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EXPERIMENTAL RESEARCH OF ELECTRIC MULTIFUNCTIONAL AGGREGATE FOR POULTRY FARMING WASTES PROCESSING

N. N. Zablodskiy, doctor of technical sciences
e-mail: zablodskiynn@gmail.com
National University of Life Environmental Sciences of Ukraine
V. E. Pliugin, candidate of technical sciences
National Technical University "Kharkiv polytechnic institute"
e-mail: vlad.plyugin@gmail.com

Annotation. *Results of numerical experiments on determination of interrelated electromagnetic and thermal fields in the active area of multifunctional electromechanical converter and test results of multifunctional electric aggregate for poultry farming wastes processing experimental unit are brought.*
Key words: ***electric multifunctional aggregate, experimental unit, electromagnetic field, thermal integration***

Alternative energy sources in the economy of the world countries and also in Ukraine are acquiring a greater value. At the same time in Ukraine there is a wide scale development of the poultry farming which requires creation of technologies and equipment for wastes utilization with its processing in high-quality fertilizers. Modern processing technologies are developed in two directions: anaerobic wastes fermentation with the receipt of biogas and by-product (sludge); wastes heat treatment and further usage in an agro-industrial complex as aquatic solution. Each of these technologies requires the determined amount of equipment and entail the considerable expenses of energy [1, 2, 3]. Therefore, actual task is creation of a new class of electrical engineering complexes and energy saving friable substances processing technologies on their basis.

The purpose of research is parameters and performance experimental determination of electrical multifunctional aggregate for growing and poultry farming wastes drying.

Researches material and methodology. In different branches of industry there is determined amount of technological processes, which present operations of transporting, growing, interfusion shallow are in, homonisation and substance heat treatment. For such processes the new class of multifunctional electromechanical converter with structural, functional and thermal integration is created [4,5]. In accordance with methodology [4] with the use of initial data and requirements of technical task, thermal and hydrodynamic calculations are executed. Results of calculations must be as shown below:

- amount of thermal energy, necessary for substance drying;

- geometrical sizes of external rotor-screw;

- mechanical power and loading performance at transporting and growing of material.

On the basis of structural and functional integration principles we delegate to the nodes of multifunctional electric screw aggregate (MESA) the next basic functions of technological system (TS) devices:

- to the external solid rotor - executive mechanism (screw), basic heater element, external shell of IM;

- to the system of stators of the moving and brake units with general solid rotor-screw - asynchronous drive with a mechanical reducing gear.

The next design step is forming of preliminary distribution diagram of basic MESA thermal and substance exchange streams. In accordance with thermal streams integration principle in MESA, it is necessary to distribute in advance thermal powers (hot utilities) between active parts, to set the temperature gradients orientation, eliminate formation of "cold areas", and also to divide thermal and substance exchange streams on "hot" and "cold". The example of such distribution, where directions of streams are inflicted on the structural chart of MESA diagram is shown on fig. 1. Practically all MESA internal nodes and details are the sources of hot utilities, where "hot" streams outcomes. Stream of processed material we consider as a "cold" stream, in which at moving along the rotor-screw there is an increase of thermal capacity, temperatures, and also moisture evaporation process.

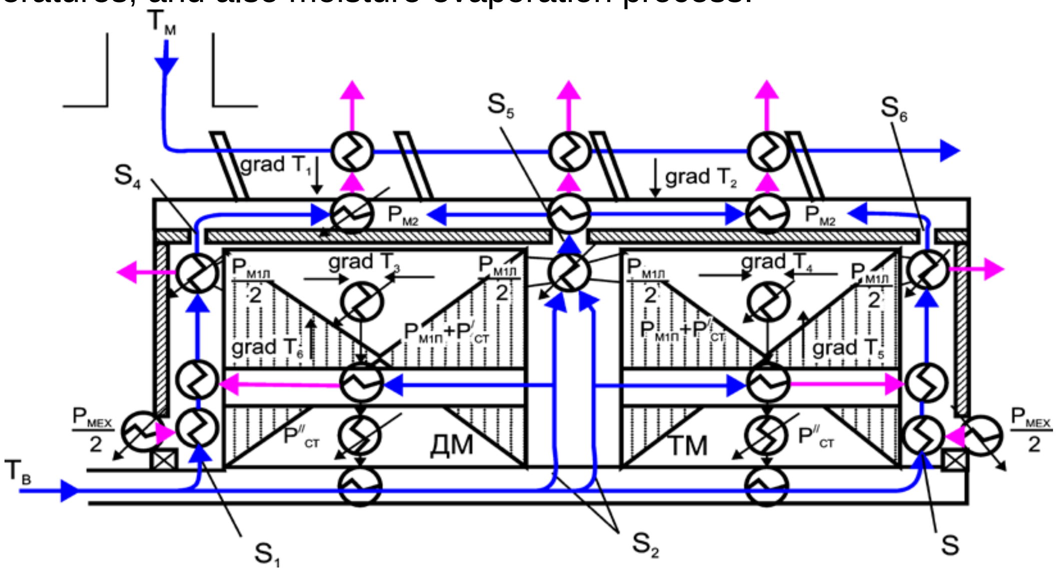

Fig. 1. "Cold» and «Hot» streams dominate directions diagram

MESA unit structure is formed taking into account recommended rotation speed and obtained in preliminary calculations mechanical and thermal powers. The method of speed reduction providing with the usage of the Braking Unit (BU) working in opposite direction mode, i.e. forming of low rotor rotation speed without mechanical reducing gears and frequency converter is offered. Processed material, in combination with the internal cooling system executes the functions of MESA loading-cooling environment. A basic way for "hot" streams integration is creation of additional parallel “cold” air stream with the maximally possible amount of branches in the area of MESA active parts location.

Forming of such directions in the branches of additional «cold» stream is assisted by the correct selection of outlet ducts crossing in the hollow shaft *S1-S3*, rotor ducts *S4-S6*and axial ducts in stators of Moving Unit(MU) and BU. Due to the intensive mixing, creation of the pseudo rarefied layer, complex influence of thermal stream and acoustic ultrasonic vibrations along all length of spiral screw growing, effective heat exchange and evaporation of moisture are occurring. Intensity of both heat exchange and apparat mass-transfer is regulated due to the frequency selection, voltage value, phases order of separate inductors and high-pressure ventilator productivity.

The generalized MESA mathematical model (MM)is based on the use of general fundamental equations of MESA winding circuit, equations of the physical fields in an active area and equations of movable part motion [6, 7, 8].

Regard to the complicated active area configuration of the MESA units, non-linearity of materials physical properties formulated MM can be solved only by numerical methods. Practical realization of MESA mathematical model is made within the framework of programmatic-calculable complexes Comsol Multiphysics, Ansys Maxwell, and research of the dynamic modes – in the software package Matlab / Simulink.

Basic tests of experimental unit are intended for the determinations of drying aggregate working ability, determination of its real performance, basic parameters and efficiency. At unit creation methodology of the object-oriented design [9] and technical decisions in accordance with a patent [10] was applied. The general view of MESA experimental unit for poultry farming wastes processing on fig. 2 is shown.

Fig. 2. The Experimental MESA unit

Measuring of mode parameters by means of informatively-measuring complex which consists from PC and connection unit with external objects was made.

For measuring of currents active values of the separate units and full current “Sturm MM 1202”multimeter with clamps was used. The moving electromagnetic part of clamp embraces a corresponding cable in the terminal box.

The actual rotation speed value of frequency of rotor-screw was determined with noncontact digital universal photo-tachometer ATT-6006, mounted above the loading pipe unit.

Telemetering of moving parts and MESA aggregate housing temperature was made with digital infra-red thermometer of IR608. Measuring of stator parts temperatures was made with copper-constantan thermocouples mounted inward the stator and connected to the 12-channel variplotter. Control of processed material humidity and temperature was made before its loading in the aggregate, and also after every processing cycle with digital temperature-moisture measuring device “AMPROBE IR 608A”. Control movable parts of MESA motion and processed material was made with video camera. All registered values were synchronized in time. Control of air moving speeds in aggregate inlet, in the loading and unloading pipe units coupling and entrance to the heat-exchange system were made with anemometer.

Research results. The feature of MESA functioning is its work at allow rotor rotation speed in the conditions of instability resistance torque. The working rotor slip range for the Moving Unit is s = 0,85...0,95 and for a Braking Unit–respectively s = 1,05…1,15. Known in classic theory calculation methods of induction machines mechanical performance do not provide necessary accuracy of MESA electromagnetic torque in interval of big slip. Such calculation with the exact account of current displacement effect in a solid rotor, nonlinear magnetic permeability and influence of temperature is possible only with the methods of field theory. Thus the real slip value is obtaining by imposition of mechanical diagrams of units and loading resistance.

Calculation picture of the electromagnetic field of the first unit in start time (slip s = 1) is shown on fig. 3. Curve lines are represented isolines of vector magnetic potential, and currents intensity is represented by different background colors. Maximal induced currents density on the surface of solid rotor at s = 1 gains a value 42 А/мм^2.

At the mutual moving of magnetic-field and electric conductive environment eddy currents on the surface of environment and in its depth differ not only in a value but also in time phase. It is good evidently from fig. 4, where instantaneous s eddy currents density distribution on the depth of solid rotor at start time is shown.

On fig. 5 the temperature distribution in the transversal MESA crossing at long time rotor duffing (steady state short-circuit mode s = 1) on condition that the down rotor part is submerged in a friable material. It goes out from the presented results, that a temperature in the down solid rotor part gains a value 45 °C. The temperature of stator winding does not reach a limited value.

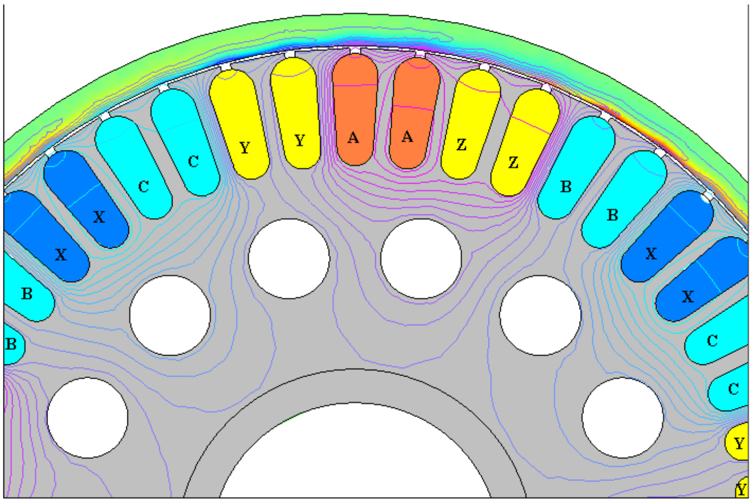

Fig. 3. Electromagnetic field distribution in MESA unit at start time

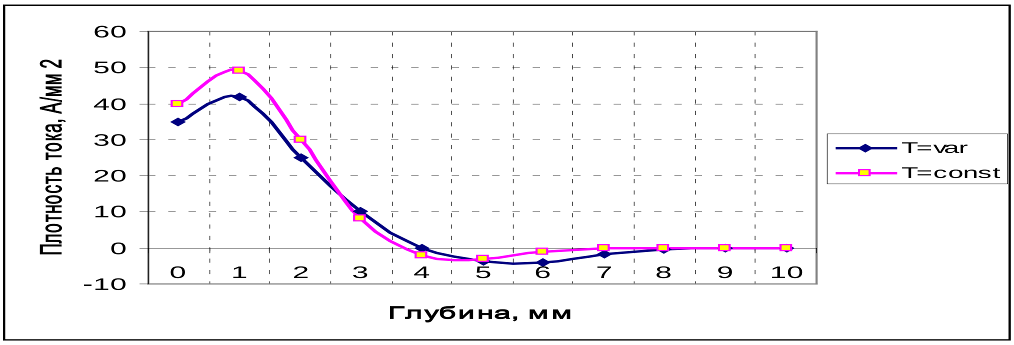

Fig. 4. Distribution of current density on the depth of solid rotor

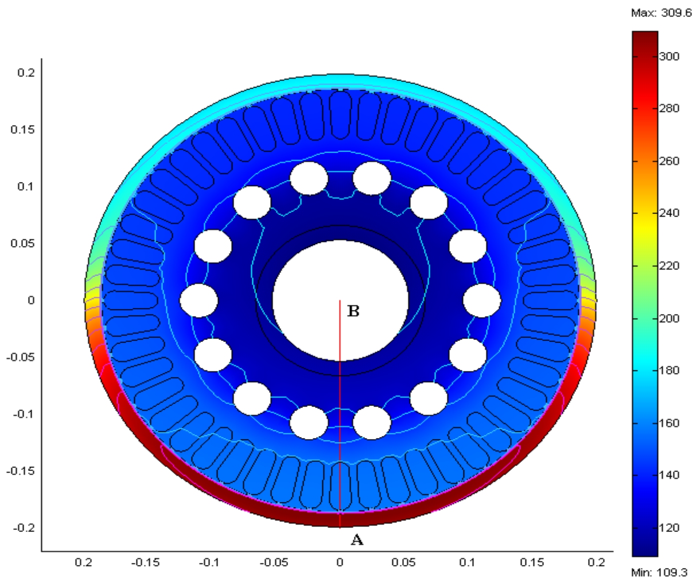

Fig. 5. Temperature distribution in MESA transversal crossing

On the whole worked out mathematical model provides high authenticity of design results. Below in a table for comparison is presented experimental and calculation values of electromagnetic torques of the moving and braking MESA units in the short-circuit mode (s = 1).

MESA electromagnetic torque values

Unit	Calculation, T_{EM}(Nm)	Experiment, T_{EM}(Nm)
Moving	702	666
Braking	496	452

On fig. 6 transient dependences of MESA experimental unit basic values of at step-by step rotor-screw loading up to its complete stop.

Determination of processed material moving disposition in respectively to rotor-screw is a most important information for structural improvements and increase of material drying process efficiency. On fig. 7 instantaneous position of material is presented in the drying box is shown. Distribution of air coolant is determined foremost by air speeds along a vent path.

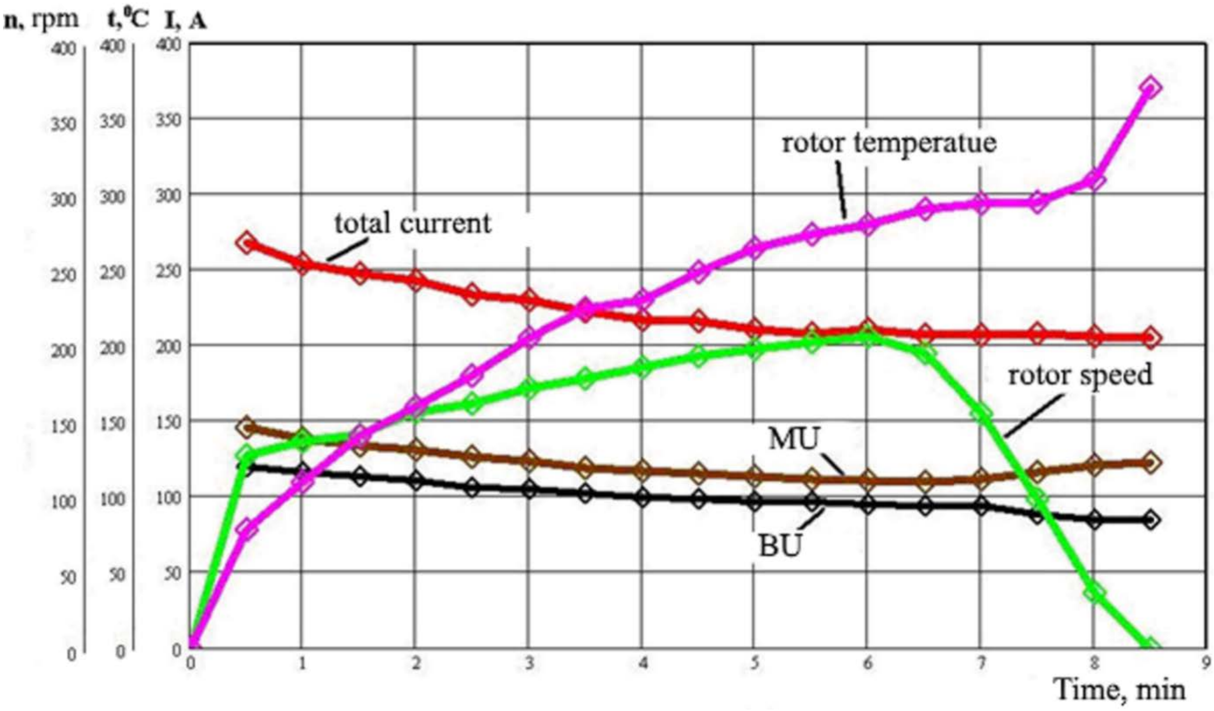

Fig. 6. MESA basic dependences values at sequential work from idle mode up to loading till the complete stop

Registered following speed values: air speed at hollow shaft inlet – 9,2 m/s; air speed at drawing unit coupling inlet – 5,8 m/s; air speed at rotor sprayers outlet- 2,7 m/s.

At wastes processing of in the cyclic mode (screw reversing) one cycle time is 12 s. The registered humidity decrease for one cycle is about 8% at the screw productivity 1.2 tons/hour. Electric power consumption on one kilogram of the evaporated moisture is 0.5 kW/kg.

Comparison of wastes grain-size before and after processing in MESA specifies on the intensive growing process which takes place in a drying box – the particles (6–10) mm are ground down to (0.8–1.2) mm.

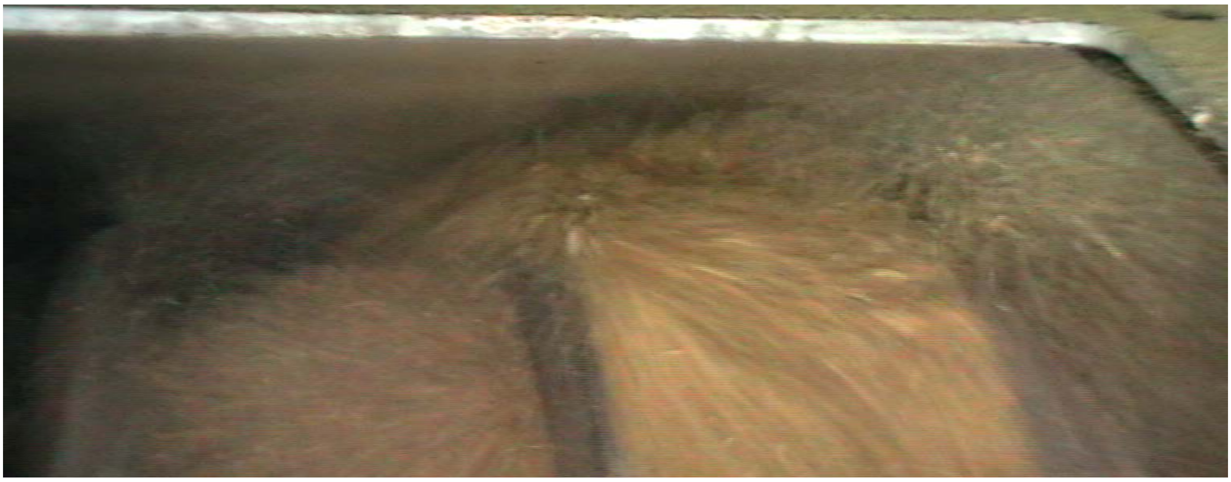

Fig. 7. Instantaneous material positions (*n* = 110 rpm)

As a result of drying providing the increasing of thermal-substance exchange surface, diminishing of particles drying time, fast particles extirpation from the drying area by the heat stream agent.

Conclusions

Electromechanical transients in MESA are closed actually after 155 ms, that much lower than in IM of traditional construction; at the same time multifunctional electromechanical converter with a solid rotor has a higher quality factor.

The most important conclusion from tests results and researches of experimental unit is MM adequacy and confirmation of basic aggregate performance values: considerable (in twice) diminishing of aggregate energy consumption on specific evaporated moisture value in comparing to the existent drying aggregates (approximately 0.5 kW/kg of evaporated moisture); providing the necessary productivity of substances processing; diminishing of the industrial area; process ecological cleanness.

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ЕКСПЕРИМЕНТАЛЬНІ ДОСЛІДЖЕННЯ ЕЛЕКТРИЧНОГО ПОЛІФУНКЦІОНАЛЬНОГО АГРЕГАТА ДЛЯ ПЕРЕРОБКИ ВІДХОДІВ ПТАХІВНИЦТВА

М. Н. Заблодський, В. Е. Плюгін

Анотація. *Наведено результати чисельних експериментів з визначення взаємопов'язанних електромагнітних і теплових полів в активній зоні поліфункціонального електромеханічного перетворювача та результати випробувань експериментального зразка електричного поліфункціонального агрегата для переробки відходів птахівництва.*

Ключові слова: ***електричний поліфункціональний агрегат, експериментальний зразок, електромагнітне поле, теплова інтеграція***

ЭКСПЕРИМЕНТАЛЬНЫЕ ИССЛЕДОВАНИЯ ЭЛЕКТРИЧЕСКОГО ПОЛИФУНКЦИОНАЛЬНОГО АГРЕГАТА ДЛЯ ПЕРЕРАБОТКИ ОТХОДОВ ПТИЦЕВОДСТВА

М. Н. Заблодский, В. Е. Плюгин

Аннотация. *Приведены результаты численных экспериментов по определению взаимосвязанных электромагнитных и тепловых полей в активной зоне полифункционального электромеханического преобразователя и результаты испытаний экспериментального образца электрического полифункционального агрегата для переработки отходов птицеводства.*

Ключевые слова: ***электрический полифункциональный агрегат, экспериментальный образец, электромагнитное поле, тепловая интеграция***