THE ACCESS TRACK

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Abstract: An algorithm for simulating the number and order of cars in a train arriving at an access track.

The paper presents an algorithm for randomly generating the characteristics of trains arriving at the access road. Trains are characterized by the following parameters: the number of uncoupling cars arriving at the internal stations of the access track, the number of cars in each uncoupling, the order of the uncoupling in the train. The number of detachments is formed randomly in the range from one to the value of the total number of internal stations of the access road. The number of cars in each uncoupling is formed randomly from zero to one-third of the size of the train composition. Moreover, the proportionality of the volumes of car traffic going to each station is observed. The number of options for the location of detachments (permutations) is determined by the factorial of the number of stations. The number of the permutation variant is randomly selected.

Key words: train, simulation modelling, number of cuts, industrial transport, car turnover, car traffic volume optimization, access road, transport management.

The duration of technological processes with trains arriving on the access roads of industrial enterprises depends largely on the order in which the number of cars directing to various internal stations of the access road is located.

It is obvious that the order and quantitative composition of cars is random.

For mathematical modelling of technological processes for processing trains arriving on access roads, it is necessary to develop an algorithm for simulation of the number and order of cars in the train.

Since this algorithm can be used for mathematical modelling of various technological processes, the solution to this problem is quite relevant.

Typically, access roads of industrial enterprises are made as follows: there is an access road station with access to an adjoining station of the backbone network and connected to other stations or freight points of the access road. Let us call it the Receiving station. Let us assume that the access road is also characterized by several internal stations that receive a certain car traffic volume and are located in a specific order and at a certain distance from the Receiving station and among each other.

The algorithm of this simulation model includes the following steps:

1. Calculation of conditional-constant variables

We determine the total car traffic volume at the stations of the access road according to the following formula:

$$V = \sum_{i=1}^{n_{cm}} m_{Bi}\,, \quad (1)$$

where m_{Bi} - is a car traffic volume directing to *i*-th station of the access road;

n_{st} - is the number of stations under consideration in the model.

We determine a share *i*-th in the total car traffic volume according to the formula:

$$\alpha_i = \frac{m_{\textit{в}_i}}{V} \quad (2)$$

We determine the distance travelled by groups of cars to the stations of the access road according to the formula:

$$l_{npi} = l_{nepi-1} + l_{nepi}\,, \quad (3)$$

where l_{nepi} - is a line distance between *i*-th and *i-1* stations of the access road, moreover l_{nepi} is equal to the line distance between the Receiving station and the first one in the direction of travel of the station of the access road.

We determine the annual number of domestic trains according to the formula:

$$N = \frac{V}{m} \quad (4)$$

.

where *m* - is the number of cars in this train.

The algorithm flow chart implemented in the Scilab software environment is shown in Figure 1.

In the flow chart of the algorithm for the calculation of conditional-constant variables of the simulation model:

- in blocks 1-2, the total car traffic volume by stations is determined;

- in blocks 3-4, a share of the car traffic volume directing to each station is calculated of the total car traffic volume;

- in blocks 5-6, the haul distance of groups of cars from the Receiving station to each internal station of the plant is calculated;

- in block 8, the number of domestic trains made up at the Receiving station to the internal stations of the plant per year is calculated.

2. Formation of groups of cars and the number of groups of cars by destination stations

The number of cars in the group arriving from the connecting station is determined according to the following formula:

$$m_{cuti} = \mathrm{int}(m \cdot rand(i) \cdot \alpha_i) \quad (5)$$

where *int* - is a function that returns an integral value from the parameter to be calculated;

m - is the number of cars in the made up train;

i - is the number of the group of cars

α_i - is a share of *i*-th car traffic volume in the made up train;

rand(i) - is a function that returns a random number between 0 and 1

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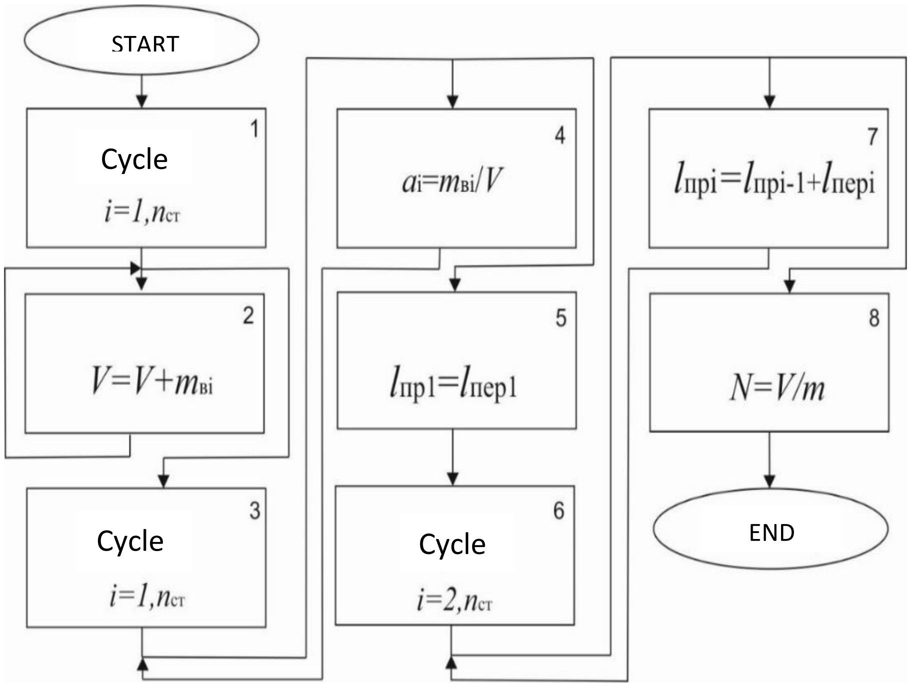

Рисунок 1 - Блок-схема алгоритма расчета условно-постоянных переменных имитационной модели

Figure 1 – Flow chart of the algorithm for the calculation of conditional-constant variables of the simulation model

The number of cars in the groups of cars in the made up train must correspond to the total number of cars in the train, thus, the number of cars in the group arriving at *i*th station m_{cut_i} must be controlled for their correspondence to the total number of cars in the train, according to the following scheme.

We calculate the actual total number of formed cars in the train:

$$m_{act.} = \sum_{i=1}^{n_{cm}} m_{cut_i} \, . \qquad (6)$$

We calculate the obtained difference due to the random formation of the indicator $m_{omц_i}$, determining the difference between the actually received number of cars and the required one according to the formula:

$$\Delta = m - m_{act.} \, . \qquad (7)$$

We adjust the previously calculated number of cars according to the following ratio:

$$m_{cut} = m_{cut_i} + \Delta \cdot \alpha_i \, . \qquad (8)$$

Then we calculate the actual total number of formed cars in the train again according to formula (6) and calculate Δ according to formula (7). We estimate the value Δ based on the condition that it should not exceed the accuracy ε of the total number of cars in the train, i.e. the following condition must be met:

$$\frac{\Delta}{m} \le \varepsilon \qquad (9)$$

If condition (9) is not met, repeat the calculation according to formulas (6) - (9); if condition (9) is met, we adjust the maximum element by organizing a cyclic process for the formation of m_{cuti} and verification of compliance with the condition:

$$m_{cut\max} = m_{cut\max} + \Delta \, . \qquad (10)$$

As a result of this process, we obtain the compliance

$$m = m_{act.}.$$

This algorithm, implemented in the Scilab software environment, is shown in Figure 2. In blocks 1-2, the number of cars in the group is randomly formed by assignment to various stations of the plant. In blocks 3-5, the actual obtained number of cars in the train is calculated. In block 6, the difference between the actual and the given number of cars in the train is calculated. In block 7, the calculated relative error is compared with the allowable one. In block 8, the final adjustment of the maximum number of cars is carried out.

3. Determination of the random odder of groups of cars in the train.

According to the mathematical theory of combinatorics, the number of options for arranging groups is subject to the following law

$$A = n! \qquad (11)$$

where *n*is the number of arrangement options that is equal to the number of stations of the access road.

We use the development provided in [1], using which we create a file in the Microsoft Excel environment containing *n*! possible swithing options.

To ensure a random selection of option, we form a random number between 1 to *n*!, using a structure

$$n_{opt.} = \text{int}(n!*rnd(1)). \qquad (12)$$

Then, we select the line with the switching option corresponding to the number $n_{вар}$ from the previously created Excel file.

Thus, a distribution file of the random arrangement of groups of cars in the made up train is formed.

A file which indicates the number of cars in groups at destination stations, as well as the order of their location in compliance with the location of stations of the access road, are finally formed.

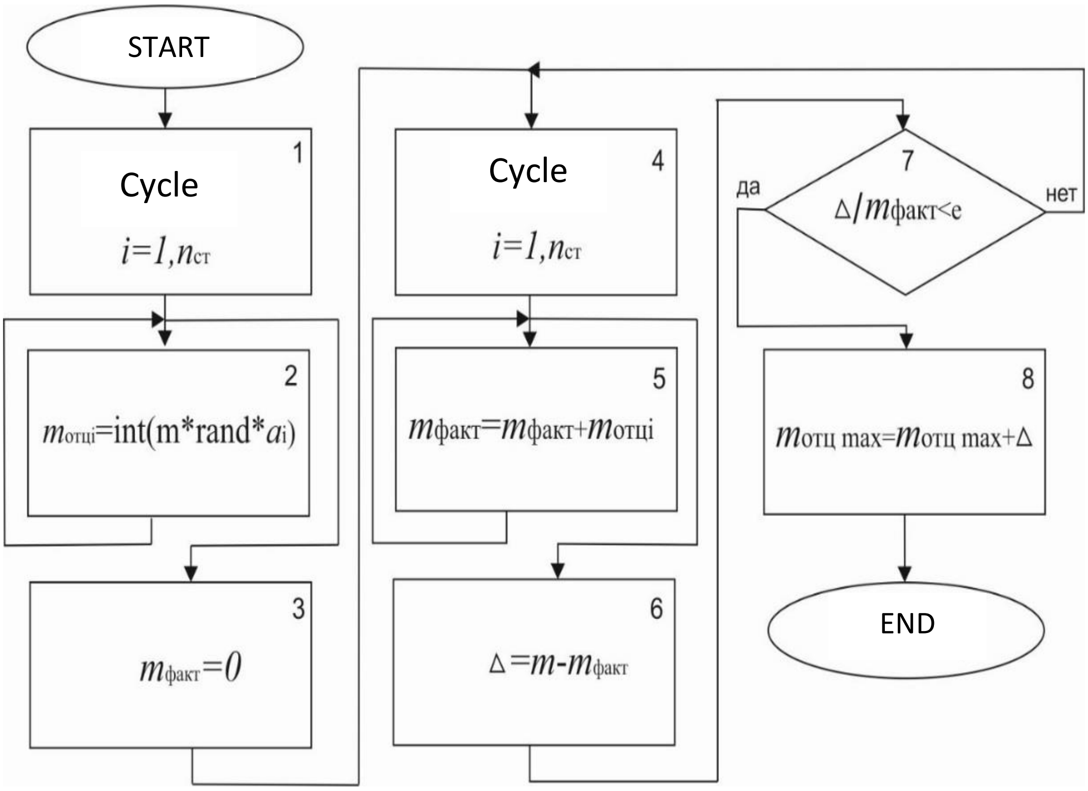

Рисунок 2 - Алгоритм случайного определения количества автомобилей в группах, реализованный в программной среде Scilab

Figure 2 - Algorithm for the random determination of the number of cars in groups, implemented in the Scilab software environment

This algorithm, implemented in the Scilab software environment, is shown in Figure 3.

In block 1, the file with switching options for groups of cars is loaded. In block 2, the number of the switching option is randomly determined. In block 3, the vector nst1 is assigned with a random value of the switching option for groups of cars.

This algorithm was used to develop a mathematical model for the optimization of car traffic volumes at the Karaganda Metallurgical Plant of "ArcelorMittal Temirtau" JSC (Kazakhstan). In this model, the above algorithm is used to simulate the technological process of processing trains coming from the backbone network on the access road [2].

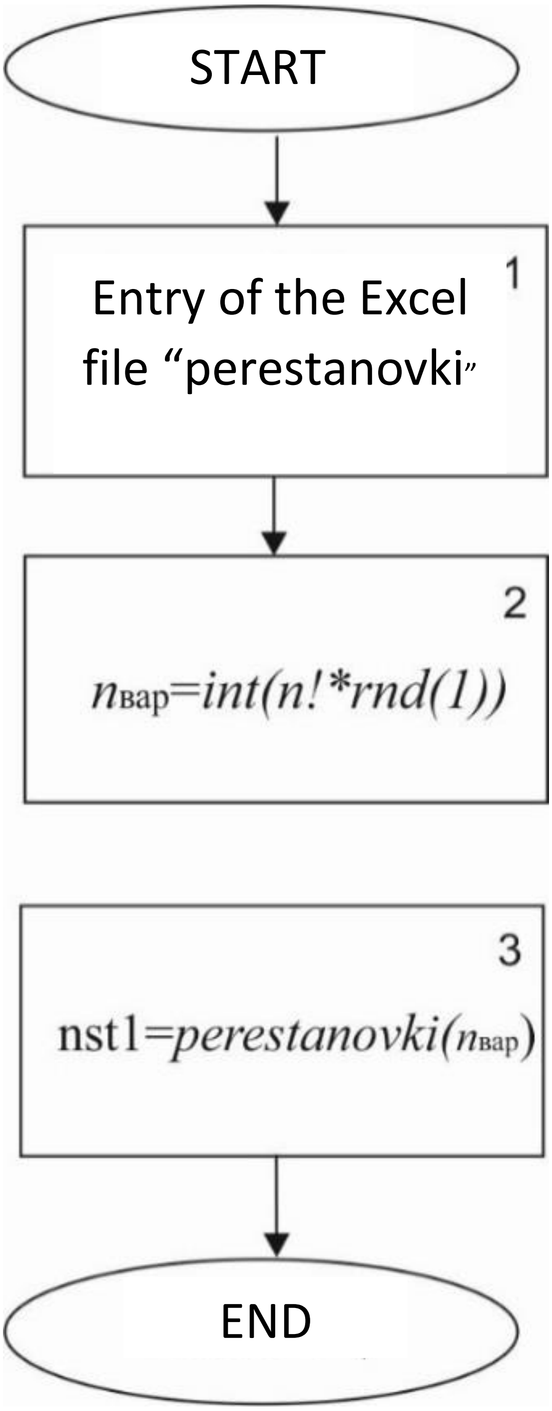

Рисунок 3 - Алгоритм случайного выбора порядка вагонов в поезде
Figure 3 - Algorithm for the random selection of the order of cars in the train

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АЛГОРИТМ ИМИТАЦИОННОГО МОДЕЛИРОВАНИЯ КОЛИЧЕСТВА И ПОРЯДКА РАСПОЛОЖЕНИЯ ВАГОНОВ В СОСТАВЕ ПОЕЗДА, ПРИБЫВАЮЩЕГО НА ПОДЪЕЗДНОЙ ПУТЬ

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Аннотация. В работе представлен алгоритм формирования случайным образом характеристик составов, прибывающих на подъездной путь. Составы характеризуются следующими параметрами: количеством отцепов вагонов, прибывающих на внутренние станции подъездного пути, числом вагонов в каждом отцепе, порядком расположения отцепов в составе поезда. Количество отцепов формируется случайным образом в пределах от единицы до значения общего количества внутренних станций подъездного пути. Число вагонов в каждом отцепе формируется случайным образом от нуля до трети величины состава поезда. Причем соблюдается пропорциональность объемам вагонопотоков, следующих на каждую станцию. Количество вариантов расположения отцепов (перестановок) определяется факториалом от количества станций. Случайным образом выбирается номер варианта перестановок.

Ключевые слова: железнодорожный состав, имитационное моделирование, количество отцепов, промышленный транспорт, оборот вагонов, оптимизации вагонопотоков, подъездной путь, управление перевозками.

КІРМЕ ЖОЛҒА КЕЛЕТІН ПОЕЗДЫҢ ҚҰРАМЫНДАҒЫ ВАГОНДАРДЫҢ САНЫ МЕН ОРНАЛАСУ ТӘРТІБІН ИМИТАЦИЯЛЫҚ МОДЕЛЬДЕУ АЛГОРИТМІ.

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Андатпа: Жұмыста кірме жолға келетін құрамдардың кездейсоқ сипаттамаларын қалыптастыру алгоритмі ұсынылған. Құрамдар мынадай параметрлермен сипатталады: кірме жолдың ішкі станцияларына келетін вагондардың ағытпаларының саны, әрбір ағытпадағы вагондардың саны, поездың құрамында ағытпалардың орналасу тәртібі. Ағытпалардың саны бір бірліктен кірме жолдың ішкі станцияларының жалпы санының мәніне дейінгі шектерде кездейсоқ түрде қалыптасады. Әрбір ағытудағы вагондар саны кездейсоқ түрде нөлден поезд құрамы шамасының үштен бір бөлігіне дейін қалыптастырылады. Бұл ретте әрбір станцияға баратын вагон ағындарының көлемдеріне тепе-теңдік сақталады. Ағытпалардың орналасу нұсқаларының саны станциялардың санынан факториалмен анықталады. Кездейсоқ түрде ауыстыру нұсқасының нөмірі таңдалады.

Түйінді сөздер: теміржол құрамы, имитациялық модельдеу, ағытпалар саны, өнеркәсіптік көлік, вагондар айналымы, вагон ағындарын оңтайландыру, кірме жол, тасымалдарды басқару.

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MEASURES TO IMPROVE THE INFRASTRUCTURE OF THE KHORGOS - ALTYNKOL BORDER CROSSING

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Abstract. The development of border cooperation is closely related to the strengthening of the contact function of the border, which is determined by the degree of development of border cooperation institutions and mediated by the infrastructure of border crossings. Border crossings are an important characteristic of international transport routes. They represent a gap in the transport chain in the form of a period of time during which the cargo or passengers do not physically move. Such delays bring additional costs for participants in cross-border cooperation. Thus, the capacity of the border crossing infrastructure practically affects the development of cross-border cooperation and determines the competitiveness of a particular transport corridor in international markets.

This article describes measures for the development of the Altynkol station. To control the process of reloading from 1520 mm wagons. track gauge in wagons 1435 mm. track gauge and ensuring the reloading of rolling stock on one Interstate Butt Point, a single operator of rolling stock is needed, whose functions will include the supply of empty cars to the Interstate Butt Point and its distribution between the transfer points in accordance with their needs. It is also planned to build 3 receiving-departure tracks on the 1520 mm gauge to increase the daily reception of trains at the station. The projected track length will be 1200 meters or 84 conventional cars.

China is a promising and capacious market for Kazakhstani products, which will most likely determine the course of economic development of the world community in the 21st century. The high growth rates of the economy of this country require an annual increase in the demand for such resources as energy, metal products and building materials.

Key words: border crossing, organization of transportation, transshipment of goods, Altynkol station, track width, rolling stock, customs operations