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**DEVELOPMENT OF EQUIPMENT FOR SEPARATION OF
LIQUID HETEROGENEOUS SYSTEMS**

ABSTRACT

on dissertation work PhD - doctoral student Shayakhmetova M.K.
for the Doctor of Philosophy (PhD) degree in the educational program
8D07101 - Technological machines and equipment

Relevance of the work. In his Address to the people of Kazakhstan, President K. Tokayev paid special attention to the agro-industrial complex. The agricultural sector is becoming more attractive for business. According to the Ministry of Agriculture, the industry has attracted \$3.3 billion (1.3 trillion tenge) in investments over the past five years. One of the priority directions for the development of medium and small enterprises in the country is the development of waste-free raw material processing technologies. Among such productions are medium and small meat processing enterprises. In the waste-free technology of meat products, the production of dry animal feed has higher nutritional value compared to other feed products. In the production of dry feeds at large enterprises, continuous high-performance equipment is widely used for the separation of liquid heterogeneous systems.

However, for small and medium enterprises, which are being developed in the Republic, such continuous equipment with lower productivity is needed. Therefore, the development of such equipment is a highly relevant task. Previously conducted studies were mainly focused on the technological and dynamic aspects of high-performance centrifugation machines used in related industries, particularly in the chemical industry, while there were insufficient studies on machines with small and medium productivity. This is especially relevant for the meat industry, where the processes of centrifugation of liquid systems have been insufficiently studied. This is due to the fact that meat products represent a complex colloidal-disperse system consisting of tightly bound moisture and dry residue, with high adsorption capacity. The qualitative and quantitative characteristics of centrifugation have not been fully studied. Insufficient attention has been paid to the technological features of production alongside the design features of the equipment.

The solution to the goals of this dissertation was based on the research of the following scientists: A.I. Pelev, M.L. Fayvishevsky, S.G. Liberman, V.A. Maslikov, I.A. Rogov, A.V. Gorbatov, A.Ya. Sokolov, Yu.A. Machikhin, M.B. Azarov, U.Ch. Chomanov, D.T. Zhaylaubaev, S.N. Tumenov, A.A. Ospanov, E.S. Spandiaryov, A.B. Ospanov, M.Ch. Tultabaev, S.V. Fedotov, A.E. Erengaliev, A.K. Kakimov, A.L. Kassenov.

The aim of the dissertation work is to improve the design and develop a centrifuge for separating and filtering fat from cracklings.

Tasks of the work:

- Analysis of equipment designs for centrifugation.
- Study of technical characteristics depending on the design parameters of the installation and selection of optimal operating modes.
- Development of a mathematical model for centrifugal filtration.
- Improvement of the centrifugal separation process based on the derivation and use of regression equations. Proof of the validity of the obtained results.
- Development and improvement of the design of a filtering centrifuge for separating fat from cracklings.
- Development and implementation of an engineering method for calculating the centrifuge and auxiliary equipment.
- Conducting industrial testing and implementing the research results into production.

Research objects. The research objects are pork fat, centrifugation, and the separation of fat from cracklings.

Research subject.

- Determination of fat viscosity;
- Determination of rotational speed;
- Selection of time modes.

Research methods. Experimental studies were carried out in the laboratories of the departments «Technological Equipment», «Scientific Center for Radioecological Research», and the Federal State Budgetary Educational Institution of Higher Education «Kemerovo State University».

The experiments used proven research methods, modern instruments and equipment, and methods of mathematical statistical processing of results using software such as MathCAD and Excel.

Scientific novelty of the work.

- A mathematical model of the centrifugal filtration process has been developed, and optimal values of technological parameters have been obtained. The derived regression equations, based on multifactorial analysis, allow for the determination of harmonious process parameters.
- A physical model of the centrifugal filtration process has been developed. Criterion equations have been obtained, which allow calculating optimal material and dynamic parameters of the process.
- Based on the analysis of the developed mathematical and physical models of centrifugal filtration, operational and technological performance

indicators of the centrifuge have been improved when the parameters are correctly selected, taking into account the improved proposed design.

- A methodology for engineering calculations has been proposed, describing the quantitative and qualitative nature of the separation processes of simultaneous centrifugal sedimentation and filtration. The consistency of the results obtained is proven by the correspondence of mathematical and physical modeling results to experimental studies.

- A patent for the invention «Centrifuge for separating liquid heterogeneous systems» was granted on September 9, 2022.

Key points to be defended:

- Results of theoretical and experimental research on separating fat from cracklings in an experimental setup.

- Obtained parameters of the process separation regime for fat from cracklings in the proposed filtering centrifuge.

- Results of engineering calculations of the centrifuge and working bodies.

Scientific and practical significance of the work. The filtering centrifuge, developed with improvements to the fat separation and filtration process from cracklings, was developed and tested at the Semey branch of the «Kazakh Scientific Research Institute of Food Processing and Food Industry».

It was established that the obtained cracklings meet the requirements of GOST 17536-82.

The novelty of the technological solution, including the equipment design to improve the fat removal processes from cracklings, is confirmed by the patent from the Committee for Intellectual Property Rights of the Ministry of Justice of the Republic of Kazakhstan, No. 35832.

Based on experimental and theoretical research, an engineering methodology for calculating equipment for separating liquid heterogeneous systems has been developed for this and similar designs.

Optimal rational modes for the technological process of centrifugal filtration have been obtained.

Author's personal contribution. Development of the design of a filtering centrifuge. Tasks related to physical modeling have been identified and solved. Criterion equations for mass, kinetic, and dynamic characteristics of the process have been derived. The main equation for centrifugal filtration has been obtained. Tasks related to mathematical modeling have been identified and solved. A block diagram for mathematical modeling has been developed.

Testing of practical results. The main findings and results of the work were presented at international scientific and practical conferences: «XVIII Mezinarodnivedecko - praktickaconference, Vedaatechnologie: krokdobudoucnosti» – «Processing of slaughterhouse blood» – (Prague, 2021);

«XVIII Mezinarodnivedecko - praktickaconference, Vedaatechnologie: krokdobudoucnosti» – «The value of feed meal»; «Proceedings of the XVIII International Scientific and Practical Conference, Food. Ecology. Quality» – «Review of centrifugal separation of fat from cracklings» SFNCA RAN (Krasnoborsk 18-19.11.2021); X International Scientific Conference of Students, PhD Students, and Young Scientists Food Innovations and Biotechnology, «Centrifuge for separating fat from cracklings», RINC Kemerovo, 23.06.2022; International Scientific and Practical Conference «Transformation of the AIC of Kazakhstan into the Global Food Hub» – «Modern methods and equipment for feed pelletizing», Semey, 1.04.2022; Conference Proceedings, The V International Science Conference, «Theoretical and Applied Aspects of the Application of Modern Science», «Separation of heterogeneous systems," Tokyo, February 7-9, 2022; Poster presentation on «Development of equipment for separating liquid heterogeneous systems», Semey, 06.04.2022.

Publications. The main content of the dissertation has been published in 18 works, including: 7 works at international conferences; 3 articles in journals recommended by the Committee for Quality Assurance in Education and Science of the Republic of Kazakhstan; 3 articles in the Vestnik of Shakarim University; 2 articles in scientific journals with non-zero impact factors (Scopus and Web of Science databases); 1 patent for an invention and 2 patents for utility models in the Republic of Kazakhstan.

Structure and volume of the dissertation. The dissertation consists of an introduction, five chapters, a conclusion, a list of references, and appendices. The main content of the work is presented on 145 pages of typed text, with 46 figures, 41 tables, and the bibliography includes 81 sources (including 10-15 foreign sources) and appendices.

Evaluation of the completeness of the solutions to the tasks set. The obtained data allow concluding that the goal of the dissertation has been achieved and all the tasks set have been accomplished.

1. A comparative analysis of the designs and characteristics of modern filtering centrifuges made it possible to develop an original experimental vertical filtering centrifuge with screw loading of raw material.

2. Kinetic modes have been determined: $n = 33,333 \text{ s}^{-1}$, $\tau = 600 \text{ s}$, $M_{III} = 0,0283 \text{ kg/s}$, $M_c = 0,1210 \text{ kg/s}$.

3. Theoretical studies of the centrifugation process have been presented in the form of kinetic and material equations.

4. Tasks related to physical modeling have been identified and solved. The physical model of the process has been described. Criterion equations for mass, kinetic, and dynamic characteristics of the process have been obtained. The main equation for centrifugal filtration has been derived.

5. Technical documentation has been developed, and the improved design of the filtering centrifugal installation, whose novelty is confirmed by the patent for the invention in Kazakhstan No. 35832, has been manufactured and implemented.

6. Tasks related to mathematical modeling have been identified and solved. A block diagram of mathematical modeling has been developed. The mathematical model of the process has been described.

7. Industrial testing was carried out at the Semey branch of the «Kazakh Scientific Research Institute of Food Processing and Food Industry». The results are recommended for implementation in small and medium-sized enterprises.