INVESTIGATION OF TECHNOLOGICAL PARAMETERS INFLUENCE ON THE DYNAMICS OF TEMPERATURE-HUMIDITY REGIME IN EGG PRODUCTS SPRAY DRYER THROUGH A MODEL

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Abstract: The dynamics of egg melange temperature and humidity variation significantly affects the egg powder quality. It depends on a number of interrelated parameters. Such are the drying agent temperature and humidity, the mélange temperature and feed rate, the design parameters and others. The research purpose is the assessment through a model of the technological parameters influence on the temperature and humidity variation of the mélange and drying agent as a function of time.
Computer software has been used for this purpose. It is based on a model, describing the drying process in an egg spray dryer. Methodology for the research has been developed. The results of this investigation are represented graphically. The level of certain parameters influence has been estimated.

Key words: egg drying, investigation, spray dryer.

1. INTRODUCTION

The dynamics of egg melange temperature and humidity variation significantly affects the egg powder quality [1, 2]. The control of egg products spray drying is managed through a control action variation. Such are the drying agent input temperature, the dried product feed rate (mélange, egg white, yolk) and the dried product degree of dispersion. The drop diameter value is controlled through the variation of the spraying disk spin rate. The drying process is also influenced by the drying agent humidity, the mélange input temperature, the environmental temperature, the dryer pressure and other parameters. These parameters are objectives for certain environmental conditions, and they cannot be controlled. For example, the input drying agent humidity is higher during a rain, but it is lower in the summer dry weather. The spray dryer works at an air temperature above 20^0C in summer conditions, and below 10^0C in winter conditions. Design parameters affect the drying process as well. There are complex dependencies and interrelations between the listed parameters. To achieve quality dryer control it is essential to estimate the impact of these parameters on the drying process dynamics.

The research purpose is the assessment through a model of the control action influence on the dried products kinetic curves of temperature and humidity.

2. METHODOLOGY

Computer software has been used for this research. It is based on the algorithms, modelling the drying process in the egg products spray dryer [3, 4]. An investigated parameter is altered (while the other parameters are kept constant) and the obtained dependencies for the variation in the time of the temperature and moisture content of the drying product are compared. Experimental research was done with an LPG-Spray Dryer at Dion Factory in Ruse, Bulgaria in October 2007. The obtained values are counted as basis values. These are shown in the Table 1, and the main software menu and the parameter settings menu are shown in the Fig. 1.

The parameters values are altered at a step of 20 % of the parameters range in relation to the basis value with the aim to estimate the influence of certain parameters on the drying process.

Basis values of the investigated parameters Table 1.

№	Parameter	Basis value	Variation range
1	Drying agent inlet temperature, ^0C	160	$140 \div 210$
2	Dried product feed rate, $m^3.s^{-1}$	8.10^{-5}	$2.10^{-5} \div 12.10^{-5}$
3	Sprayed drops diameter, m	60.10^{-6}	$40.10^{-6} \div 90.10^{-6}$

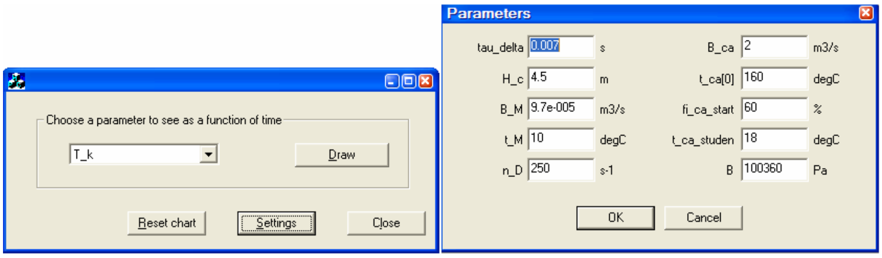

Figure. 1. Main menu and parameter settings menu

The program execution is started after the setting of certain parameter values, and the selected graphic is drawn in the window. Afterwards, the parameter values are altered and the drawing of the next graphic is run. Three values for each investigated parameter are set consecutively. As a result three graphics are shown in the same window and conclusions are made.

Variable parameters values for the research Table 2.

Parameter \№ test	1	2	3
Drying agent inlet temperature, ^0C	146	160	174
Dried product feed rate, $m^3.s^{-1}$	3.10^{-5}	5.10^{-5}	7.10^{-5}
Sprayed drops diameter of, m	40.10^{-6}	50.10^{-6}	60.10^{-6}

3. RESULTS

3.1. Research of the inlet drying agent temperature influence on the kinetic curves of the dried product temperature and moisture content.

The influence of the inlet drying agent temperature on the dried product temperature and moisture content kinetic curves is shown respectively in the Fig. 2 and Fig. 3.

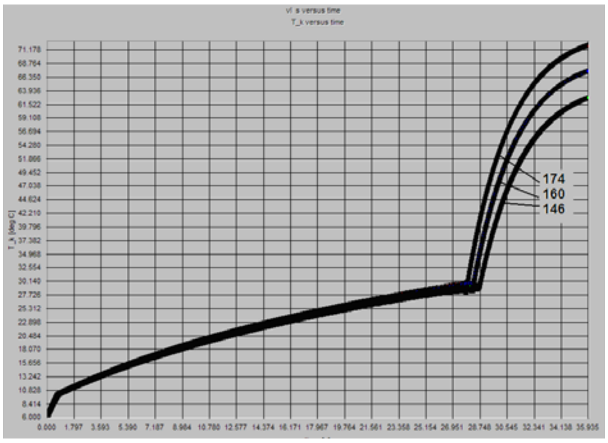

Figure 2. Influence of the inlet drying agent temperature on the kinetic curve of the dried product temperature

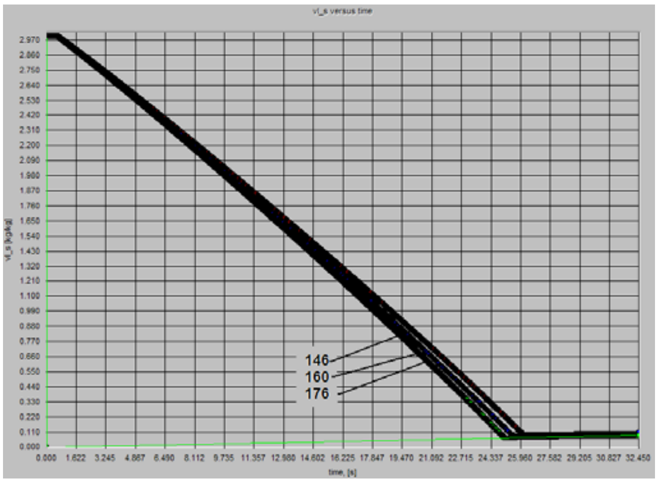

Figure 3. Influence of the inlet drying agent temperature on the kinetic curve of the dried product moisture content

The processes are described by a set of curves. A break in the graphics grade begins when the drying product moisture content reaches equilibrium moisture. It comes as a result of evaporation, after which all the energy coming from the convective heat transfer between the drying agent and the sprayed drops, is used for the dried product heating.

The research shows that the dried product temperature increases faster and reaches the equilibrium moisture content faster at a higher temperature of the drying agent. The higher inlet drying agent temperature leads to a higher dried product outlet temperature. As a result, the dried product outlet temperature is increased, which can lead to coagulation and denaturation, and it deteriorates its quality. The inlet drying agent temperature increase leads to an insignificant acceleration of the drying process, as well as an increase in the dried product temperature. For example, an increase of the drying agent inlet temperature by 14^0C leads to drying process acceleration by about $1\ s$.

3.2. Investigation of the dried product feed rate influence on the kinetic curves of the dried product temperature and moisture content.

The result of the investigation is shown in the Fig. 4 and Fig. 5.

The evaporation time of the sprayed drops is increased with the increase of the dried product feed rate. The sprayed drops temperature is increased during the heat and mass exchange. When the feed rate is higher, the drops are heated less in the third stage where only heat exchange occurs. It is explained by the fact that the quantity of heat energy yielding-up from the drying agent to the sprayed drops is larger, and the evaporated moisture from the drops per unit volume of the drying agent is larger as well, for a higher feed rate.

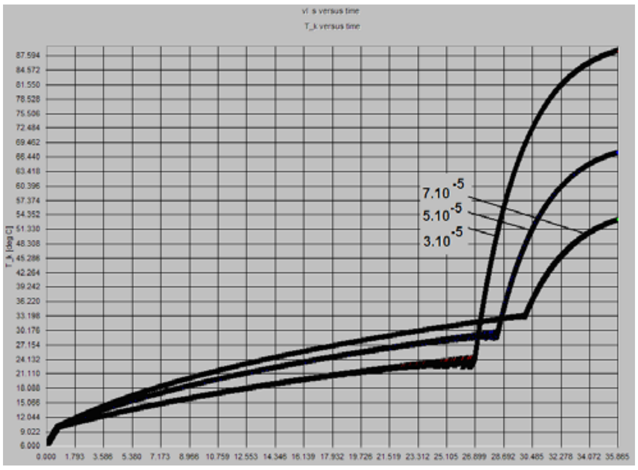

Figure. 4. Influence of the dried product feed rate on the kinetic curve of the dried product temperature

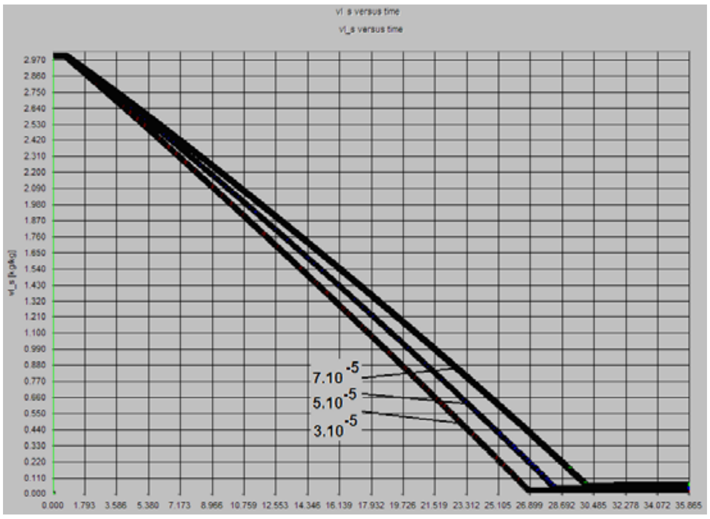

Figure. 5. Influence of the dried product feed rate on the kinetic curve of the dried product moisture content

As a result, the drying agent temperature is decreased faster, and its moisture content is also increased. These factors reduce the intensity of the diffusive mass exchange, which leads to less evaporation from the drops. Consequently, a larger quantity of the energy received through the convective heat exchange goes for an increase in the dried product temperature. With the dried product feed rate increase, the time for which the dried product reaches equilibrium moisture content is increased as well.

The dried product feed rate alteration by $2.10^{-5}\ m^3.s^{-1}$ leads to slowing-down in the reaching of the equilibrium moisture content by about 1,5 s, and it results in an increase of the outlet dried product temperature by about 17 ^0C.

3.3. Investigation of the sprayed drops sizes influence on the dried product temperature-humidity regime

The investigation results are shown in the Fig. 6 and Fig. 7.

The sizes of the sprayed drops significantly affect the drying process dynamics. When the drops size decreases by 10.10^{-6}, the apparent surface of the sprayed product increases. The time for which the dried product reaches equilibrium moisture content is increased by 14 s. The large surface significantly intensifies the heat and mass exchange. When the drops size is small, the time for which the dried product reaches equilibrium moisture content decreases. The drying agent temperature decreases slowly, and the moisture content increases quickly.

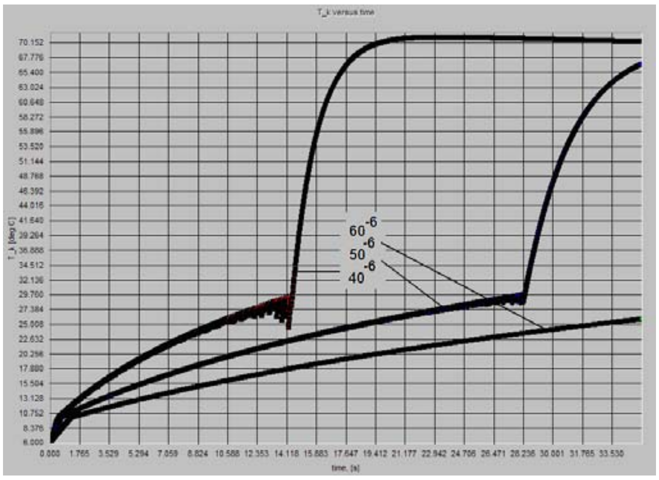

Figure. 6. Sprayed drops sizes influence on the kinetic curve of the dried product temperature

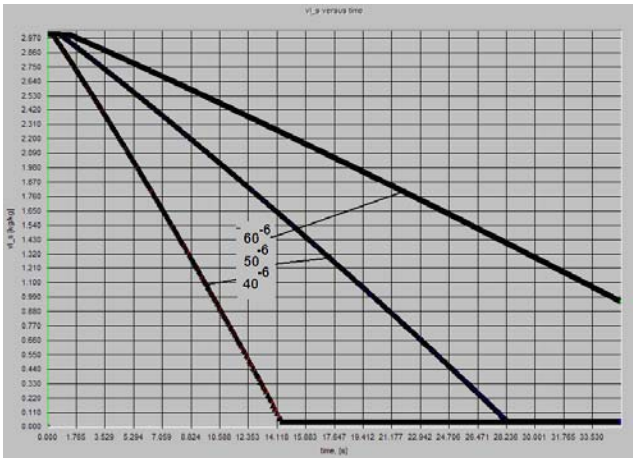

Figure. 7. Sprayed drops sizes influence on the kinetic curve of the dried product moisture content

The research concludes that the graphics illustrating the kinetic curves of the dried product temperature for the different control actions are represented as a set of curves with well-defined lines for initial heating, first drying stage and second drying stage for the heating. Within the second dispersed product drying stage nearly all the energy, exchanged between the drying agent and the sprayed drops, goes for its heating because the dried product moisture content has reached its equilibrium value.

4. CONCLUSIONS

The drying agent initial temperature has a slight influence on the kinetic curves of the dried product temperature and moisture content, and the dried product feed rate alteration influences them to a larger degree.

The dried product drop size significantly affects the kinetic curves of the dried product temperature and moisture content and leads to a substantial increase in the time for product drying.

5. REFERENCES

[1].Konovalov V.I., Gatapova N,Z. and Kudra T.. Drying of liquid dispersions – a united approach to kinetics and modeling. Vol.21, №6, pp 1029 – 1047, Drying technology, 2003.
[2].Birchal V.S., Passos M.L., Wildhagen C.R.S., Mujumdar A.S. Effect of spray-dryer operating variables on the whole milk powder quality. Vol. 23, pp 610 – 636, Drying technology, 2005.
[3].Евстатиева Н. Моделиране на процеса сушене в разпръсквателна сушилня.. Кн.1,2, стр.22-27, Електротехника и електроника, 2008.
[4].Евстатиева Н., Димитров В., Георгиев Г. Алгоритми и структурна схема на система за моделиране на процеса сушене в разпръсквателна сушилня. Кн.3,4, стр.15-21, Електротехника и електроника, 2008.