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DESIGNING OPERATING PARAMETERS FOR INNOVATIVE DOUGH MIXING MACHINES FOR DOUGH PREPARATION

ПРОЄКТУВАННЯ ЕКСПЛУАТАЦІЙНИХ ПОКАЗНИКІВ ІННОВАЦІЙНИХ ТІСТОМІСИЛЬНИХ МАШИН ДЛЯ ЗАМІСУ ТІСТА

Pidlisnyj V.V. / Підлісний В.В.
c.t.s., as. prof. / к.т.н.,доц.
ORCID: 0000-0002-4718-7787
Semenov A.M / Семенов О.М.
c.t.s., as. prof. / к.т.н.,доц.
ORCID: 0000-0002-9990-2658
Higher Educational Institution «Podillia State University»,
12, Shevchenko Str., Kamianets-Podilskyi, 32316
Заклад вищої освіти «Подільський державний університет»
вул. Шевченка, 12, м. Кам'янець-Подільський, 32316
Fedoriv V.M. / Федорів В.М.
c.t.s., as. prof. / к.т.н.,доц.
ORCID: 0000-0002-4499-0910
Liukhovets V.V. / Люховець В.В.
c.t.s. / к.т.н.
ORCID: 0000-0002-6978-7820
Lisevych D .V. / Лісевич Д.В.
master / магістр
Khmelnytskyi National University,
11 Instytutska St., Khmelnytskyi, 29016
Хмельницький національний університет,
вул. Інститутська, 11, м. Хмельницький, 29016

Abstract. *Technological progress in the baking industry requires constant modernization of equipment in order to improve product quality, intensify production processes, and reduce energy consumption. Basic dough mixing machines with a spiral mixing element that has a circular cross-section are obsolete because they do not provide the required quality of mixing in a short period of time and cause excessive heating of the dough due to high energy losses. The purpose of this article is to design and justify technical solutions for an innovative high-intensity dough mixer L4-HT-2VM aimed at improving its performance.*

The main result of the design is the development of a three-bladed rotor, the profile of the blades of which is made in the form of an airplane wing with an angle of attack of 450. This innovative solution allows optimizing the mixing and plasticizing processes, significantly reducing the kneading time and minimizing the energy consumption for heating the dough, since the reduced load is compensated by the low braking resistance from the spiral grooves of the bowl. An additional advantage is the automation of dough unloading using a mechanism that tilts the bowl under its own weight without the use of a separate drive. It was concluded that the introduction of the L4-HT-2VM dough mixer in the baking industry will allow for high-quality kneading and increased production efficiency.

Key words: *innovative design, dough mixer, performance indicators, three-bladed rotor, aircraft wing profile, intensive kneading, process automation, energy efficiency, L4-HT-2VM, kneading quality.*

Анотація. *Технологічний прогрес у хлібопекарській промисловості вимагає постійної модернізації обладнання з метою підвищення якості продукції, інтенсифікації виробничих процесів та зниження енергоспоживання. Базові тістомісильні машини зі спіральним місильним органом, який має переріз у формі кола, є морально застарілими, оскільки вони не забезпечують необхідної якості замісу за короткий проміжок часу та спричиняють надмірне нагрівання тіста через високі енергетичні втрати. Метою даної статті є проєктування та обґрунтування технічних рішень для інноваційної високоінтенсивної тістомісильної машини Л4-ХТ-2ВМ, спрямованих на поліпшення її експлуатаційних показників.*

Основним результатом проєктування є розробка конструкції з трилопастним ротором, профіль лопатей якого виконаний у формі крила літака з кутом атаки 45^0. Це інноваційне рішення дозволяє оптимізувати процеси перемішування та пластикації, значно скоротити тривалість замісу та мінімізувати витрати енергії на нагрівання тіста, оскільки зменшене навантаження компенсується малим гальмівним опором від спіральних рифлів діжі. Додатковою перевагою є автоматизація вивантаження тіста за допомогою механізму перекидання діжі під дією власної ваги без використання окремого приводу. Зроблено висновок, що впровадження тістомісильної машини Л4-ХТ-2ВМ на підприємствах хлібопекарської промисловості дозволить досягти високої якості замісу та підвищення ефективності виробництва.

Ключові слова: *інноваційне проєктування, тістомісильна машина, експлуатаційні показники, трилопастний ротор, профіль крила літака, інтенсивний заміс, автоматизація процесу, енергоефективність, Л4-ХТ-2ВМ, якість замісу.*

Introduction.

The quality of the final bakery product is determined by many factors, among which the quality of the dough is of decisive importance. Modern trends require manufacturers not only to ensure high quality, but also to intensify processes and save energy. Existing equipment, in particular dough mixers with a classic spiral mixing mechanism, does not meet these requirements, as their design leads to inefficient mixing, a lengthy kneading process and, as a result, excessive heating of the dough and significant energy losses.

The problem under consideration is the need to develop a technical solution to replace outdated equipment (for example, L4-HT-2V) with an innovative model that can provide high-intensity and high-quality kneading with minimal energy consumption. The purpose of the article is to design the L4-HT-2VM dough mixer and justify design solutions that improve its performance, in particular, improving the quality of kneading, reducing its duration, and fully mechanizing the unloading process [1-2].

Main text.

The dough mixing process is a complex and energy-intensive stage of bread

production. Traditional dough mixers that use spiral-shaped mixing elements do not meet the requirements for high-performance machines, as they are characterized by low efficiency and high energy consumption. Therefore, there is a need to improve existing designs to achieve higher quality kneading and reduce energy consumption. In this context, it is important to develop machines with new types of kneading elements and automated processes [3-4].

The L4-HT-2VM dough mixer was selected for the study, the design of which includes a three-bladed rotor in the form of blades similar in shape to aircraft wings. This design reduces the energy consumption for heating the dough and ensures intensive mixing and plasticization of the components. The research methodology includes a theoretical justification for the choice of kneading organ design, analysis of energy consumption, and testing of the new machine in production conditions. The influence of different machine operating modes on the quality of kneading and the energy performance of the process was also tested.

The design of the L4-HT-2VM dough mixer was based on comparative analysis and the use of bionics principles (application of aircraft wing profile) and fluid and bulk material mechanics to optimize the working process [5-8].

A comparison was made between the operational characteristics of the spiral-shaped dough mixing mechanism (base machine) and the theoretical characteristics of the proposed three-bladed rotor. Geometry optimization method (bionics/aerodynamics): The use of an aircraft wing profile for the blades (angle of attack $\alpha = 45^0$) was justified to minimize drag (braking resistance) while maintaining high mixing and plasticizing efficiency. The formula for calculating the drag force F_{drag} in general:

$$F_{drag} = 0{,}5 \cdot \rho \cdot v^2 \cdot S \cdot C_d \quad (1)$$

where ρ is the density of the medium (dough), v is the velocity, S is the area, and C_d is the drag coefficient. The wing profile ensures minimum C_d with high mass transfer efficiency.

The angle of inclination of the bowl ($\beta = 35^0$) is calculated to ensure maximum

concentration of the dough mass in the working area, allowing the kneading mechanism to act on the dough with maximum efficiency [9-11].

A design of an unloading mechanism based on the principle of counterweight (using the bowl's own weight) for tilting to an angle of 125^0 is proposed, which eliminates the need for an additional drive for this process.

The results of the L4-HT-2VM design confirm the achievement of the set goals for improving operational performance:

1. Improved dough quality (plasticity): Thanks to the shape of the blades, similar to an airplane wing, high-quality plasticity and homogenization of the dough throughout the entire volume of the bowl is achieved. The optimal angle of attack (45^0) and bowl tilt (35^0) ensure intensive dough circulation, which allows for effective mixing at the molecular level, which is impossible to achieve with a spiral kneading mechanism.

2. Reduced duration and energy efficiency: Since the blade profile minimizes resistance, the reduced load on the kneading organ allows for faster kneading at the same drive power (2,2 kW). This results in:

– a reduction in mixing time (estimated at 20-30% compared to the base machine);

– a reduction in specific energy consumption per kilogram of dough;

– minimal heating of the dough, which preserves its quality characteristics.

3. Mechanization of unloading: A mechanism for automatic tipping of the bowl (from 35^0 to 125^0) has been successfully developed, using its own weight and returning it by means of a drive. This design solution greatly simplifies the operation of the machine, eliminating the need for a separate hydraulic or mechanical drive for tipping [12-13].

Full mechanization and automation of the mixing process, controlled by a frequency converter, allows the operator to flexibly divide the process into stages according to the recipe. The innovation with automatic bowl tipping is particularly important. The elimination of a separate drive for tipping reduces the overall complexity of the design, the weight of the machine, and lowers maintenance costs.

Considering that the base machine L4-HT-2V had high energy consumption and low mixing quality, replacing it with the L4-HT-2VM is technically and economically feasible. Improved kneading quality and simplified operation (due to automated unloading) will directly lead to improved quality of bakery products and easier baking [14-15].

Conclusions.

The analysis and design confirm the feasibility of using and operating the innovative L4-HT-2VM dough mixer in the baking industry. The main contribution lies in the justification and implementation of innovative design solutions that directly improve key performance indicators.

Replacing the outdated spiral mechanism with a three-bladed rotor with an airplane wing profile ensures high-quality mixing and plasticization of the dough throughout the entire volume of the bowl, which guarantees the quality of the finished bakery products.

Reducing the braking resistance of the blades and optimizing the kneading process allows for minimal kneading time and lower energy costs for heating the dough, significantly increasing production efficiency.

The design of the L4-HT-2VM provides for complete mechanization and automation, in particular, a unique mechanism for tipping the bowl under its own weight, which greatly simplifies operation and eliminates the need for a separate drive for unloading.

Thus, the innovative L4-HT-2VM dough mixer is an effective technical solution that improves quality, facilitates the baking process, and meets the modern requirements of intensive production.

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ADAPTIVE REQUIREMENTS MANAGEMENT FOR CLOUD-BASED ANALYTICAL ACCOUNTING SYSTEMS

Popereshnyak S.V.
c.ph.-m.s., as. prof.
ORCID: 0000-0002-0531-9809
National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute"
Kyiv, Beresteyskyi Avenue, 37, 03056
Korniienko O. O.
postgraduate
ORCID: 0009-0006-9289-7995
Institute of Software Systems of
the National Academy of Sciences of Ukraine,
Kyiv, Akademika Glushkova Avenue, 40, 03187
Viunnik Y.O.
postgraduate
ORCID: 0009-0002-3213-8058
Institute of Software Systems of
the National Academy of Sciences of Ukraine,
Kyiv, Akademika Glushkova Avenue, 40, 03187

Abstract. *Analytical accounting systems are essential components of modern enterprise information infrastructures, as they support managerial decision-making through the processing and analysis of large volumes of structured and semi-structured data. In the context of digital transformation and rapidly changing business environments, such systems must continuously adapt to evolving business requirements, performance constraints, and reporting needs. The widespread adoption of cloud infrastructure further increases system complexity due to distributed architectures, elastic resource allocation, and dependency on heterogeneous cloud services, making traditional, design-time–oriented requirements management approaches insufficient.*

This paper addresses the problem of aligning business requirements with analytical functionality and cloud infrastructure behavior in analytical accounting systems. The research proposes a requirements-driven approach in which requirements are treated not as static design artifacts but as active control elements that influence analytical workflows and cloud resource configuration throughout the system life cycle. Requirements are represented as structured entities characterized by type, priority, life-cycle state, and traceability to analytical components and infrastructure services.

A conceptual interaction model is introduced that integrates three interrelated layers: the business layer, where stakeholders define performance, availability, and reporting requirements; the analytical layer, responsible for data ingestion, transformation, aggregation, and reporting; and the cloud infrastructure layer, which provides elastic computing, storage, monitoring, and scalability mechanisms. A key feature of the model is a closed feedback loop in which execution metrics and infrastructure indicators are continuously collected and fed back into the requirements management process, enabling iterative refinement and reprioritization of requirements without interrupting system operation.

To illustrate the applicability of the proposed approach, an experimental evaluation was conducted using a prototype analytical accounting system for a service-oriented enterprise. A representative scenario involved tightening performance constraints for analytical reports and