Spanish Journal of Innovation and INTEGRITY
ISSN: 2792-8268
Volume: 42, May-2025
http://sjii.indexedresearch.org

Control of Dairy Product Storage Processes Using Fuzzy Logic

Okilov Azizbek Kozimzhon ugli
Andijan State Technical Institute Doctoral student Republic of Uzbekistan, Andijan,
E-mail: oqilovazizbek078@gmail.com

Jalilov Mashkhurbek Islomidin ugli
Andijan State Technical Institute Assistant of the department "AMP", Republic of Uzbekistan, Andijan
E-mail: mashkhurbekjalilov@gmail.com

Annotation: *This article discusses the application of fuzzy logic in managing the storage processes of dairy products, highlighting its advantages over traditional PID controllers. It emphasizes the limitations of PID systems in handling variable microclimate parameters such as temperature, humidity, and CO_2 levels. By employing fuzzy logic, the article illustrates how control systems can adapt to dynamic conditions, reduce human error, and integrate expert knowledge for optimal dairy storage. The structure of a fuzzy logic control system is explained, detailing its components: fuzzification, rule-based inference, and defuzzification. Practical examples demonstrate the effectiveness of fuzzy control in maintaining product quality and stability.*

Keywords: *Fuzzy Logic, Dairy Storage, Microclimate Control, PID Controllers, Intelligent Control Systems, Automation, Fuzzification, Defuzzification, Rule-Based Inference, Temperature Management*

Control of the storage process of dairy products based on fuzzy logic is one of the main directions of modern intelligent control technologies. According to the results of the literature analysis and mathematical description of the control object, it was found that the use of traditional PID controllers to stabilize microclimate parameters has a number of limitations. During the storage of dairy products, parameters such as temperature, humidity, and CO_2 content are constantly changing. PID controllers are not effective enough in maintaining these variable parameters constant and stable. This is because the operation of PID controllers is based on precise mathematical equations and has limited ability to adapt to uncertainty and dynamic changes in the system. In addition, the constant participation of the operator in controlling technological processes is required, which increases the likelihood of human error and reduces the stability of the control process. The variability of microclimate parameters and the complexity of technological processes require intelligent control approaches for the effective control of dairy storage systems. In particular, control algorithms developed based on fuzzy logic show high efficiency in controlling the complex dynamics of microclimate parameters. Fuzzy control systems operate based on human experience and intuitive rules rather than mathematical models. These systems are developed based on the practical experience of engineers and technologists and allow for effective control of microclimate parameters even under uncertain conditions.

A fuzzy logic control system consists of three main components. The first component is the fuzzification stage, at which the input parameters (temperature, humidity, CO_2 content) are converted into fuzzy language variables. For example, temperature is presented as "low", "normal" or "high". The second component is the rule base and inference, at which the system develops control decisions based on the input parameters based on predefined logical rules. For example, if the temperature is high and the humidity is within the norm, activate the cooling system. The third is the defuzzification stage, at which the results obtained based on fuzzy rules are converted into precise control signals and transmitted to the appropriate technological equipment.

The effectiveness of the control system developed based on fuzzy logic has been confirmed by a number of practical studies. This approach plays an important role in stabilizing the storage process of dairy products in variable conditions and maintaining their quality for a long time. For example, using fuzzy control algorithms, it is possible to automatically control temperature and humidity in warehouses where dairy products are stored. This ensures the stability of microclimate parameters and significantly reduces the likelihood of product spoilage.

One of the advantages of fuzzy control is its effective operation in complex dynamic systems and reduces the accuracy requirements of the mathematical model. For example, when controlling microclimate parameters in a warehouse, such variable factors as seasonal changes in temperature and air flows entering and leaving the warehouse are taken into account. Traditional PID controllers have difficulty adapting to such changes, since they operate only on the basis of constant and clear limits. Fuzzy logic bypasses these limitations and allows for real-time control of technological processes.

In addition, a control system based on fuzzy logic can fully reflect the experience of specialists and be integrated into automatic control algorithms. For example, a fuzzy rule base developed for temperature and humidity control in dairy storage may be as follows: “If the temperature is too high and the humidity is too low, turn off the cooling system and activate the humidifier.” These rules are based on the practical experience of specialists and provide effective control in uncertain and changing conditions.

- the traditional use of PID controllers in automated control systems of the microclimate of a dairy storage facility to stabilize microclimate parameters cannot provide a sufficient level of control automation due to the dependence of the requirements for the technological process on external factors and the need for constant operator participation in the formation of technological process parameters [17];
- full coverage of the task of controlling the technological process in changing conditions (for example, taking into account the seasons) is currently considered a problem that needs to be solved;
- program-based adjustment of the microclimate parameters of the technological process does not allow using the accumulated experience of engineers-technologists to optimize processes and increase their efficiency;
- a promising direction for automating technological process control [16] is the use of intelligent control technologies.

An intelligent system is a control system with intellectual support capable of solving heuristic tasks without human intervention.

Intelligent control technologies currently include the following areas [1-9]:

- use of expert systems;
- fuzzy logic;
- neural network structures;
- Associative memory.

In the management of dairy storage processes, the principle of situation-based control is applied, which should fully take into account the experience of engineers and technologists. This control experience can be described quite fully in the form of logical conditions that link the control effect on the process with its state and external factors.

This approach makes it possible to choose the direction of logical control based on fuzzy logic as the basis for creating a control system.

The generalized structure of a control system based on fuzzy logic is presented in Figure 1.

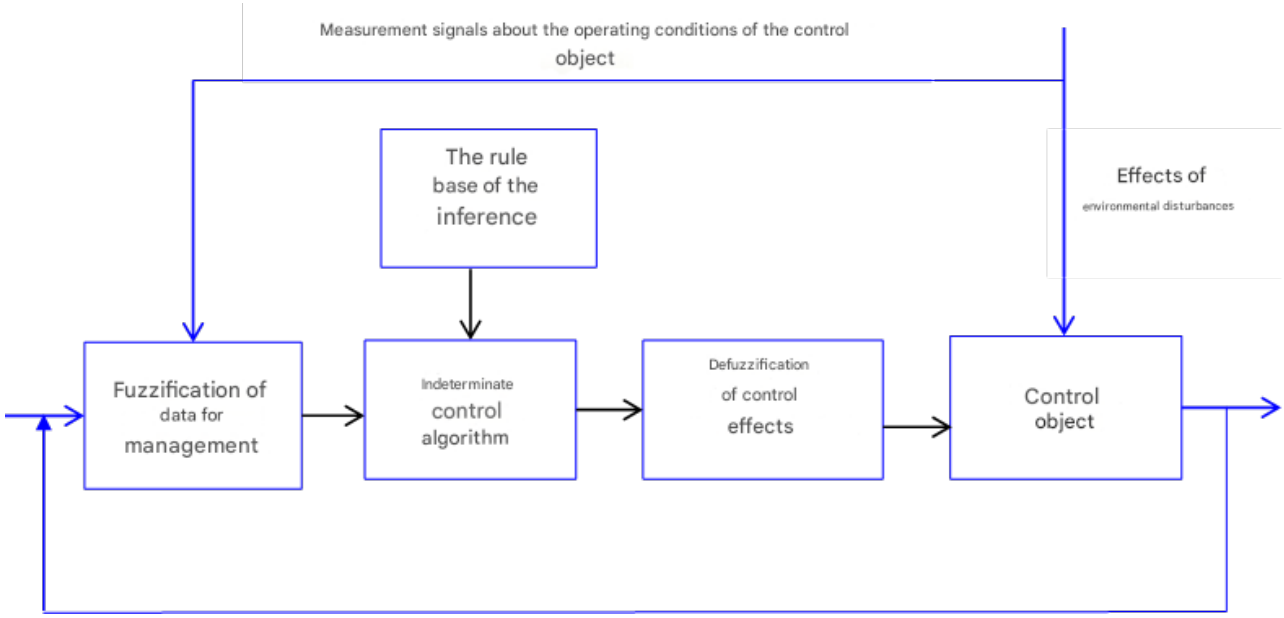

Figure 1. Structure of a control system based on fuzzy logic

When creating a control system for the storage of dairy products based on fuzzy logic, it is necessary to solve the following fundamental issues:

- Fuzzification process: The information used for control should be presented in terms of fuzzy logic. By fuzzifying the microclimate parameters (temperature, humidity, CO_2 concentration) during the storage of dairy products, numerical values are converted into fuzzy language variables. For example, the process is introduced into the automatic control system through descriptions such as "low humidity", "normal temperature" or "high CO_2 content".
- Formation of a base of fuzzy logical inference rules: When creating a control system, it is necessary to develop a base of logical inference rules based on the expert knowledge of engineering technologists. These rules are determined in relation to microclimate parameters to ensure optimal storage conditions for dairy products. For example, rules such as "If the temperature is high and the humidity is low, activate the ventilation system" are formed. This process requires the transformation of the knowledge of experienced specialists into logical rules, taking into account the complexities of the technological process.
- Defuzzification process: This is the output of the system, where the results of the fuzzy inference are converted into precise control signals. Defuzzification results in precise control actions to control the temperature, humidity, and CO_2 levels in the dairy storage facility. For example, commands such as "activate the ventilation system at 60%" or "turn off the humidifier to reduce the humidity to 55%" are generated [12].

References

1. F. Karimov, "Sut mahsulotlarini qayta ishlash texnologiyasi", Toshkent, 2021.
2. J. Hasanov, "Oziq-ovqat sanoati uskunalari", Samarqand, 2019.
3. D. Aliyev, "Homogenlash texnologiyalari", Toshkent, 2020.
4. Xalqaro oziq-ovqat texnologiyalari konferensiyasi materiallari, London, 2023.
5. M. Usmonov, "Qadoqlash texnologiyalari asoslari", Toshkent, 2022.
6. S. Akmalov, "IoT texnologiyalarining oziq-ovqat sanoatidagi qo‘llanilishi", Toshkent, 2023.

7. D. Petrov, "Food Storage and Intelligent Control Systems", Moscow, 2020.
8. Incropera, F. P., & DeWitt, D. P. "Fundamentals of Heat and Mass Transfer," Wiley, 2007.
9. M. Usmonov, "IoT-based Food Storage Systems," Toshkent, 2023.
10. F. Karimov, "Noqat'iy Mantiq Asosidagi Boshqaruv Tizimlari," Toshkent, 2021.
11. Xalqaro Sovutish Texnologiyalari Konferensiyasi Materiallari, London, 2022.
12. D. Petrov, "Advanced Packaging Solutions for Dairy Products," Moscow, 2020.
13. F. Karimov, "Noqat'iy Mantiq Asosidagi Boshqaruv Tizimlari," Toshkent, 2021.
14. Xalqaro Sovutish Texnologiyalari Konferensiyasi Materiallari, London, 2022.
15. D. Petrov, "Thermodynamic Systems in Cold Storage Facilities," Moscow, 2020.
16. M. Usmonov, "IoT va Sun'iy Intellekt Boshqaruvidagi Innovatsion Texnologiyalar," Toshkent, 2023.
17. Singx, R., & Tivari, P. "Artificial Neural Networks in Climate Prediction for Storage Environments," Journal of Applied Neural Networks, 2020.
18. Castaneda, L., & Kastano, J. "Levenberg-Marquardt Training in Neural Networks for Environmental Control," Climate Systems Journal, 2019.
19. Choi, Y., et al. "Short-Term Temperature and Humidity Forecasting Using Neural Networks," Advances in Environmental Control Systems, 2021.
20. Hongkan, P., et al. "Dynamic Microclimate Control with Elman Neural Networks," International Journal of Smart Systems