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MATHEMATICAL MODELS OF COAL MINES CONVEYER TRANSPORT SYSTEMS FUNCTIONING

Abstract. Based on dynamics of average method for Markov processes we developed mathematical model of functioning of conveyer transport systems with serial and parallel connection of conveyer and hoppers, and also with dendritic harp and self-similar structures. As result for these conveyer transport systems we obtained recursive algorithm to determine their carrying capacity at various ratios of incoming cargo traffic from lavas and productivity of batcher. We obtained minimum and maximum values of carrying capacity of mentioned above conveyer transport systems, also was given example of calculations.

Keywords: conveyer transport systems, hopper, Markov process, functioning, carrying capacity, self-similar structure.

Conveyer transport systems of coal mines have difficult branched structure consisting of conveyers and hoppers which are connected together using batcher, loaders and unloaders. Failures of conveyers often lead to downtime in lavas and as result to poor productivity of conveyer transport systems.

To increase carrying capacity conveyer transport systems of coal mines because of limited space accumulative hoppers (temporal redundancy) [1, 2] have received wide application. However the effective use of accumulative hoppers is limited by lack of mathematical ensuring and software that allows to optimize the process of conveyer transport system functioning.

Currently we developed mathematical models of conveyer transport system functioning without hoppers, which are used mainly for open mining [3, 4].

Many researchers studied questions of functioning of conveyer transport system with hoppers [1, 5–7].

In this case obtained mathematical models of conveyer transport system functioning mainly related to the system with a simple structure «conveyer – hopper – conveyer».

We obtained simulation models for more complex structure of conveyer transport system. In [8] were obtained mathematical models of reliability of complex multifunctional automatic systems with hoppers which can’t be directly used to determine carrying capacity of branched conveyer transport system with hoppers.

In paper we developed mathematical models of conveyer transport system functioning with serial and parallel connection of hoppers and also with self-similar dendritic structure.

Mathematical model is based on method of dynamics of medium for markov process [9], where simple system «conveyer – hopper – conveyer» is replaced by element(conveyer) with equivalent parameters of failure and recovery.

Analysis of conveyer transport system of coal mines showed that in general they have a self-similar dendritic structure. In other words a block diagram of conveyer transport system can be divided into hierarchical levels. At each level the same graph is repeated. Such geometric structures according to [10], are called dendritic fractals.

Fig. 1 shows typical schemes of conveyer transport system of coal mines with serial and parallel connection of hoppers and also conveyer transport system with self-similar dendritic structure.

Dendritic structure of conveyer transport system of coal mines can be explained by cyclical technology: penetration – mining – excavation. As a result each new section of conveyer transport system is connected to existing system, which was formed as a result of many cycles of coal mines. This process can be compared to the growth of tree, where the cycle is spring – summer – autumn.

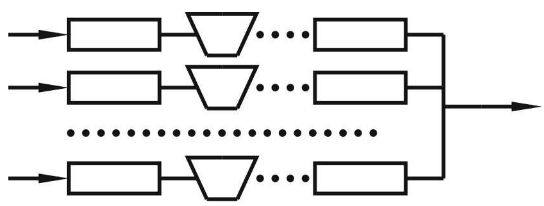
Therefore mathematical modeling will be made for these types of conveyer transport system.

As was shown in [3, 11], one of the main parameter of conveyer transport system functioning is average value of carrying capacity m_c, determined by formula

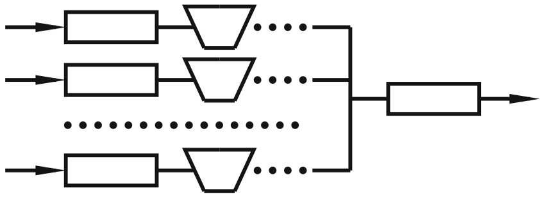
$$m_c = \sum_{i=0}^{s} P_i Q_i \,, \qquad (1)$$

where P_i – probability that conveyer transport system is in i-th state; Q_i – productivity of conveyer transport system i-th state; s – number of possible states of conveyer transport system while stops and failures of conveyers.

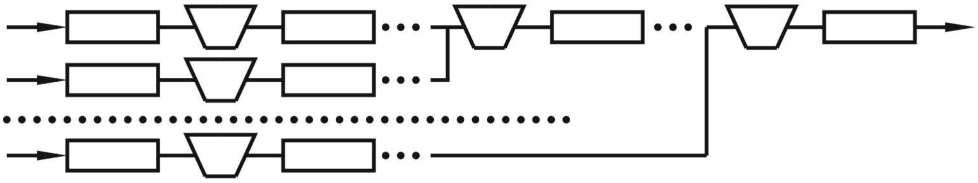
1) serial connection of conveyers



2) parallel connection of conveyers



3) dendritic structure (harp)



4) dendritic structure (self-similar)

Рис. 1. Structural schemes of conveyer transport system of coal mines with hoppers

It is clear from (1), to determine value m_c it is necessary to know the structure of conveyer transport system from which we can determine number of possible states of system s and probabilities P_i of transport system being in each i-th state (i = 1,s).

Consider first serial connection of hoppers (fig. 2).

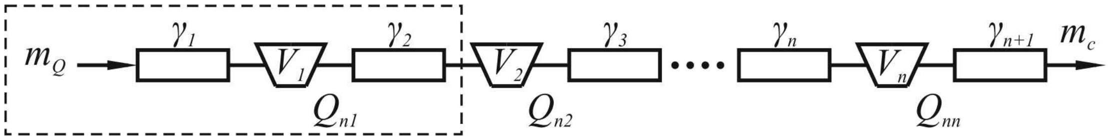


Fig. 2. Calculation scheme of serial connection of hoppers

For getting mathematical models of conveyer transport system functioning with hoppers let’s use property of self-similarity of structure with serial connection of hoppers.

Let’s distinguish in this scheme from the left edge simple system «conveyer – hopper – conveyer» encircled by a dotted line (fig. 2).

According to [12], average carrying capacity of this simple scheme can be determined from formula:

when $m_Q > Q_{n_1}$

$$m_{c_1} = \left[\frac{\dfrac{e^{A_{11}\gamma V_1}}{\gamma_1} + \dfrac{\overline{m}_{Q_1}}{(\overline{m}_{Q_1} - \overline{Q}_{n_1})}\left(e^{A_{11}\gamma V_1} - 1\right)}{1 + \dfrac{e^{A_{11}\gamma V_1}}{\gamma_1} + \dfrac{\overline{m}_{Q_1}}{(\overline{m}_{Q_1} - \overline{Q}_{n_1})}\left(e^{A_{11}\gamma V_1} - 1\right)} \right] \overline{Q}_{n1}, \quad (2)$$

where m_Q – productivity of above-hopper conveyer; Q_{n1} – – productivity of batcher; V_1 – volume of batcher; γ – specific cargo weight;

$$A_{11} = \frac{\mu_1\left[m_Q - (1+\gamma_1)\overline{Q}_{n_1}\right]}{\left(m_Q - \overline{Q}_{n_1}\right)\overline{Q}_{n_1}};\ \overline{m}_{Q_1} = \frac{m_Q}{1+\gamma_1};\ \overline{Q}_{n_1} = \frac{Q_{n_1}}{1+\gamma_2};\ \gamma_1 = \frac{\lambda_1}{\mu_1};\ \gamma_2 = \frac{\lambda_2}{\mu_2};$$

γ_1, γ_2 – coefficients of accidents of above-hopper and under-hopper conveyers; λ_1, μ_1 and λ_2, μ_2 – parameters of failures and recoveries of above-hopper and under-hopper conveyers accordingly;

when $m_Q \le Q_{n_1}$

$$m_{c_1} = \left[\frac{1 + \dfrac{(Q_{n_1} - \overline{Q}_{n_1})}{(\overline{Q}_{n_1} - \overline{m}_{Q_1})}\left(1 - e^{A_{21}\gamma V_1}\right)}{1 + \gamma_2 e^{A_{21}\gamma V_1} + \dfrac{(Q_{n_1} - \overline{Q}n_1)}{(\overline{Q}_{n_1} - \overline{m}_{Q_1})}\left(1 - e^{A_{21}\gamma V_1}\right)}\right]\overline{m}_{Q_1}, \tag{3}$$

where $A_{21} = \dfrac{\mu_2\left[\overline{m}_{Q_1}(1+\gamma_2) - Q_{n_1}\right]}{\overline{m}_{Q_1}\left(Q_{n_1} - \overline{m}_{Q_1}\right)}$.

Consider now system of serial connection of two first hoppers of scheme with serial connection of hoppers (fig. 3).

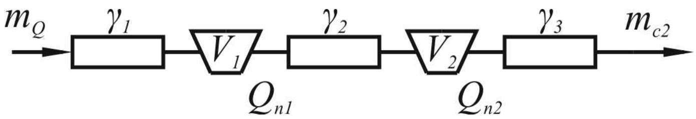


Fig. 3. System of serial connection of two first hoppers

Let’s replace this scheme with simple system «conveyer – hopper – conveyer» where the input of above-hopper conveyer is cargo of medium productivity m_Q (fig. 4).

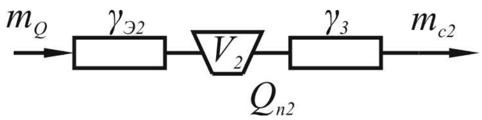


Fig.4.Equivalent scheme «conveyer – hopper – conveyer»

Coefficients of accident of above-hopper conveyer is equal to some equivalent value $\gamma_{э2}$. Average value of carrying capacity m_{c2} on the exit of equivalent scheme according to [12], is determined from formula:

when $m_Q > Q_{n_2}$

$$m_{c_2} = \left[\frac{\dfrac{e^{A_{12}\gamma V_2}}{\gamma_{э_2}} + \dfrac{\overline{m}_{Q_2}}{(\overline{m}_{Q_2} - \overline{Q}_{n_2})}\left(e^{A_{12}\gamma V_2} - 1\right)}{1 + \dfrac{e^{A_{12}\gamma V_2}}{\gamma_{э_2}} + \dfrac{\overline{m}_{Q_2}}{(\overline{m}_{Q_2} - \overline{Q}_{n_2})}\left(e^{A_{12}\gamma V_2} - 1\right)} \right] \overline{Q}_{n_2}, \qquad (4)$$

where $A_{12} = \dfrac{\mu_1\left[m_Q - (1 + \gamma_{э_2})\overline{Q}_{n_2}\right]}{\left(m_Q - \overline{Q}_{n_2}\right)\overline{Q}_{n_2}}$; $\overline{m}_{Q_2} = \dfrac{m_Q}{1 + \gamma_{э_2}}$; $\overline{Q}_{n_2} = \dfrac{Q_{n_2}}{1 + \gamma_3}$;

$\gamma_{э_2} = \dfrac{m_Q}{m_{c_1}} - 1$; $\gamma_3 = \dfrac{\lambda_3}{\mu_3}$;

when $m_Q \le Q_{n_2}$

$$m_{c_2} = \left[\frac{1 + \dfrac{(Q_{n_2} - \overline{Q}_{n_2})}{(\overline{Q}_{n_2} - \overline{m}_{Q_2})}\left(1 - e^{A_{22}\gamma V_2}\right)}{1 + \gamma_3 e^{A_{22}\gamma V_2} + \dfrac{(Q_{n_2} - \overline{Q}_{n_2})}{(\overline{Q}_{n_2} - \overline{m}_{Q_2})}\left(1 - e^{A_{22}\gamma V_2}\right)} \right] \overline{m}_{Q_2}, \qquad (5)$$

where $A_{22} = \dfrac{\mu_2\left[\overline{m}_{Q_2}(1 + \gamma_3) - Q_{n_2}\right]}{\overline{m}_{Q_2}\left(Q_{n_2} - \overline{m}_{Q_2}\right)}$; $\overline{m}_{Q_2} = m_{c_1}$; $\overline{Q}_{n_2} = \dfrac{Q_{n_2}}{1 + \gamma_3}$.

Continuing this process *n* times (*n* – number of hoppers in system), we come to recurrence formulas:

when $m_Q > Q_{n_i}$

$$m_{c_i} = \left[\frac{\dfrac{e^{A_{1i}\gamma V_i}}{\gamma_{э_i}} + \dfrac{\overline{m}_{Q_i}}{(\overline{m}_{Q_i} - \overline{Q}_{n_i})}\left(e^{A_{1i}\gamma V_i} - 1\right)}{1 + \dfrac{e^{A_{1i}\gamma V_i}}{\gamma_{э_i}} + \dfrac{\overline{m}_{Q_i}}{(\overline{m}_{Q_i} - \overline{Q}_{n_i})}\left(e^{A_{1i}\gamma V_i} - 1\right)} \right] \overline{Q}_{n_i}, \qquad (6)$$

where $A_{1i} = \dfrac{\mu_c\left[m_Q - (1 + \gamma_{э_i})\overline{Q}_{n_i}\right]}{\left(m_Q - \overline{Q}_{n_i}\right)\overline{Q}_{n_i}}$; $\overline{m}_{Q_i} = \dfrac{m_Q}{1 + \gamma_{э_i}} = m_{c_{i-1}}$; $\overline{Q}_{n_i} = \dfrac{Q_{n_i}}{1 + \gamma_{i+1}}$;

$\gamma_{э_i} = \dfrac{m_Q}{m_{c_{i-1}}} - 1$; $\gamma_i = \dfrac{\lambda_i}{\mu_i}$; $(i = 1,n;$ $m_{c_0} = \dfrac{m_Q}{1 + \gamma_1}$; $\mu_c = \mu_i)$;

when $m_Q \le Q_{n_i}$

$$m_{c_i} = \left[\frac{1 + \dfrac{(Q_{n_i} - \overline{Q}_{n_i})}{(\overline{Q}_{n_i} - \overline{m}_{Q_i})}\left(1 - e^{A_{2i}\gamma V_i}\right)}{1 + \gamma_{i+1} e^{A_{2i}\gamma V_i} + \dfrac{(Q_{n_i} - \overline{Q}_{n_i})}{(\overline{Q}_{n_i} - \overline{m}_{Q_i})}\left(1 - e^{A_{2i}\gamma V_i}\right)} \right] \overline{m}_{Q_i}, \qquad (7)$$

where $A_{2i} = \dfrac{\mu_c\left[\overline{m}_{Q_i}(1+\gamma_{i+1}) - Q_{n_i}\right]}{\overline{m}_{Q_i}\left(Q_{n_i} - \overline{m}_{Q_i}\right)}$; $\overline{m}_{Q_i} = m_{c_{i-1}}$; $\overline{Q}_{n_i} = \dfrac{Q_{n_i}}{1+\gamma_{i+1}}$; ($i = 1,n$;

$m_{c_0} = \dfrac{m_Q}{1+\gamma_1}$; $\mu_c = \mu_i$).

In this case carrying capacity of entire conveyer transport system with serial connection of hoppers is determined on n-th iteration by formula:

$$m_c = m_{c_n}, \tag{8}$$

where n – number of hoppers in system.

Consider now system conveyer transport system with parallel connection of hoppers (fig. 5).

For this system as in previous case using self-similarity of its structure we will obtain recursive ratios

when $m_{Q_i} > Q_{n_i}$

$$m_{c_i} = \left[\frac{\dfrac{e^{A_{1i}\gamma V_i}}{\gamma_i} + \dfrac{\overline{m}_{Q_i}}{(\overline{m}_{Q_i} - \overline{Q}_n)}\left(e^{A_{1i}\gamma V_i} - 1\right)}{1 + \dfrac{e^{A_{1i}\gamma V_i}}{\gamma_i} + \dfrac{\overline{m}_{Q_i}}{(\overline{m}_{Q_i} - \overline{Q}_{n_i})}\left(e^{A_{1i}\gamma V_i} - 1\right)}\right]\overline{Q}_{ni}, \tag{9}$$

where $A_{1i} = \dfrac{\mu_c\left[m_{Q_i} - (1+\gamma_i)\overline{Q}_{n_i}\right]}{\left(m_{Q_i} - \overline{Q}_{n_i}\right)\overline{Q}_{n_i}}$; $\overline{m}_{Q_i} = \dfrac{m_{Q_i}}{1+\gamma_i}$; $\overline{Q}_{n_i} = \dfrac{Q_{n_i}}{1+\gamma_{0_i}}$; $\gamma_i = \dfrac{\lambda_i}{\mu_i}$;

when $m_{Q_i} \le Q_{n_i}$

$$m_{c_i} = \left[\frac{1 + \dfrac{(Q_{n_i} - \overline{Q}_{n_i})}{(\overline{Q}_{n_i} - \overline{m}_{Q_i})}\left(1 - e^{A_{2i}\gamma V_i}\right)}{1 + \gamma_{0_i} e^{A_{2i}\gamma V_i} + \dfrac{(Q_{n_i} - \overline{Q}_{n_i})}{(\overline{Q}_{n_i} - \overline{m}_{Q_i})}\left(1 - e^{A_{2i}\gamma V_i}\right)}\right]\overline{m}_{Q_i}, \tag{10}$$

where $A_{2i} = \dfrac{\mu_c\left[\overline{m}_{Q_i}(1+\gamma_{0_i}) - Q_{n_i}\right]}{\overline{m}_{Q_i}\left(Q_{n_i} - \overline{m}_{Q_i}\right)}$; $\overline{m}_{Q_i} = \dfrac{m_{Q_i}}{1+\gamma_i}$; $\overline{Q}_{n_i} = \dfrac{Q_{n_i}}{1+\gamma_{0_i}}$; $i = 1,n$;

$\mu_c = \mu_i$.

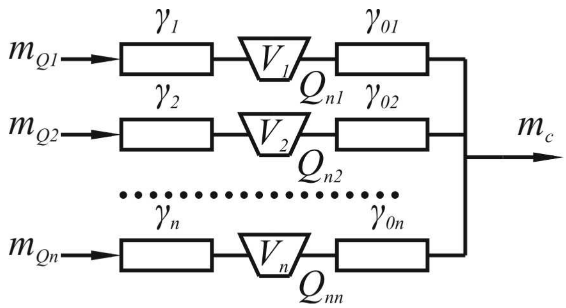


Fig. 5. Calculation scheme of parallel connection of hoppers

In this case carrying capacity of entire conveyer transport system with parallel connection of hoppers is determined by formula:

$$m_c = \sum_{i=1}^{n} m_{c_i} \ , \qquad (11)$$

where n – number of hoppers in system.

For dendritic harp structure of hoppers connection (fig. 6) average value of carrying capacity of conveyer transport system also is determined by same formalas (9) and (10), where values of coefficient of accident γ_{0_i} of above-hopper conveyer is replaced by value of coefficient of accident γ_0 made-up conveyer ($\gamma_{0_i} = \gamma_0$, $i = 1,n$).

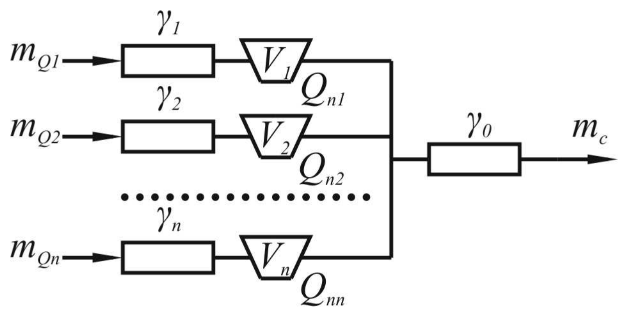


Fig. 6. Calculation scheme of harp structure of hoppers connection

Consider self-similar dendritic structure of conveyer transport system with hoppers (fig. 7).

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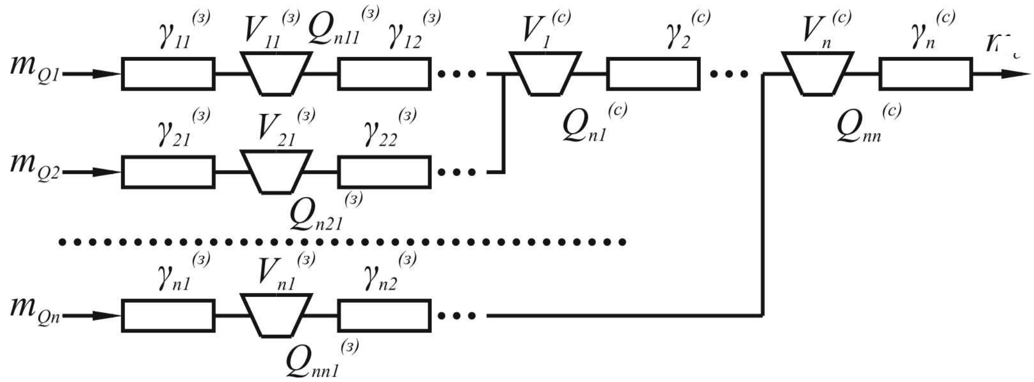

Fig. 7. Calculation scheme of self-similar dendritic structure of hoppers connection

For this system using self-similarity of structure as in previous cases we will obtain recursive ratios which determine average carrying capacity of the system:

when $m_{Q_i} > Q_{n_i}$

$$m_{c_i} = \left[\frac{ \dfrac{e^{A_{1i}\gamma V_i^{(c)}}}{\gamma_{э_i}^{(c)}} + \dfrac{m_i^{(s)}}{(m_i^{(s)} - \overline{Q}_{n_i}^{(c)})}\left(e^{A_{1i}\gamma V_i^{(c)}} - 1\right) }{ 1 + \dfrac{e^{A_{1i}\gamma V_i^{(c)}}}{\gamma_{э_i}^{(c)}} + \dfrac{m_i^{(s)}}{(m_i^{(s)} - \overline{Q}_{n_i}^{(c)})}\left(e^{A_{1i}\gamma V_i^{(c)}} - 1\right) } \right] \overline{Q}_{n_i}^{(c)}, \tag{12}$$

where $A_{1i} = \dfrac{\mu_c\left[m_i^{(s)}(1+\gamma_{э_i}^{(c)}) - (1+\gamma_{э_i}^{(c)})\overline{Q}_{n_i}^{(c)}\right]}{\left[m_i^{(s)}(1+\gamma_{э_i}^{(c)}) - \overline{Q}_{n_i}^{(c)}\right]\overline{Q}_{n_i}^{(c)}}$; $\gamma_{э_i}^{(c)} = \dfrac{\sum_{k=1}^{i} m_{Q_k}}{m_i^{(s)}} - 1$;

$m_i^{(s)} = m_{c_{i-1}} + \dfrac{m_{Q_i}}{1+\gamma_{э_i}^{(з)}}$; $\overline{Q}_{n_i}^{(c)} = \dfrac{Q_{n_i}^{(c)}}{1+\gamma_{i+1}^{(c)}}$; $m_{c0} = 0$; $\mu_c = \mu_i$; $i = 1,n$;

$\gamma_i^{(c)}$ – coefficients of accidents of shafts paths with hoppers; $\gamma_{э_i}^{(c)}$ – equivalent coefficients of accidents of shafts paths with hoppers; $\gamma_{э_i}^{(з)}$ – equivalent coefficients of accidents of faces paths with hoppers;

when $m_{Q_i} \le Q_{n_i}$

$$m_{c_i} = \left[\frac{ 1 + \dfrac{(Q_{n_i}^{(c)} - \overline{Q}_{n_i}^{(c)})}{(\overline{Q}_{n_i}^{(c)} - m_i^{(s)})}\left(1 - e^{A_{2i}\gamma V_i^{(c)}}\right) }{ 1 + \gamma_{i+1}^{(c)} e^{A_{2i}\gamma V_i^{(c)}} + \dfrac{(Q_{n_i}^{(c)} - \overline{Q}_{n_i}^{(c)})}{(\overline{Q}_{n_i}^{(c)} - m_i^{(s)})}\left(1 - e^{A_{1i}\gamma V_i^{(c)}}\right) } \right] m_i^{(s)}, \tag{13}$$

where $A_{2i} = \dfrac{\mu_c\left[m_i^{(s)}(1+\gamma_{i+1}^{(c)}) - Q_{n_i}^{(c)}\right]}{m_i^{(s)}\left(Q_{n_i}^{(c)} - m_i^{(s)}\right)}$, ($\mu_c = \mu_i$; $i = 1,n$).

Here efficient coefficients of accidents of faces paths with hoppers are determined by formulas:

$$\gamma_{э_i}^{(з)} = \frac{m_{Q_i}}{m_{c_i}^{(з)}} - 1, \ (\gamma_{э_1}^{(c)} = \gamma_{э_1}^{(з)}, \ i = 1,n), \tag{14}$$

where $m_{c_i}^{(з)}$ – average carrying capacity i-th face path of conveyer transport system with hoppers which are determined as in (6) and (7).

Average carrying capacities of faces paths $m_{c_i}^{(з)}$ are determined by formulas (6)–(8) for serial connection of faces conveyers with hoppers.

To determine minimum and maximum values of carrying capacities mentioned above conveyer transport systems with hoppers set up in above recursive formulas values $V_i = 0$ and $V_i \to \infty$ accordingly to minimum and maximum values. In result we obtain:

– for serial hoppers connection:

when $m_Q > Q_{n_i}$

$$\frac{Q_{n_1} \cdot Q_{n_2} \cdot \ldots \cdot Q_{n_n}}{m_Q^{n-1} \cdot \prod_{i=1}^{n+1}(1+\gamma_i)} \le m_c \le \frac{Q_{n_n}}{1+\gamma_{n+1}}; \tag{15}$$

when $m_Q \le Q_{n_i}$

$$\frac{m_Q}{\prod_{i=1}^{n+1}(1+\gamma_i)} \le m_c \le \frac{m_Q}{1+\gamma_1}; \tag{16}$$

– for parallel hoppers connection:

when $m_{Q_i} > Q_{n_i}$

$$\sum_{i=1}^{n} \frac{Q_{n_i}}{(1+\gamma_i)(1+\gamma_{0_i})} \le m_c \le \sum_{i=1}^{n} \frac{Q_{n_i}}{1+\gamma_{0_i}}; \tag{17}$$

when $m_{Q_i} \le Q_{n_i}$

$$\sum_{i=1}^{n} \frac{m_{Q_i}}{(1+\gamma_i)(1+\gamma_{0_i})} \le m_c \le \sum_{i=1}^{n} \frac{m_{Q_i}}{1+\gamma_i}; \tag{18}$$

– for harp hoppers connection:

when $m_{Q_i} > Q_{n_i}$

$$\frac{1}{1+\gamma_0}\sum_{i=1}^{n}\frac{Q_{n_i}}{1+\gamma_i} \le m_c \le \frac{1}{1+\gamma_0}\sum_{i=1}^{n} Q_{n_i}\,; \tag{19}$$

when $m_{Q_i} \le Q_{n_i}$

$$\frac{1}{1+\gamma_0}\sum_{i=1}^{n}\frac{m_{Q_i}}{1+\gamma_i} \le m_c \le \sum_{i=1}^{n}\frac{m_{Q_i}}{1+\gamma_i}\,; \tag{20}$$

– for self-similar hoppers connection with dendritic structure

when $m_{Q_i} > Q_{n_i}$

$$m_c^{(0)} \le m_c \le \frac{Q_{n_n}}{1+\gamma_{n+1}^{(c)}}\,; \tag{21}$$

when $m_{Q_i} \le Q_{n_i}$

$$m_n^{(t)} \le m_c \le \sum_{i=1}^{n}\frac{m_{Q_i}}{1+\gamma_i^{(з)}}\,, \tag{22}$$

where $m_c^{(0)}$ – average carrying capacity of conveyer transport system with dendritic self-similar structure when $V_i^{(c)} = 0$, and $V_{ij}^{(з)} = 0$; $m_n^{(t)}$– carrying capacity of conveyer transport system with dendritic self-similar structure without hoppers [3]; $\gamma_i^{(з)}$ – equivalent coefficient of accident in faces paths without hoppers determined by formulas (14) when $V_{ij}^{(з)} = 0$ (i=1,n; j=1,k_i, k_i – number of hoppers in i-th face path).

Carrying capacity $m_n^{(t)}$, according to [3], is determined by recursive formulas:

$$m_n^{(t)} = \frac{m_{n-1}^{(t)}}{1+\gamma_{n+1}^{(c)}}\,, \tag{23}$$

where $m_{n-1}^{(t)} = \dfrac{m_{n-2}^{(t)}}{1+\gamma_n^{(c)}} + \dfrac{m_{Q_n}}{1+\gamma_n^{(з)}}$; …; $m_1^{(t)} = \dfrac{m_0^{(t)}}{1+\gamma_2^{(c)}} + \dfrac{m_{Q_2}}{1+\gamma_2^{(з)}}$;

$m_0^{(t)} = \dfrac{m_{Q_1}}{1+\gamma_1^{(з)}}$ ($\gamma_1^{(c)} = \gamma_1^{(з)}$).

Here $m_i^{(t)}$ – average carrying capacity of conveyer transport system with self-similar structure without hoppers after i-th iteration.

Based on obtained analytical expressions we made calculations of carrying capacity of conveyer transport system with self-similar structure with (see fig. 7).

The initial data and results of calculations are given in tables 1 and 2.

In tables 1 and 2 we show results of calculation of carrying capacity by formulas (13) and (14) when $m_{Q_i} > Q_{n_i}$ and $m_{Q_i} \le Q_{n_i}$ accordingly.

From tables 1 and 2 it is clear that when $m_{Q_i} \le Q_{n_i}$ carrying capacity of conveyer transport system is 5 times higher than when $m_{Q_i} > Q_{n_i}$.

Calculations on the basis of obtained ratios showed that with increasing of accumulative hoppers volume carrying capacity of conveyer transport system of different structure increases but when volume of hoppers is $V_i^{(c)} \ge 500$ m^3 and $V_i^{(з)} \ge 500$ m^3 carrying capacity almost doesn't change.

Table 1 – Initial data and results of calculation of carrying capacity in case when $m_{Q_i} > Q_{n_i}$ (n=5; k_i = 5)

m_{Q_i}, t/min	$Q_{n_i}^{(c)}$, t/min	$Q_{n_i}^{(з)}$, t/min	$\gamma_i^{(c)}$	$\gamma_{ij}^{(з)}$	μ_i, 1/min	$V_i^{(c)}$, m^3	$V_{ij}^{(з)}$, t/min	$m_i^{(s)}$, t/min	m_c, t/min
5,6	5,0	5,0	0,037	0,193	0,054	300,0	100,0	3,14	4,42
5,6	5,0	5,0	0,037	0,193	0,054	300,0	100,0	4,56	
5,6	5,0	5,0	0,037	0,193	0,054	300,0	100,0	4,57	
5,6	5,0	5,0	0,037	0,193	0,054	300,0	100,0	4,48	
5,6	5,0	5,0	0,037	0,193	0,054	300,0	100,0	4,42	

Table 2 – Initial data and results of calculation of carrying capacity in case when $m_{Q_i} \le Q_{n_i}$ (n=5; k_i = 5)

m_{Q_i}, t/min	$Q_{n_i}^{(c)}$, t/min	$Q_{n_i}^{(з)}$, t/min	$\gamma_i^{(c)}$	$\gamma_{ij}^{(з)}$	μ_i, 1/min	$V_i^{(c)}$, m^3	$V_{ij}^{(з)}$, t/min	$m_i^{(s)}$, t/min	m_c, t/min
5,6	6,0	6,0	0,037	0,193	0,054	300,0	100,0	4,28	20,69
5,6	6,0	6,0	0,037	0,193	0,054	300,0	100,0	8,53	
5,6	6,0	6,0	0,037	0,193	0,054	300,0	100,0	12,61	
5,6	6,0	6,0	0,037	0,193	0,054	300,0	100,0	16,75	
5,6	6,0	6,0	0,037	0,193	0,054	300,0	100,0	20,69	

In addition calculations of limit values of carrying capacity of set type of conveyer transport system of self-similar dendritic structure showed that in when m_{Q_i} = 5,6 t/min and Q_{n_i} = 5 t/min ($m_{Q_i} > Q_{n_i}$) carrying capacity has minimal value $m_{c\min} = m_c^{(0)} = 0{,}25$ t/min when $V_i^{(c)} = V_{ij}^{(з)} = 0$ and maximal value $m_{c\max} = 4{,}8$ t/min when $V_i^{(c)} = V_{ij}^{(з)} = \infty$.

When m_{Q_i} =5,6 t/min and Q_{n_i} = 6 t/min ($m_{Q_i} < Q_{n_i}$)carrying capacity has minimal value $m_{c\min} = m_c^{(t)}$ = =8,72 t/min when $V_i^{(c)} = V_{ij}^{(з)} = 0$ and maximal value $m_{c\max}$ = 23,47 t/min when $V_i^{(c)} = V_{ij}^{(з)} = \infty$.

Conclusions. On the basis on method of dynamics of medium for markov process we obtained mathematical models of conveyer transport system functioning with serial and parallel connection of hoppers and also with self-similar dendritic structure that allow to determine carrying capacity of coal mines conveyer transport system.

It was found that if average carrying capacity from lavas of cargo m_{Q_i} is higher than batcher productivity Q_{n_i} ($m_{Q_i} \geq Q_{n_i}$), then carrying capacity of conveyer transport system is much lower than carrying capacity in case when $m_{Q_i} < Q_{n_i}$.

Moreover, with increasing of accumulative hoppers volume to certain value carrying capacity of conveyer transport system increases, but when values of volume are higher from that value – almost doesn’t change.

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