Project name: IRN No. AP09259673 "Development of an intensive device for drying, grinding, mixing particles of feed flour from animal waste."

Relevance: as you know, the development of farm animals and birds, as well as food meat and dairy products, depends on meeting the needs of farm animals and birds for nutrients and biologically active substances. One of the full-fledged components in mixed fodders is fodder meal of animal origin. Of particular importance in increasing the production of feed flour is the use of non-food raw materials, veterinary confiscated products, etc., which form the so-called waste. In the production of feed flour, the most important processes are drying, grinding and mixing. An analysis of drying equipment at the present stage allows us to state that an effective means of intensifying and improving the quality of drying is to combine drying with grinding and mixing in one apparatus, which allows you to increase the rate of heat and mass transfer, reduce production costs and obtain high-quality homogeneous feed from various animal waste origin. In addition, the combination of grinding with mixing and drying allows for sufficiently deep dehydration of the material and the possibility of mixing several components, excluding the preliminary sorting of raw materials, but in a number of such installations there are drawbacks, which is very relevant.

Purpose: development, design and implementation of an intensive device for drying, grinding, mixing particles of feed flour from animal waste.

Expected results: Up to 7-10 main factors influencing the combined process of drying with grinding and mixing in the production of animal feed meal will be identified. A mathematical model of the process of heat and mass transfer and segregation will be developed. An experimental study of the thermophysical and physical-mechanical properties of waste and feed meal of animal origin will be carried out. Patents included in the Derwent Innovations Index database (Web of Science, Clarivate Analytics) will be applied for. Design documentation will be developed for a prototype device for drying, grinding, mixing feed flour particles from animal waste. A prototype device for drying, grinding, mixing feed flour particles from animal waste will be obtained. The results of research will be published in articles and (or) reviews in peer-reviewed scientific journals, indexed in the Science Citation Index Expanded Web of Science and (or) with a CiteScore percentile in the Scopus database of at least 35 (thirty-five), in an article or review in a peer-reviewed scientific publication that is included in the 1 (first) or 2 (second) quartile in the Web of Science database and (or) has a CiteScore percentile in the Scopus database of at least 65 (sixty-five), as well as in articles or reviews in a peer-reviewed foreign or domestic edition recommended by the Committee for Quality Assurance in Science and Higher Education, books and monographs. A pilot sample of a device for drying, grinding, mixing feed meal particles from animal waste will be tested. It will be produced using a designed device for drying, grinding and mixing a batch of bone and meat and bone meal of 1, 2, 3 grades and a study was carried out for compliance with the current GOST 17536-82 "Fodder meal of animal origin". A license agreement for an intellectual property object will be concluded. Scientific,

technical, design documentation will be developed in accordance with the requirements of a unified system of technological and design documentation, current standards and regulatory documents for serial production and implementation of a device for drying, grinding and mixing with the elimination of all kinds of risks. The results will be presented at conferences or seminars (forums).

Results achieved: the factors influencing the process of drying, grinding and mixing were identified. The circle of main and secondary factors influencing the process of drying, grinding and mixing has been determined. This is the temperature of the drying agent in the working zones of drying, grinding and mixing; the rate of supply of the drying agent to the working zones of drying, grinding and mixing; rotational speed of crushing strikers and mixing blades; the type of raw materials loaded into the device for drying, grinding, mixing (size, moisture and fat content, density, etc.); duration of processes; passive zones; design parameters (design of impact elements and blades, design of impact elements, number of impact elements and blades, clearance between impact and impact elements, holes in replaceable sieve, etc.). These factors are important and interrelated in the operation of the device for drying, grinding, mixing. As part of the development of a mathematical model, the differential equation of heat and mass transfer in partial derivatives of cylindrical coordinates, as well as boundary and initial conditions are written. Possible ways of solving the obtained equations by approximate methods are shown. A review is made of a possible spontaneously proceeding segregation process, when there is a redistribution of the composition of the bone mass by size and heterogeneous layers are formed. The ways of technical overcoming of the segregation process are indicated. The influence of the speed of the drying agent on the homogeneity index of the ground and mixed material is shown. As a result of a series of research experiments, data on the thermal conductivity of greaves and fodder bone meal were obtained, on the basis of which experimental graphs were constructed. The average value of thermal conductivity according to the research data was λshk. = 0.1100 W / (m * K) for greaves, λkm. = 0.0830 W / (m * K), respectively. The calculated data on the temperature conductivity of greaves and fodder bone meal were obtained. The average conductivity temperature for greaves at a density of 1000 kg / m^3 and a specific heat capacity at a temperature of 20 ° C - 583 J / (kg * K) was ashk = 18.6 * 108 m^2 / s. The average conductivity temperature for fodder bone meal at a density of 880 kg / m^3 and a specific heat capacity at a temperature of 20 ° C - 1717 J / (kg * K) was accm = 5.5 * 108 m^2 / s. Based on the data obtained, the following conclusions were drawn in relation to the dependences a = f (pH) and a = f (W): with a change in the bulk density, the bulk heat capacity has a decisive influence on the temperature conductivity coefficient of greaves and fodder bone meal, and with a change in humidity, the thermal conductivity coefficient. It has been established that the operating mode of the device for drying, grinding and mixing depends on the moisture content in the object being processed. It was revealed that with a decrease in moisture in the processed object, the thermal conductivity coefficient decreases and, therefore, the heating temperature should be increased to t = 120-250 ° C, depending

on the duration of drying. The dependence of the rheological properties of waste raw materials of animal origin on the duration of time and temperature and humidity has been obtained experimentally.Based on the axioms and hypotheses, it was revealed that the drying time also depends on the area of the newly formed surface in the processed object and the degree of grinding, tending to increase i = 4-7. Based on the results of the research, applications for inventions were submitted to the National Institute of Intellectual Property of the Republic of Kazakhstan and the Eurasian Patent Office.

A general view of the structural and technological scheme of the device for drying, grinding and mixing has been developed (including the axonometry of the device). Technical requirements for the device for drying, grinding and mixing (experimental sample) have been prepared. When developing design documentation, the Compass-3D program was used with the necessary calculations. Configurations of a 3D model of the rotor shaft, a 3D model of the body, a 3D model of impact elements, a 3D model of the screw (coils (feathers) on the shaft), a 3D model of the screw assembly in the lower part of the body, and a 3D model of feathers (coils) have been developed. A sketch of the device for drying, grinding and mixing, and a sketch of its kinematic diagram has been made. Sketches of the auger, device body, pipe, auger shaft, rotor shaft, covers, percussion elements, coils (feathers), frame, flanges for the auger and rotor, trunnions were made. Working drawings of the housing, auger, auger shaft, rotor shaft, impact elements, coils (feathers), trunnions, flanges, knives, frame, flanges for auger and rotor, trunnions were made. Completed assembly drawings and a general view of the impact elements, auger, device for drying, grinding and mixing. The working and assembly drawings show the minimum number of dimensions sufficient for the manufacture and control of parts and assemblies. Functional, free and reference sizes are indicated. The drawings indicate the maximum deviations of linear dimensions, geometric shape, as well as errors in the relative position of the axes, surfaces and structural elements of the parts in order to eliminate the harmful effect on the performance of the parts, causing dynamic loads, vibrations, noise, jamming or interference. For the manufacture of a device for drying, grinding and mixing, structural and consumable materials and components were selected and purchased. Based on the developed kinematic scheme, design documentation, calculations on the volume of the loaded mass of raw materials, theoretical studies and necessary technical and economic calculations, using the knowledge and skills of the research team members, qualified specialists and craftsmen, using metal-cutting machines and tools, welding machines, devices and equipment, structural and consumable materials, components, measuring accessories, the design of the device for drying, grinding and mixing was made. The device for drying, grinding and mixing consists of a housing, a pipe for supplying raw materials, a pipe for supplying a drying agent, an outlet window, a horizontally positioned rotating spiral screw with ridge knives, rotating working fingers, and an outlet tubular air duct. During the machining of parts, the calculation of the coefficient of use of materials was carried out. Calculations of turns (feathers) of the screw, geometric

calculation of the selection of the diameter of the screw, selection of the pitch of the turns (feathers) and their number, calculation of the shaft, calculation of general installation dimensions, calculation of impact elements were made. Frame selection completed. Typical calculations were carried out using built-in tools in the Compass 3D application library program. The body walls were made of sheet steel material 4.5 mm thick and connected by welding seams. The frame was made using a channel (size 16). The auger was made from a pipe with a diameter of 102 mm, coils (feathers) with a diameter of 300 mm, knives, pins. Coils (feathers) were welded on the shaft (pipe), while knives were welded on the coils (feathers). The auger is fastened to the housing by means of trunnions and flanges in the housing walls with bolts, washers and nuts. To rotate the auger, 2 sealed bearings 62132RS, a chain drive and a 3 kW helical gear motor are used. In the upper part of the structure, a rotor shaft is provided, which is fixed with the help of flanges, bolts, washers, nuts, and rotates by means of 2 GOST 107 sealed bearings and a worm gear motor with a power of 1.5 kW. The design provides loading and unloading windows for raw materials and feed mixture, a hole for supplying a drying agent from a heat gun, impact elements, a hole and a pipe for removing moist air. According to the plan, the article "Development Of Mathematical Description Of Mechanical Characteristics Of Integrated Multi-Motor Electrical Drive For Drying Plant" (authors Sultanbek Issenov, Ruslan Iskakov, Kazhybek Tergemes, Zhanat Issenov) was published in the Eastern-European Journal of Enterprise Technologies, (2022) , 1/8(115), 46-54. https://doi.org/10.15587/1729-4061.2021.251232 (SCOPUS per.56). The article "Obtaining a formula describing the interaction of fine particles with an expanding gas flow in a fluid layer" (authors Yessenbay Alpeissov, Ruslan Iskakov, Sultanbek Issenov, Aru Ukenova) was published in the Eastern-European Journal of Enterprise Technologies, (2022), 2/1(116), 87-97. https://doi.org/10.15587/1729-4061.2022.255258 (SCOPUS per.56). Received patent No. 7276, publ. 07/08/2022 MJ RK National institute of intellectual property for the useful model "Device for the production of feed flour of animal origin" (author Iskakov R.M.). Received patent No. 7050, publ. 04/29/2022 MJ RK National institute of intellectual property for the utility model "Impact-splitting hammer for grinding" (author Iskakov R.M.). The article "Analysis of mixing equipment, taking into account the segregation of the feed mixture and its uniformity" was published in the publishing house of the Karaganda Technical University, the republican journal "Proceedings of the University", 3 (88) 2022. - P. 53-60 (Committee for Quality Assurance in Science and Higher Education) (authors Iskakov R.M., Isenov S.S., Abilzhanuly T., Kubentaeva G.K., Kasym R.T.). Technical solutions were tested at the international scientific and practical conference "Seifullinskie readings-18 (2)" "Science of the XXI century - the era of transformation" and published in the form of a thesis "Technical devices for grinding animal waste" (author Iskakov R.M.), 1 v., 1 hour, 2022. - P. 218-219. Received a patent for invention No. 35954 "Device for drying, grinding and mixing particles of feed flour from waste of animal origin", publ. November 25, 2022 MJ RK National institute of intellectual property (authors Iskakov R.M., Isenov S.S., Kubentaeva

G.K., Zaichko G.A., Alpeisov E.A.). Received a patent for invention No. 35955 "Hammer for crushing and grinding", publ. November 25, 2022 MJ RK National institute of intellectual property (authors Iskakov R.M., Isenov S.S., Zaichko G.A.). Received a patent for invention No. 35956 "Hammer for grinding", publ. November 25, 2022 MJ RK National institute of intellectual property (authors Iskakov R.M., Kubentaeva G.K., Isenov S.S., Zaichko G.A.).

Automation of the control of the experimental installation equipment (devices for drying, grinding, mixing feed flour particles from animal waste) has been carried out. In particular, it was installed to connect two gear motors and one electric motor of the crusher, connect a heat gun, install and configure a frequency converter, automate all equipment through external push-button posts. A control cabinet has been assembled and installed for automatic control of the experimental installation. The experimental installation was tested at idle and running speed. During the experimental work, the InfiRAY C210 thermal imager with a resolution of 256x192 pixels was used for high-temperature measurement of thermal processes; a universal moisture meter with an AMF038 remote probe for measuring humidity in raw materials and feed flour. The efficiency of heating the heat transfer medium during drying occurs due to heaters and often depends on the heating mode, heat transfer time, heater design configuration, thermal contact of the core with the heated gas medium by convection, thermal conductivity and radiation, heating elements and their power. A classification of the designs of the working surfaces of impact elements for grinding is proposed. The production of feed flour was carried out on an experimental device for drying, grinding and mixing. A method for the production of feed flour has been developed. Experimental studies have been conducted on the developed device for drying, grinding, mixing in order to substantiate the technological processes of leveling the layer, mixing and drying of feed materials. To verify the reliability of theoretical studies, experiments were conducted on a developed device for drying, grinding, and mixing feed flour particles. The results of the experimental determination of the required power showed the value of Ne = 0.273 kW, and the theoretical value of the required power - Nt = 0.286 kW, i.e. the difference between the theoretical and actual value is 4.76%. This proves the reliability of the analytical expression obtained, which provides the definition of the main parameter of the device for drying, grinding, mixing, i.e. the required power. An analytical expression is derived to determine the required power for the process of leveling the feed mass layer, which includes all the design and kinematic parameters of the developed device for drying, grinding, mixing. As a result of processing experimental data, equations for changing the humidity of various feed masses depending on the duration of drying were obtained, and the rates of moisture change of animal feed flour particles were obtained. As a result of processing experimental data, a mathematical model of the drying process of feed flour particles from animal waste was obtained, i.e. a model of intensive heat and mass transfer due to convective drying, screw and finger mixing and simultaneous grinding was obtained. To test the safety indicators of animal feed flour produced using an experimental device for

drying, grinding and mixing, samples of animal feed flour were examined at the testing center of JSC East Kazakhstan Flour and Feed Mill. As a result of the conducted research, test reports were obtained for appearance, odor, mass fraction of moisture, mass fraction of ash, mass fraction of protein, toxicity, presence of pathogenic microorganisms, total number of microbes, bacteria of the Escherichia coli group, bacteria of the genus Salmonella, bacteria anaerobes of animal feed meal samples. The results of the actual values correspond to the norms. A laboratory analysis of the produced animal feed meal was carried out in the laboratory of the technical Faculty. The results of the study of samples of bone feed meal when mixed with the control component showed a homogeneity of mixing of the order of 90.8%. In the course of the research, a sieve analysis of crushed particles of feed flour was carried out using sieves of various diameters. In the samples, the content of particles larger than 3 mm was not detected, and less than 2 mm was not detected. These results are in accordance with GOST 17536-82 "Animal feed flour", i.e. the size of the crushed particles corresponds to 2-3 mm. Moisture determination in samples of produced animal feed meal was performed with a moisture meter and in a drying cabinet. The moisture content in the feed meal samples was no more than 10%, which meets the requirements of the standard. The Eurasian patent for invention No.042280 "Device for drying, grinding and mixing feed meal particles from animal waste" was obtained, publ. 31.01.2023, bul.1 (authors Iskakov R.M., Isenov S.S., Kubentaeva G.K., Zaichko G.A., Alpeisov E.A.). The article "Characteristic features electric heating of the heat transfer medium of a convective dryer" (authors Iskakov R.M., Kubentaeva G.K., Kasym R.T., Akaev A.M.) in the journal "Bulletin of S.Toraighyrov Pavlodar State University", energy series, No. 3 (2022) – pp. 98-109 (KOKSNVO). The article "Investigation of the thermophysical properties of animal feed flour and flakes for the drying process" (authors Iskakov R.M., Isenov S.S., Mergalimova A.K., Mamyrbaeva I.A., Ybray S.) was published in the journal "Bulletin of S.Toraighyrov Pavlodar State University", energy series, No. 1(2023) – S. 145-166 (KOKSNVO). The article "Technologies for the Rational Use of Animal Waste: A Review" (authors Iskakov R., Sugirbay A.) was published in the journal Sustainability (MDPI, Switzerland), 2023, 15(3), 2278: https://doi.org/10.3390/su15032278 ., (SCOPUS per.87, Web of Science Core Collection Q2). The article "Determination of the Average Size of Preliminary Grinded Wet Feed Particles in Hammer Grinders" (authors Iskakov R., Abilzhanuly T., Abilzhanov D., Darkhan, O.) was published in the Eastern-European Journal of Enterprise Technologies, (2023), 1(121), 34-43. https://doi.org/10.15587/1729-4061.2023.268519 (SCOPUS per.47). The article "Impact elements of feed grinder: a review" (authors Iskakov R., Issenov S., Kubentaeva, G.) was published in the journal EUREKA: Physics and Engineering, 2023, (2), 121-148. https://doi.org/10.21303/2461-4262.2023.002820 (SCOPUS per.45). Patent No. 36486 was obtained for the invention "Device for drying, grinding and mixing feed flour particles" (reg. application number 2022/0540.1 dated 09/07/2022, authors Iskakov R.M., Abilzhanuly T., Kubentaeva G.K., Isenov S.S.). The article

"Development of a Layer Leveling Technology that Reduces the Energy Intensity of the Processes of Mixing and Drying the Feeder Mass" (authors Abilzhanuly, T., Iskakov, R., Issenov, S., Kubentaeva, G., Mamyrbayeva, I., Abilzhanov, D., Khaimuldinova, A., Khamitov, N.) was published in Eastern-European Journal of Enterprise Technologies, (2023), 4(7 (124), 106-115. https://doi.org/10.15587/1729-4061.2023.286 325 (SCOPUS per.47, CiteScore 2022, 2.1). The monograph "Drying with grinding and mixing of colloidal capillary-porous materials" was published in the domestic publishing house "ADAL KITAP", Almaty, 2023. - 160 p. (authors Mergalimova A.K., Iskakov R.M., Isenov S.S., Alpeisov E.A., Abilzhanuly T.). The book "Drying of feed" was published in a foreign publishing house "Buk", Kazan, 2023. - 138 p. (authors Iskakov R.M., Userbaev M.T., Abilzhanuly T., Kubentaeva G.K., Mergalimova A.K.). The book "Urdister men apparattar (Processes and apparatuses)" was published in the domestic publishing house "ADAL KITAP", Almaty, 2023. - 160 p. (authors Iskakov R.M., Userbaev M.T., Abilzhanuly T., Kubentaeva G.K., Ukenova A.Zh.). The final report of the entire project has been prepared and approved.

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List of publications and patents published within the framework of this project: (with links to them): -.

Information for potential users: the target consumers of the project results are meat and poultry processing enterprises, farms and livestock farms, feed preparation shops. It is expected that farm animals and poultry will receive the required amount of highly nutritious protein feed, which will have a positive effect on livestock products (milk, meat, etc.) and poultry (eggs, meat, broth, etc.).

Additional information: high social and environmental impact will be obtained.