OPERATION ALGORITHM OF AN ELECTRONIC SYSTEM FOR CONTROL OF THE LOADING - UNLOADING DURATION IN A FOOD STORAGE REFRIGERATED CHAMBER

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Abstract: *The specifics of existing electronic systems for control of a food storage refrigerated chambers have been analyzed. The results show that during prolonged loading and unloading procedures the technological requirements for storing the production are violated. The necessity for automated control of the duration of loading and unloading with a model has been substantiated. The criteria for control and the basic tasks, required to perform the technological requirements, have been formulated. An algorithm and a structure of an electronic control system have been presented. The algorithm is based on a model, describing the heat exchange in a food storage refrigerated chamber.*
Key-words: *food storage refrigerated chambers, model, and electronic control system.*

1. INTRODUCTION

The existing electronic systems for control of refrigerated chambers maintain the required temperature in the chamber [4]. During loading and unloading procedures long or short periods of open doors are observed, which violates the technological requirements for production storing. That's why it is important to know the maximal time for these procedures which doesn't violate the requirements.

There are a number of known model based control systems – for a hatcher [2], for a sectional heat exchanger [3], for drying installations [1, 5]. They all account for the parameters, which influence the process and determine the most effective actions in order to fulfill the criteria for optimality – accurate maintenance of the process parameters, minimal energy consumption, etc.

The aim of this research is to develop an electronic system for control of the loading and unloading procedures in a refrigerated chamber. The control criteria should be maintenance of the technological requirements for production storing.

2. CONTROL CRITERIA

The main criterion for control of a refrigerated chamber is to maintain the products temperature in certain boundaries. It is performed by the electronic system of the refrigeration unit, when there are no loading or unloading procedures or during short ones.

In case the chamber is opened for a longer duration of time, the temperature of the products rises and it is possible to go out of the technological requirements boundaries.

Another factor which could lead to a rise in the temperature of the stored products is when there is a large amount of new products with higher temperature.

The second criterion for control is to ensure the required cooling rate, which depends on the power of the refrigeration unit. It is important to account the warming rate too, which depends on the volume of the products in the refrigeration chamber.

3. REQUIRED TASKS FOR ENSURING THE CRITERIA PERFORMANCE

In order to ensure the performance of the criterion for maintenance of the product temperature in the necessary boundaries, the process should be simulated with a model which estimates in how much time the temperature of products in the chamber will get outside the technological requirements. This depends on the loading/unloading duration, the environment temperature, the number of openings, the mass of the products in the chamber and on the chamber parameters. In order to prolong the loading/unloading procedures time interval it is possible to cool down the new products in advance. Such information could be taken from the control system.

Another way to fulfill this criterion is to control the time and periods of opening of the chamber doors.

In order to fulfill the criterion for ensuring the cooling rate of the products and accounting their warming rate, with the use of the model of heat exchange in a food storage refrigerated chamber, the dynamics of the process cooling and warming is evaluated.

4. ALGORITHM OF AN ELECTRONIC SYSTEM FOR CONTROL OF THE LOADING - UNLOADING PROCEDURES DURATION IN A FOOD STORAGE REFRIGERATED CHAMBER

During the development of the algorithm it is assumed that the volume of the loaded and unloaded products is proportional to the opening duration.

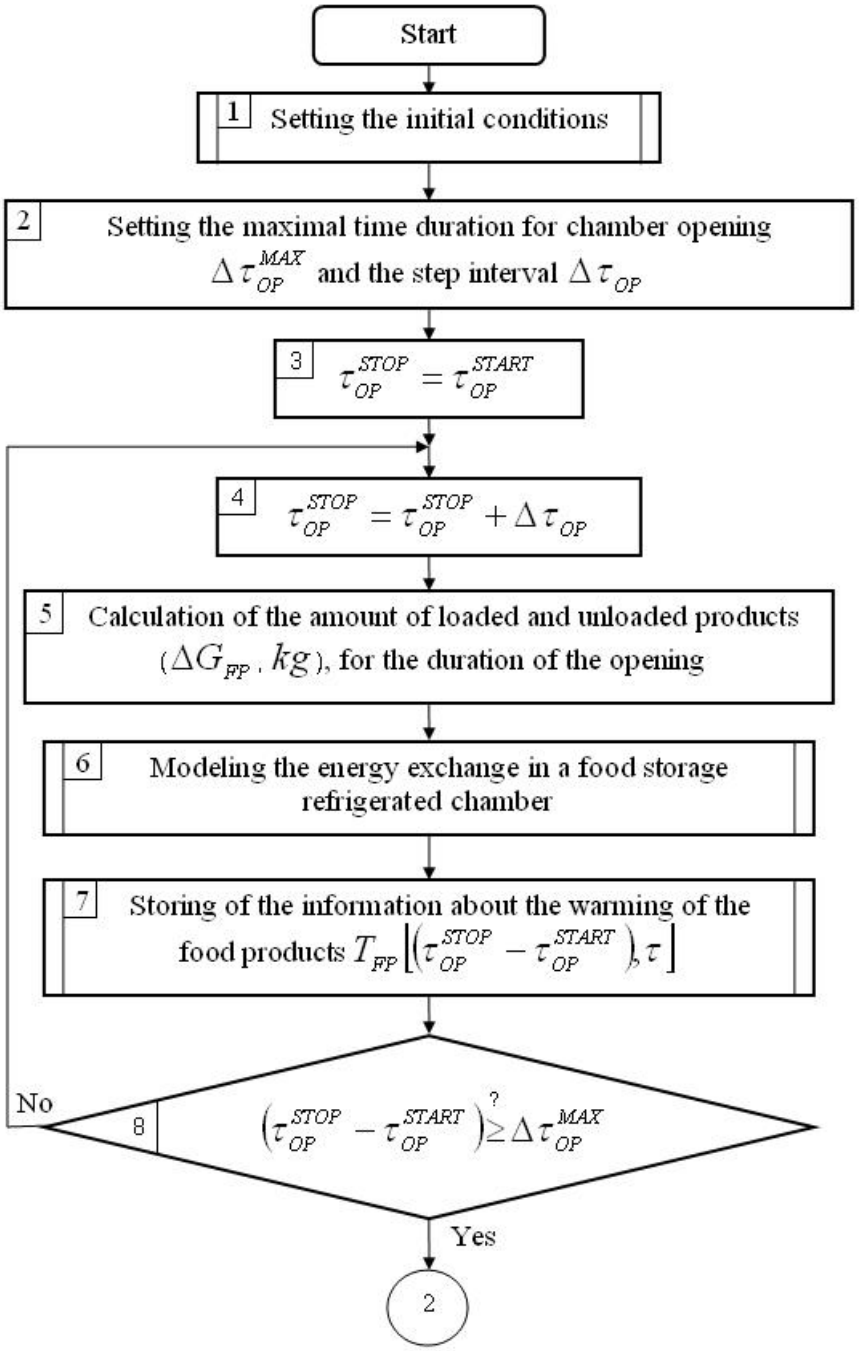

Fig.1.a.Algorithm of an electronic system for control of the loading - unloading procedures duration in a food storage refrigerated chamber

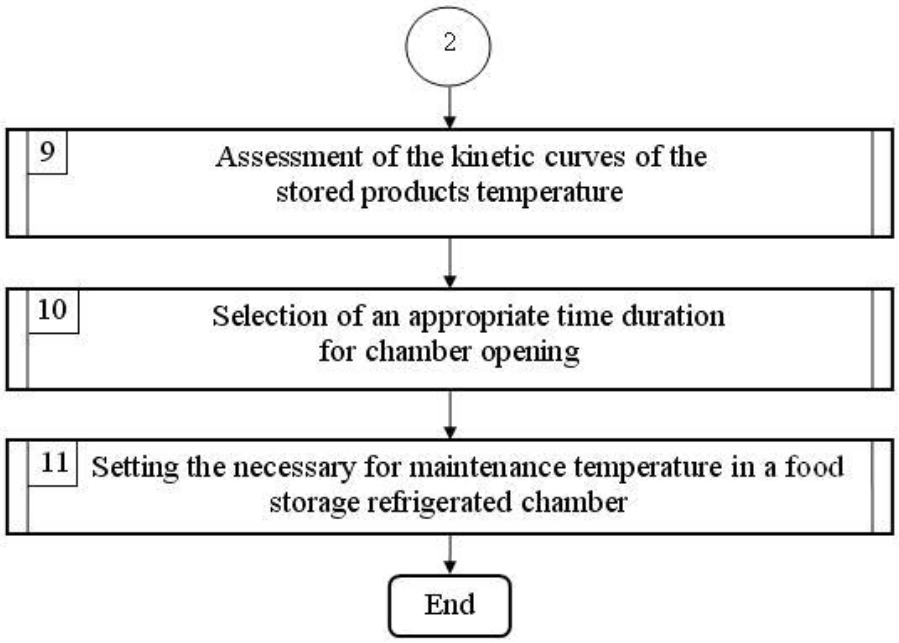

Fig. 1.b Algorithm of an electronic system for control of the loading - unloading procedures duration in a food storage refrigerated chamber

It is also assumed, that for a maximal duration of the chamber opening $\Delta\tau_{OP}^{MAX}$ it is fully unloaded and then fully loaded. The amount of loaded and unloaded products is determined according to:

$$\Delta G_{FP} = \tau_{OP}.m_{FP} = \tau_{OP}.\frac{G_{FP}^{MAX}}{\Delta\tau_{OP}^{MAX}},\ kg\ , \qquad (1)$$

where ΔG_{FP} is the amount of loaded and unloaded products, kg ;

τ_{OP} - the time duration of the chamber opening, s ;

m_{FP} - the mass debit of the loading/unloading procedure, $kg.s^{-1}$;

G_{FP}^{MAX} - the maximal amount of stored products in the chamber, kg .

The operation algorithm of the electronic control system is presented on Fig. 1. In block 1, the initial conditions for evaluation of the time duration of loading and unloading procedures are set. In block 2, the maximal time duration $\Delta\tau_{OP}^{MAX}$ and the evaluated opening interval $\Delta\tau_{OP}$ are set. In block 3, the opening time ($\tau_{OP}^{STOP} = \tau_{OP}^{START}$) is set equal to zero. In blocks 4 and 8, simulation of the time for opening of the chamber doors is organized. Based on the evaluated opening time the amount of the loaded/unloaded food products is calculated (block 5). In block 6, the energy exchange of the refrigerated chamber is modeled. This kinetic curves of the stored products temperature is stored in a database (bock 7). After the calculation cycle is complete (block 8), in block 9 an estimation of the received results is performed. Based on the used criteria, in block 10 a suitable time interval for opening of the chamber is chosen. In block 11, a command to the refrigeration unit for maintenance of the required temperature is sent.

5. STRUCTURE OF THE ELECTRONIC CONTROL SYSTEM

The electronic system for control of the loading - unloading procedures duration in a food storage refrigerated chamber consists of a personal computer PC with a specialized software product, implementing the algorithm from Fig. 1, also based on the model of the energy exchange of a refrigerated chamber. The required information about the process parameters is gathered through a serial interface to the refrigeration unit EBRU. This allows to read the values of the temperature inside the chamber and to set the maintained temperature.

Additionally the recommended time intervals for loading and unloading procedures are displayed on the monitor of the PC. The time schedule of the loading and unloading is taken from the information system of the process.

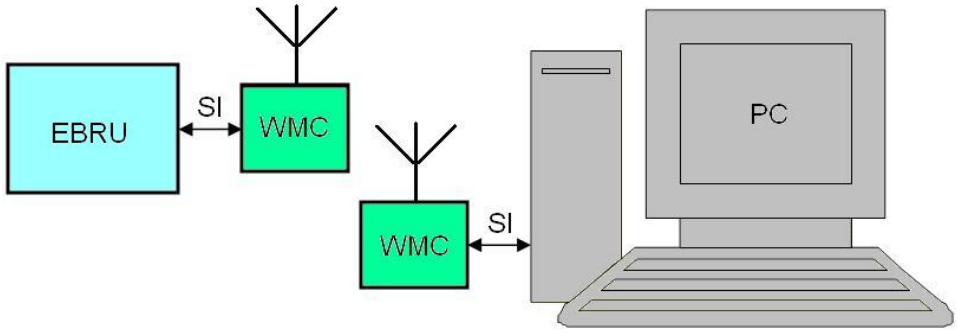

Fig.2. Structure of an electronic system for control of the loading and unloading procedures duration in a food storage refrigerated chamber
PC – personal computer; EBRU – electronic block of the refrigeration unit; WMC – wireless module for communication; SI – serial interface.

6. RESULTS AND DISCUSSION

The specifics of existing electronic systems for control of a food storage refrigerated chambers have been analyzed. The results show that during prolonged loading and unloading procedures the technological requirements for storing the production are violated.

The criteria for control and the basic tasks, required to perform the technological requirements, have been formulated.

The algorithm and structure of an electronic system for control of the loading and unloading procedures duration in a food storage refrigerated chamber have been synthesized. The algorithm is based on a model, describing the heat exchange in a food storage refrigerated chamber.

The developed algorithm and structure of the electronic control system ensure the technological requirements for product storing are met which also leads to a energy effective control of the process.

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