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ELECTROMECHANICAL CONVERTER FOR DRYING AND PROCESSING OF COAL CONCENTRATES AND SLUDGES

Presented by the study of the influence holes of rotor on dynamic characteristics, which was carried out on the basis of comparing the characteristics of the electromechanical converter with smooth and perforated rotor.

Key words: *electromechanical converter, coal concentrate, drying, dynamic characteristics, perforated rotor, torque, inductance.*

Introduction. Of all the processed coal at concentrating plants most of the enriched wet methods. Therefore, along with ash, sulfur, calorific value, humidity shipped coal is one of the most important indicators of quality. Reducing the moisture content of coal concentrates and sludge due to the decrease in traffic volumes of ballast in the form of excess moisture, preventing freezing in winter and leads to an increase in the efficiency of thermal power plants and industrial boilers.

Among the current trends in the field of scientific research of XXI century include the use of electromechanical converters as a technological chain links for the processing of bulk and viscous materials. A promising class of polyfunctional electromechanical energy converters (PEMC) intended for direct implementation of the technological processes, characterized by enhanced concentration and functional properties of energy and almost full use of the network coming from the electric energy [1]. Creating PEMC and technologies on them is based on the idea of combining in a single electromechanical devices simultaneously heating, transporting, mixing functions, integration of thermal energy and the direction of the latter in the area of raw material processing. In PEMC used construction hollow ferromagnetic rotor (HFR), which serves at the same time the induction motor rotor function, the heater, the actuator and the protective housing. This HFR cooled raw materials, which is recycled. Additional cooling agent can act PEMC air and fusible material with a high heat capacity and latent heat of fusion. PEMC-type screw (fig. 1) consists of two units working in opposition mode. Two stators arranged on a common hollow shaft creates oppositely directed electromagnetic moments, providing the desired speed of the hollow cylinder rotor general without mechanical gearbox. The rotor having a screw beaming, but the displacement of the working of the material at the same time heats the latter. PEMC have no analogues in the world that allows you to create competitive technologies. Figure 2 shows a general view of the experimental sample auger PEMC, which is made at the Electromechanical plant them. Karl Marx (Pervomaisk). Provided minimum heat transfer efficiency in the environment PEMC screw reaches 0.98.

Among the existing devices, the closest in ideology creation are electromechanical converters that combine substances transporting function and the generation of thermal energy. Important results obtained by the authors [2] belongs to the theoretical basis of the principles of designing electromechanical pumping devices. Realized devices such as induction motors with rotating secondary elements with pressure blades, spiral coiling, etc.

In the article [3] presents the principles of structural classification, the methodology of the directed synthesis of electro-mechanical motion converters, combined with a working body – a mechanical screw. The primary part of such converters is represented as a sequence of poles, the polarity of which alternates with concentrated windings forming the active surface of the screw. They have been used in low-speed electric drive power transmission (spindle, lifts, resistant mechanisms, and others).

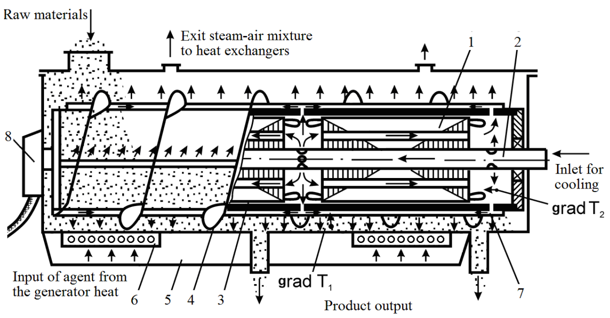

Figure 1 – Constructively-technological scheme:

1 - stator motor (brake) module; 2 - stationary hollow shaft; 3 - outer rotor-screw; 4 - bottom; 5 - the case; 6 - channels for the entrance of the thermal agent; 7 - axial channels of rotor-screw; 8 - input of voltage

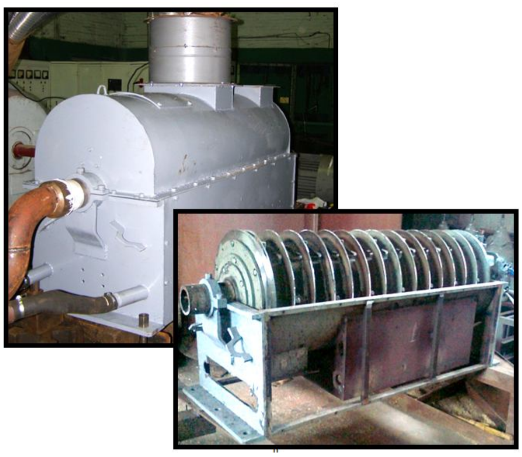

Figure 2 – General view of the experimental sample auger PEMC

The problem and its relation to scientific and practical tasks. Important benefits of technology based on PEMC is not only high value of efficiency, but also a significant reduction in the production area, the number of pieces of equipment and its payback period. In this regard, an important scientific and practical problem is to optimize the design of electromechanical PEMC to perform specific functions of technological purpose, such as, drying and processing of coal slurry and concentrates, as well as extrusion processing of different materials.

PEMC screw design involves air cooling system in which coolant enters the zone coil ends through three groups of radial holes in the rotor. Work converter with special modes of drying and processing requires a predetermined speed-rotor screw. In addition to reducing the intensity of mechanical action on the material, reducing the rotational speed of the screw-rotor because radial holes can result in an unacceptable increase in temperature in the working zone.

The distribution of the magnetic induction in the air gap with a perforated rotor PEMC unlike traditional electric machines is very original character. Discrete arrangement of the holes of the rotor leads to nonuniformities of the magnetic field in the air gap in both axial and tangential directions, as well as to the redistribution of eddy currents in the rotor, which in turn affects the output characteristics of PEMC.

It should be noted that in the domestic and foreign technical literature no work, which would be considered mathematical models and methods of calculation of electromechanical converters with a perforated rotor, and the influence of the perforations of the ferromagnetic rotor on the output characteristics.

Presentation of the material and its results. It is known, the analysis of dynamic modes of motor with a ferromagnetic rotor can be made using the theory of generalized electrical machine, which is based on replacing the real machine - bipolar biphasic symmetrical idealized machine, with orthogonal-governmental windings on the stator and on the rotor (fig. 3). For such a machine valid system of equations consisting of equations of Kirchhoff's equations of the electromagnetic torque and the equation of motion.

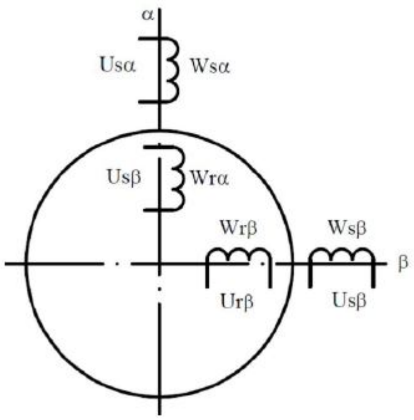

Figure 3 – Generalized electric machine

Inductor windings are calculated using the known expressions. An important feature of the system is the dependence of the parameters of the secondary circuit of the slip, the precise determination of which, based on a generalized theory of electrical machines is not possible. To establish these relationships it is advisable to use a field analysis methods. Investigation of the influence on the ferromagnetic rotor openings form a dynamic mechanical characteristic comparison was performed on the basis of the characteristics of a smooth PEMC perforated rotor and received among «Matlab-Simulink».

The main differences, which are caused by the presence of the perforations and the rotor require consideration in the calculation of the mechanical characteristics PEMC with smooth and perforated cage are the values of the parameters of the ferromagnetic rotor and its moment of inertia. Evaluation particular distribution of eddy currents as the thickness and along the rotor axis is required to calculate and design. However, this eddy current distribution pattern defines the bulk resistance value of the rotor, which plays a pivotal role in the formation of the output characteristics and properties PEMC with a perforated rotor. The resistance of smooth and perforated rotors defined by the results of numerical experiments for various slip values (fig. 4). The inductive reactance was calculated based on the known relationship for ferromagnetic rotor $x_2/r_2 = 0.6$ [6]. Calculation of moments of inertia values was carried out on the basis of three-dimensional geometric models of smooth and perforated rotor using the built-in function «Subdomain Properties» of program «Comsol Multiphysics».

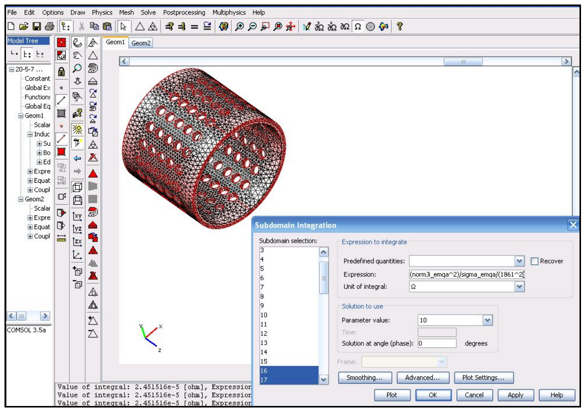

Figure 4 – Determination of the active rotor resistance

Structure of a model for the study of dynamic mechanical properties PEMC hollow ferromagnetic rotor, working as part of generator heat systems. Actually the model of the object of research is rolled into a subsystem (Subsystem), fed from a source (Source). To measure and build dependencies torque and speed are units Scope and Graph. Lookup Table block is used to set the function of the load torque. For machines with the fan load, gradually increase as the speed of the moment of resistance, it can be represented as a nonlinear function

$$M_o(s) = M_d \cdot \left(\frac{n}{n_{nom}}\right)^2 + M_r, \qquad (1)$$

where M_d – design moment resistance at $n = n_{nom}$; $M_r = (0.05 \div 0.1)M_d$.

Only static pressure arises in the case of PEMC the closed valve. In this case, the performance is equal to zero. In the case of gradually opening the valve, part of the energy is converted into rotational energy of motion of the medium, and the initial pressure will be reduced. Therefore, the pressure dependence of the performance (torque of the speed) will take the form of a falling curve. Theoretically, the point of intersection with the axis of the performance curve is achieved if the transported medium contains the energy of motion and there is no static pressure. The operating point is located at the intersection of PEMC characteristics and performance of the system.

Undoubtedly, the main factor determining the difference of mechanical characteristics PEMC with smooth and perforated cage are the values of the active and inductive resistance of the rotor. Introduction of the rotor moves the perforation characteristics PEMC down parallel to itself. In this case, the operating point, moving along the system characteristic, take the lower position, therefore, a decrease in the flow developed by reduced pressure.

Figure 5 shows the dynamic mechanical properties PEMC with smooth and perforated cage, clearly demonstrating the process at the start of the fan load.

From the simulation results show that PEMC characteristic hollow perforated rotor is operating point at lower values of torque and speed, respectively, of its work will be accompanied by large losses and heating.

Start PEMC accompanied by a surge of short duration and the time at the time of its pulsations (fig. 6), which are more pronounced for PEMC with smooth rotor. The amplitude of the starting torque PEMC perforated rotor is 27% less than the starting torque PEMC amplitude with smooth rotor. At the same time to steady state in both cases is almost the same and is about $t \approx 0.4$ seconds.

Depending smooth angular velocity of the rotor and perforated PEMC of time are shown in fig. 7. In both cases, the acceleration process is rapid and takes place virtually without pulsations.

Figure 8 shows temporal comparisons depending electromagnetic torque (a) and angular velocity (b) of the base rotor induction motor when starting the fan with the load.

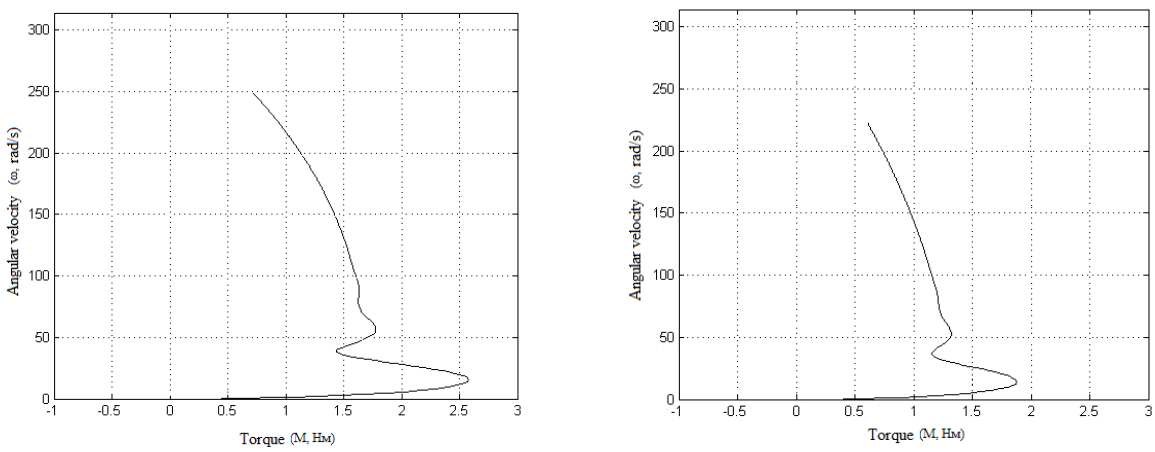

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Figure 5 – Dynamic mechanical characteristics PEMC: with smooth hollow rotor (a); with hollow perforated rotor (b)

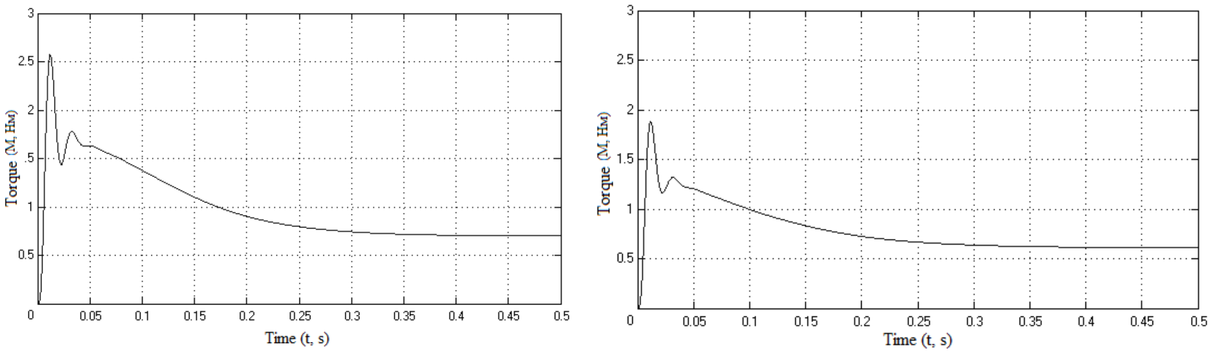

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Figure 6 – Dependence of M = f(t) at the start PEMC: with smooth hollow rotor (a); with hollow perforated rotor (b)

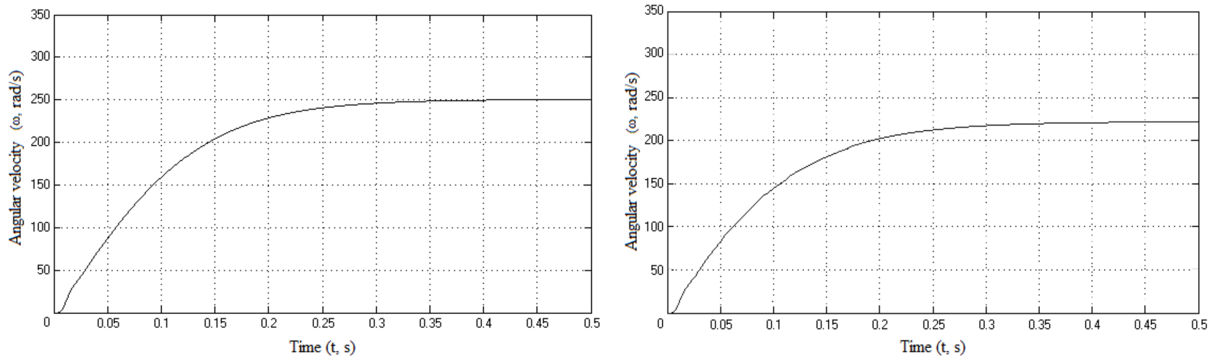

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Figure 7 – Dependence of ω = f(t) at the start PEMC: with smooth hollow rotor (a); with hollow perforated rotor (b)

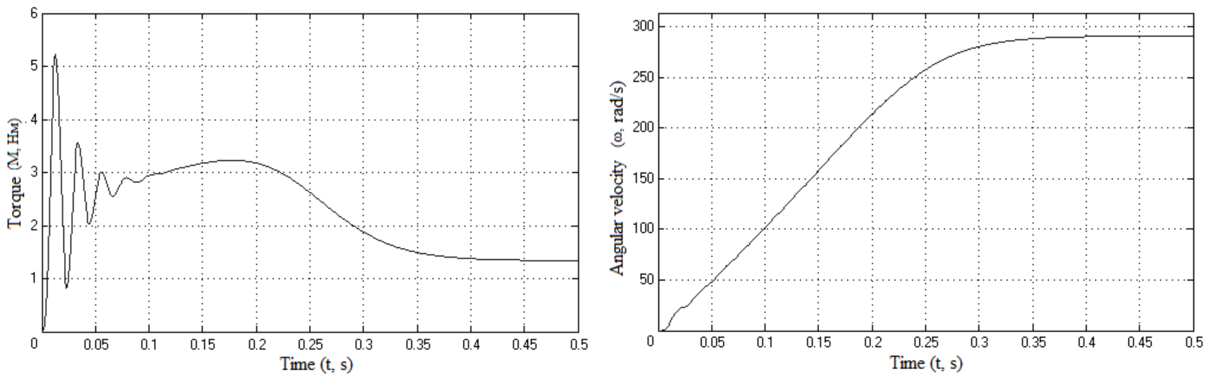

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Figure 8 – Dependence of M = f(t) and ω = f(t) of induction motor (base) at start-up with the fan load

Conclusions and directions for further research. In comparison with the starting base of the induction motor, PEMC start with a hollow ferromagnetic rotor differs substantially smaller amplitude and the number of fluctuations of the electromagnetic shock moment. Thus, PEMC start with a hollow ferromagnetic rotor can be viewed as a softer and therefore more favorable in terms of reducing water hammer and mechanical loads on the actuator.

An approach to the calculation of the dynamic characteristics of the electromechanical converter with a hollow ferromagnetic rotor, comprising the combination of the generalized theory of electrical machines with numerical solution of finite element method in three-dimensional statement. This approach was tested by comparing the calculated and experimental data obtained for the physical model of the converter with a hollow ferromagnetic rotor.

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ЕЛЕКТРОМЕХАНІЧНИЙ ПЕРЕТВОРЮВАЧ ДЛЯ СУШКИ І ПЕРЕРОБКИ ВУГІЛЬНИХ КОНЦЕНТРАТІВ І ШЛАМІВ

Представлено дослідження впливу отворів ротора на форму динамічних характеристик, яке проводилося на базі порівняння характеристик електромеханічного перетворювача з гладким і перфорованим ротором.

Ключові слова: *електромеханічний перетворювач, вугільний концентрат, сушка, динамічні характеристики, перфорований ротор, момент, індуктивність.*

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ЭЛЕКТРОМЕХАНИЧЕСКИЙ ПРЕОБРАЗОВАТЕЛЬ ДЛЯ СУШКИ И ПЕРЕРАБОТКИ УГОЛЬНЫХ КОНЦЕНТРАТОВ И ШЛАМОВ

Представлено исследование влияния отверстий ротора на форму динамических характеристик, которое проводилось на базе сравнения характеристик электромеханического преобразователя с гладким и перфорированным ротором.

Ключевые слова: *электромеханический преобразователь, угольный концентрат, сушка, динамические характеристики, перфорированный ротор, момент, индуктивность.*