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# Computer model of electric drive of 1L100K conveying unit

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**Abstract.** The paper deals with the problems of vibration damping and limiting dynamic loads in the electromechanical system of a belt conveyor by means of an adjustable electric drive. A conveying unit is represented as a three-mass ring system, which corresponds to a conveying unit with cinematically closed tape. The development of the structure of the control system for electric drives of belt conveyors with limited dynamic loads in elastic elements will reduce the dynamic loads on the belt and therefore the wear of the belts. Conditions of damping of oscillations in electromechanical system of belt conveyors are defined.

## 1 Introduction

The goal of research is determination of conditions of vibration damping in electromechanical system (EMS) of belt conveyors. It may be considered as homogeneous body consisting of elastic bars with distributed mass, which are subject to action of dry and viscous friction. Elastic vibration propagation in such bars is described by second-order partial differential equations.

Analysis of mechanical properties and synthesis electric drive control system is practically impossible at such description of elastic properties of the belt. It is convenient to perform analysis and synthesis when conveyor belt is presented in the form of lumped masses. At that, number of lumped masses is selected from condition of matching of main natural frequencies of vibrations in system with lumped masses and system with distributed masses.

Researches in this area show that at number of masses equal to six, main natural vibration frequencies correspond to system with distributed masses. Analysis at such number of masses is rather difficult because of high order of differential equations. If vibration damping in the belt with achievement of aperiodic nature of transition process will be provided by means of controlled electric drive, then it is sufficient to apply three-mass electromechanical system.

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## 2 Materials and Methods

Conveying unit may be presented in the form of three-mass calculation model. Kinematic diagrams with three masses may be conditionally divided into linear diagrams and ring diagrams [1-7]. Ring electromechanical systems (hereafter EMS) correspond to conveying unit with kinematically closed belt.

Ring kinematic chain is characterized by third rigidity with $c_3$ coefficient, which (unlike linear rigidity) realizes elastic connection between outermost masses. Natural vibration frequency of the first mass in this case is defined by expression $\Omega_1 = \sqrt{(c_1 + c_3)/J_1}$ .

To visualize and evaluate dynamic loads resulting from vibrations in the belt of conveying unit, it is necessary to perform computer modelling (MATLAB application package, Simulink subsystem), using parameters of block diagram of TEMS with ring kinematic chain.

Belt conveyor 1L100K is considered as simulation object. This type of conveyor is designed for transportation of rock mass with coal lump size not more than 300 mm and solid not more than 150 mm on rectilinear in plan mine workings with inclination angle from minus 16° to plus 18°.

Technical characteristics of 1L100K according to are shown in Table 1.

**Table 1.** Technical characteristics of 1L100K belt conveyor

| Parameters of conveying unit | 1L100K |
|---|---|
| Belt speed, m/s | 1.6 |
| Maximum output, t/h | 475 |
| Intake capacity, $m^3$/min | 9.9 |
| Belt width, mm | 1000 |
| Driving drum diameter, mm | 800 |
| Quantity of driving drums | 1 |
| Quantity of driving motors | 1 |
| Reducing gear ratio | 40 |
| Maximum conveyor length, m | 1000 |
| Conveyor belt length, m | 810 |
| Roller diameter, mm | 127 |

Conveying unit utilizes fabric-ply belt of 2ShTK-200-4,5x3,5 type which parameters are shown in Table 2.

**Table 2.** Parameters of fabric-ply belt of 2ShTK-200-4,5x3,5 type

| Parameters of fabric-ply belt | 2ShTK-200-4,5x3,5 |
|---|---|
| Specific gravity, kg/$m^3$ | 18.4 |
| Dynamic module of elasticity, N/$m^2$ | $1.65 \cdot 10^7$ |
| Quantity of spacers, pcs | 4 |

Driver of conveying unit is equipped with asynchronous motor of BP280S4. Parameters of the motor are shown in Table 3.

**Table 3.** Technical characteristics of asynchronous motor of BP280S4 type

| **Parameters of asynchronous motor** | **BP280S4** |
|---|---|
| Rated power, kWt | 110 |
| Stator nominal power, V | 380/660 |
| Stator nominal current, A | 200/116 |
| Nominal efficiency factor | 93.5 |
| Nominal power factor | 0.89 |
| Nominal synchronous rotation frequency, rpm | 1500 |
| Nominal slip | 0.01 |
| Locked-rotor current ratio | 6.8 |
| Initial starting torque ration | 2.0 |
| Torque capacity | 2.8 |
| Rotor momentum of inertia, kg·m$^2$ | 2.93 |

Technical parameters of driving motor power supply are three-phase circuit 50 Hz, 660 V.

Electric drive is equipped with explosion-proof frequency converter of PChV-K-110 U5 with the following technical characteristics (Table 4).

**Table 4.** Technical characteristics of explosion-proof frequency converter of PChV-K-110 U5 type

| **Parameters of frequency converter** | **PChV-K-110 U5** |
|---|---|
| Nominal voltage, V | 660 |
| Circuit frequency, Hz | 50 |
| Rated power, kWt | 110 |
| Current overload ration (60s) | 1.5 |
| Frequency regulation range, Hz | 0 - 200 |

Flow-chart of control system of three-mass electromagnetic system (TEMS) of conveying unit with ring kinematical scheme containing elastic mechanical constraints is shown in Fig. 1.

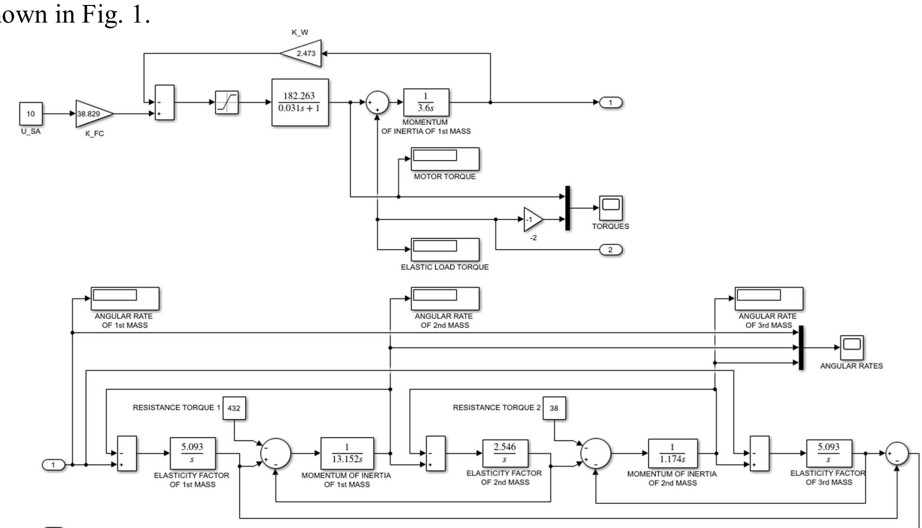


**Fig. 1.** The flow-chart of the control system of a three-mass electromechanical system of a conveyor system with an ring kinematic scheme containing elastic mechanical connections, implemented in the MATLAB application software package (Simulink subsystem).

## 3 Results and Discussion

Graphs of transient processes of open-loop control system of 1L100K conveying unit obtained during simulation in *MATLAB* application package (*Simulink* subsystem) are presented in Fig. 2.

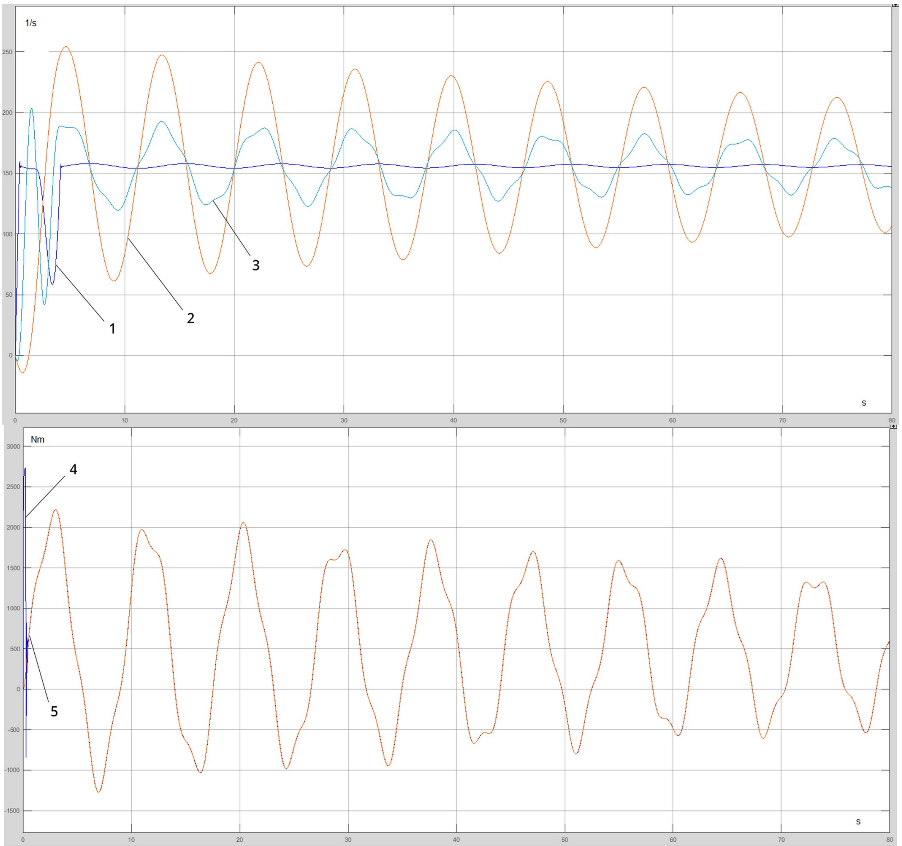


**Fig. 2.** Transient processes graphs of the open-loop control system of the 1L100K conveyor system, obtained by modeling in the MATLAB application package (Simulink subsystem).

## 4 Conclusions

1. Mathematical model of elastically connected electromagnetic system is developed. The model takes into account and interrelates coordinates of electric drive and working body of belt conveyor.
2. Interrelation between parameters of electric drive and executive body of mechanism.
3. As a result of solving simultaneous equation of sixth order it was determined that fulfilling of conditions (15) of vibration damping is impossible in the overwhelming

majority of conveying unit operation. So it is necessary create control system providing fulfilling of assigned conditions by means of changes of regulation parameters.
4. Model of conveying unit with ring kinematic chain containing elastic mechanical connections is developed. The model is implemented in MATLAB application package (Simulink subsystem).

## References

1. V.N. Fashchilenko, *Development of the structures of the control system for an adjustable electric drive of mine belt conveyors* (Moscow Mining Institute, Moscow, 1986)
2. V.N. Fashchilenko, A.A. Ivanov, *Mathematical modeling of control systems of frequency-controlled electric drive of mine belt conveyors // Improving the design, manufacturing technology and operation of mining equipment and automation equipment* (Moscow Mining Institute, Moscow, 1992)
3. V.S. Kostyuk, L.P. Volkova, V.N. Fashchilenko, *Adjustable electric mine installations* (Moscow Mining Institute, Moscow, 1984)
4. A.V. Lyakhomsky, V.N. Fashchilenko, *Management of electromechanical systems of mining machines* (Publishing House of Moscow State Mining University, Moscow, 2004)
5. N.G. Pereslegin, *Synthesis of electric drive control systems of multi-mass mechanisms with elastic coupling / Automated electric drive* (Atomic Energy Pub., Moscow, 1990)
6. V.I. Klyuchev, U.A. Mateev, E.K. Perepichienko, Electrotechnical Industry. Ser. Electric drive, 7:96, **1-6** (1981)
7. L.A. Plashchanskiy, M.M. Kholmogorov, Mining science and technology, **1**, 20-23 (2016)