Development of Expert Systems for Convective Drying of Vegetables

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Abstract. The work analyzes the development of information systems, using the example of an expert system. The introduction of expert systems in the drying process was examined. The outgoing and incoming drying parameters were studied, a plan was drawn up, and an expert system for drying vegetables was developed. Based on the selected initial parameters, the conditions of solutions were compiled to ensure the optimal process, as well as the yield of a quality product.

Keywords: Expert systems, convective, drying, vegetables, Relative humidity

1 Introduction

The development of information and communication technologies and their integration with production processes are the basis for the emergence of new areas of process control. In particular, today artificial intelligence systems are being introduced from the lowest level of production (technological processes, local control systems) to the highest (organizational management, marketing issues) and give effective results. Problems with decision-making in the face of frequent interruptions in processes and lack of information require high qualifications and sufficient experience from the manager. Expert systems based on knowledge are a good solution to problems, especially in cases where there is a shortage of highly qualified specialists or their services are very expensive [1-4].

An expert system is a system based on the knowledge of highly qualified specialists with sufficient qualifications and knowledge in a certain area, allowing them to make the necessary decisions in problem situations or in situations of lack of information. In this case, a knowledge model is formed on the basis of a knowledge base collected from specialists. Professional expert systems are somewhat complex; therefore, linear programming languages cannot be used in their formation. The algorithms of such systems are also superior to conventional algorithms. This is due to the fact that professional expert systems have several complex approaches such as fuzzy logic, probability theory, uncertainty theory, and set theory. But these problems can be solved using object-oriented programming languages [5].

Nowadays it is difficult to imagine a manufacturing industry without process automation. Day after day, science is accumulating new work in the field of automation, programming, advanced technologies and processes.

To increase the level of knowledge of experts, as well as to reduce the human factor in the industry, it was decided to develop an automated training system. The system summarizes existing experience in diagnosing and troubleshooting problems in the process, working in an interactive mode, contributes to acceleration. The most widespread and progressive method of accumulating and transferring knowledge is expert systems [4].

There are a number of installations for drying agricultural products of an industrial scale, but the convective drying method is very widespread in the territory of Uzbekistan, and there are also no automated control systems developed by new approaches that qualitatively describe the process and contribute to the selection of optimal operating parameters.

In order to study the automation of drying processes and the selection of its optimal operating parameters, an expert system was developed [6-7].

2 Methods

In Uzbekistan, they are widely used in vegetable drying plants for drying vegetables, fruits, cut into small pieces, and boiled cereals. Drying is carried out with air heated in air heaters. Their peculiarity is that the product is dried in a dense layer.

An important role in convective drying is played by the parameters of the drying agent: temperature, relative humidity, speed of the drying agent, layer thickness and its condition. Therefore, convective drying can be intensified by adjusting these parameters (Table 1).

Drying agent temperature. At the beginning of the drying process, an increase in the temperature of the drying agent accelerates the drying process. But at the same time, heat losses increase, which are most significant at the end of drying, when the material has low moisture content. The maximum permissible temperatures depend on the type of material and the drying method.

3 Results and Discussion

Air flow rate - affects the drying rate only in the constant speed section (at constant temperature and relative humidity). The higher the air flow rate, the higher the drying rate. This influence is noticeable up to an air velocity of 5 m/s. A further increase in the air flow rate is limited by the fact that the air jet "rips off" small pieces of the dried material from the drying surface. This air flow property is used in fluidized bed drying when the air flow velocity is 5-15 m/s. At the end of drying, the air flow rate does not significantly affect the drying rate. In this section, the speed is not more than 1 m/s.

Relative humidity. At a constant temperature and air flow rate, the decrease in the drying rate in the first stage is directly proportional to the increase in the relative humidity of the air. Then this dependence decreases and increases again at the final stage of drying. At this point, the dependence of the drying process on the relative humidity of the air is determined by the value of the equilibrium moisture content, which corresponds to the residual moisture content of the material being dried.

Based on the selected initial parameters (Figure 1), the conditions of solutions were compiled to ensure the optimal process, as well as the yield of a quality product.

Table 1. Inbound and outbound process parameters.

	ω_{finite}	$T_{product}$	ω_{agent}	T_{agent}	υ_{agent}	ω_{agent}
1	1	1	0	reduce	stop	increase
2	1	0	0	reduce	stop	increase
3	0	1	1	stop	stop	stop
4	0	0	1	stop	stop	stop
5	1	1	1	-	-	increase
6	-1	-1	1	stop	stop	stop
7	-1	1	1	stop	stop	stop
8	1	-1	-1	-	-	increase
9	1	1	-1	reduce	-	increase
10	-1	-1	-1	stop	stop	stop
11	-1	-1	0	stop	stop	stop
12	-1	0	0	stop	-	stop
13	0	-1	-1	stop	-	stop
14	0	0	-1	stop	-	stop

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At the same time, our drying facility is a carrot product, the moisture content of which has the input and output parameters that are key in the process. Compiled a list of conditions with a solution to ensure an optimal process. Basically, the moisture content of the product after the drying process should be less than 14% (this is a standard requirement):

- if the moisture content of the product during drying is higher than 14%, it is necessary to increase the drying time and reduce the temperature of the drying agent to 50°C;
- if the moisture content of the product at the outlet falls below 14%, the temperature and speed of the drying agent must be stopped;
- the temperature of the product at the outlet should not exceed $T_{obj} \leq 60$ °C, if it is exceeded, it is necessary to reduce the temperature of the drying agent (up to 50-60 °C) and the speed (1.5-2 m/s);
- if the product outlet temperature is below 60°C, the outlet humidity is above 14%, in this case it is necessary to increase the drying time up to 12 hours, keeping the drying agent speed 3-4 m/s;
- if the relative humidity of the drying agent at the outlet exceeds 15 ÷ 20%, the temperature of the drying agent at the outlet should be reduced;
- if the drying time increases (i.e., up to 10-12 hours), it is necessary to reduce the rate of agent drying and the drying temperature
- when the moisture content in the product is less than 20% at the end of the drying process, the temperature (50-55°C) and speed (1.5-2 m/s) of the drying agent decrease (Figure 2).

Fig. 1. Inbound and outbound process parameters.

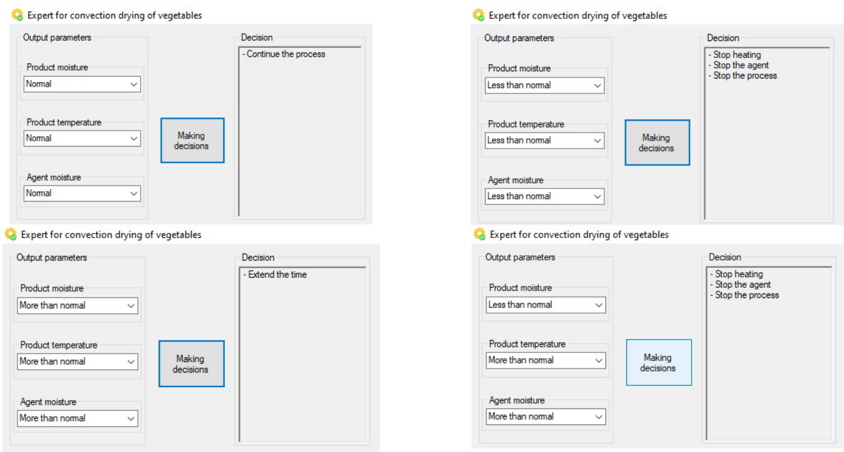

Fig. 2. Expert for convection drying of vegetables.

After that, the program itself chooses the optimal solutions based on the data.

Figure 2 shows an expert system, which, based on the input parameters, will make error-free optimal decisions.

4 Conclusion

This means that a control center based on an expert system is different from traditional control centers. Traditional control programs are usually written to controller memory, where only linear, iterative, or branching algorithms can be used. The control program based on expert programs is an object-oriented program that contains various complex algorithms and is stored in the memory of the control computer. Moreover, these systems will improve over time.

In fact, we have developed the simplest expert system for carrot drying processes. Based on the influencing factors, it is possible to make the same expert system for various drying methods (sublimation, microwave, etc.). The expert system is very simple and makes error-free decisions and also simplifies the work process.

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