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THE USE OF BLACK BOX METHOD IN AUTOMATION OF DRYING PROCESS OF FEED GRANULES ON THE BASIS OF AMARANTH

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ABSTRACT

Provision of the feed base of the livestock sector of the Republic with new, nutritious feed pellets and automation of these systems on the basis of modern information and Communication Technologies is an urgent issue.

KEYWORDS: *Grinding; Wetting; Granulation; Drying (Final Step);*

INTRODUCTION

In recent years, a valuable source of raw materials for the food industry has appeared on the world market - amaranth seeds with high nutritional and biological value, containing a wide range of functional ingredients and biologically active substances, which determines the prospects for their use in food. [1]

Amaranth (shiritsa) is an agricultural crop that attracts the attention of researchers due to its high yield, protein richness and balance, high content of vitamins, minerals and dietary fiber. According to the FAO / WHO (Food and Agriculture Organization of the United Nations) in the 21st century, this plant is able to take a leading position as a food, feed and medicinal crop. In connection with the expected global climate changes on Earth, the use of amaranth becomes even more urgent due to its high ability to adapt to adverse environmental conditions. [2]

Amaranth in livestock and poultry farming is a profitable feed with high productivity indicators, which, when properly grown, is environmentally friendly (since it does not require the use of a number of chemicals necessary for growth, for example, barley). Amaranth feed grains contain about 14-18% protein, 5-6% healthy fats, 55-62% starch, pectin, 5 micro and macro elements each. Amaranth green grass meal and grass pellets are superior in terms of vitamins to standard grass meal and pellets used in feed for pigs, cows, chickens and rabbits.

Method. The black box method is chosen as the automation method of the drying process. The main point of view using the black-box method is that input and output parameters in the technological processes are related to each other with material balance or heat balance. The black box is can be defined as a rectangle scheme. On the black box, we can see how particular output parameters that we need to automate the process (exp. humidity, temperature) have a dependence on input parameters like drying agent consumption (gas consumption), the temperature of drying agent, or others.

- **Process of producing feed granules on the basis of amaranth**

Obtaining feed granules on the basis of Amaranth consists of several stages, which can be described as follows (figure 1): 1. Grinding; 2. Wetting. 3. Granulation. 4. Drying (final step)

First, the raw amaranth product goes to grinding, where the plant turns into powder, afterward for the improving adhesive feature the water is adding to it (moreover some ingredients will be added to thicken the mixture). Then the ready batch is granulated in a granulator press, at the end the granule is dried with hot air, and the finished product is taken. [5]

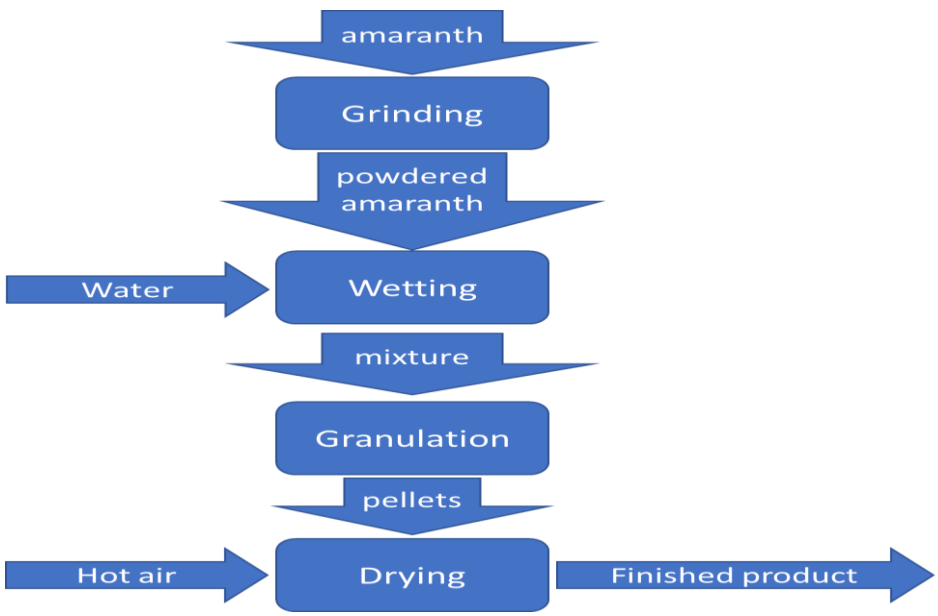

Figure 1. Production of feed granules on the basis of Amarant.

- **Problem formulation.**

The main parameters of the drying agent and material, as moisture carriers.

Relative humidity of the drying agent φ :

$$\phi = \frac{\rho_p}{\rho_n} \qquad (1)$$

Based on the Mendeleev-Clapeyron equation, one can obtain

$$\phi = \frac{P_p}{P_n} \qquad (2)$$

The relative humidity of the material* ω *is - *the ratio of the mass of moisture* M_m *to the total mass of wet material* $M = M_{dm} + M_m$, *or to the mass of absolutely dry material* M_{dm}:

Humidity attributed to the whole substance:

$$\omega = \frac{M_m}{M} * 100, \%, \text{ where } M = var \qquad (3)$$

Humidity, referred to the mass of absolutely dry material

$$\omega^C = \frac{M_m}{M_{dm}} * 100, \%, \text{ where } M_{dm} = const. \qquad (4)$$

- **Controlled object.**

The belt dryer serves as a controlled object. The material is dried continuously at atmospheric pressure. In chamber 1 of the dryer (figure. 2), the layer of dried material moves along an endless belt 2 stretched between the leading 3 and driven 4 drums. Wet material is fed to one end of the tape, and dried material is removed from the other end. Drying is carried out by hot air or flue gases, which move countercurrent or cross current to the direction of movement of the material.[6]

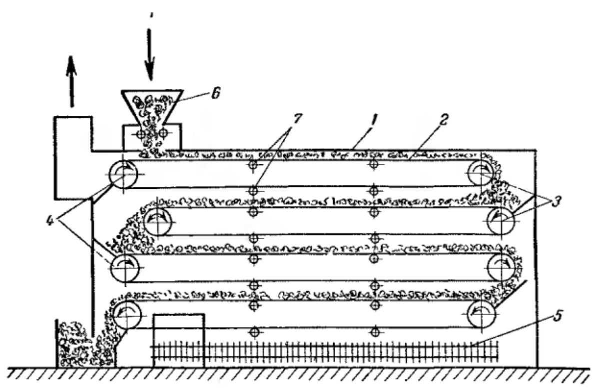

Figure 2. Belt dryer scheme.

Non-uniform drying of the material is usually observed in single-belt dryers with a continuous tape: in the inner part of the layer facing the tape, the final humidity is higher than in its outer part washed by gases or air.

More effective is the use of many belt dryers with metal mesh tapes. In them, the drying agent moves perpendicular to the plane of the tape through the layer of material located on it, i.e. cross current. When pouring material from tape to tape, the surface of its contact with the drying agent increases, which contributes to an increase in the speed and uniformity of drying. Belt dryers can work on various options for the drying process. [8]

Process performance indicator - moisture of dry material ω_{dm}

The purpose of process management is to maintain - $\omega_{dm} = \omega_{dm}^{given}$

- **Material balance in terms of the total amount of moisture in the drying process**

Dynamic equation:

$$\rho_{dm} * V_{dm} * \frac{d\omega_{dm}}{dt} = G_{wm} * \omega_{wm} + G_{da}^{in} * \phi_{da}^{in} - G_{dm} * \omega_{dm} - G_{da}^{out} * \phi_{da}^{out} \quad ; (5)$$

Here $\rho_{см}$- dry material density;

V_{dm} - dry material volume;

ω_{dm}- dry material relative humidity;

G_{wm} - wet material consumption;

ω_{wm}- wet material relative humidity;

G_{da}^{in} - input drying agent consumption;

ϕ_{da}^{in} - input drying agent relative humidity;

G_{dm} - dried material consumption;

G_{da}^{out}- output drying agent consumption;

ϕ_{da}^{out} - output drying agent relative humidity;

Static equation $\frac{d\omega_{dm}}{dt} = 0$:

$$G_{wm} * \omega_{wm} + G_{da}^{in} * \phi_{da}^{in} = G_{dm} * \omega_{dm} + G_{da}^{out} * \phi_{da}^{out} \quad ; \qquad (6)$$

(5) and (6) one can get the following from expressions

$$\omega_{dm} = f(G_{wm}, G_{dm}, G_{da}^{in}, G_{da}^{out}); \qquad (7)$$

We get below in the analysis of the combustion chamber

$$G_{da}^{in} = f(G_f, G_{pa}, G_{sa}) ; \qquad (8)$$

Here G_f – fuel consumotion;

G_{pa} – primary air consumption;

G_{sa} – secondary air consumption;

(7) and (8) of all possible controlling effects to adjust the final moisture content of the material from the statements listed, the G_f fuel consumption is the most informative one. [3]

From these dynamic and static material balance equations, we take the following relationships, in which we see a connection between fuel consumption and the main process parameters - product humidity, this method shows the relationship between control parameters and controlled variables.

- *"Black box"*

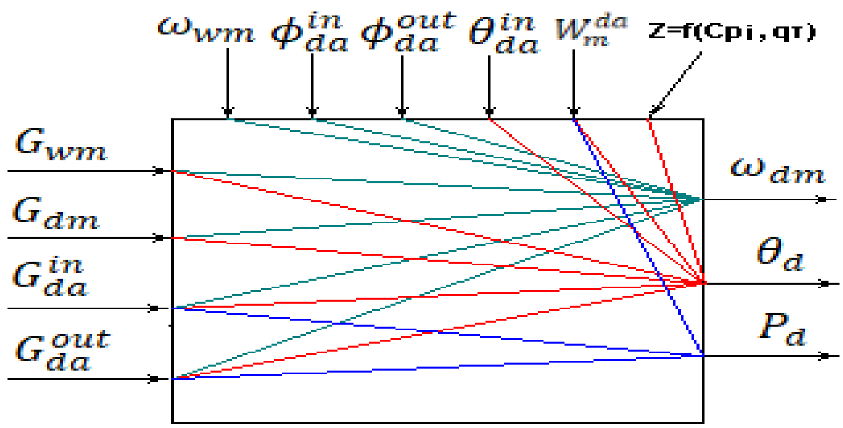

Figure 3. Information scheme of drying machine

- Possible control impacts:

$G_{wm}, G_{dm}, G_{da}^{in}(G_f, G_{pa}, G_{sa}), G_{da}^{out}$.

- Possible controlled disturbances:

$\omega_{wm},\ \phi_{da}^{in},\ \phi_{da}^{out},\ \theta_{da}^{in},\ \theta_{wm}$.

- Possible uncontrollable disturbances:

W_m^{da}, C_p

- Possible controllable variables:

$\omega_{dm},\ \theta_d(\theta_{da}^{d}),\ P_d(P_{da}^{d})$.

- A dryer is a complex, multi-connected object.
- **RESULTS AND DISCUSSIONS**

From the scheme for automation (picture 4), it can be seen dryer and sign of automation elements such as sensors, regulators and valves. Wet feed granules come from the press granulator to the ceil of dryer.

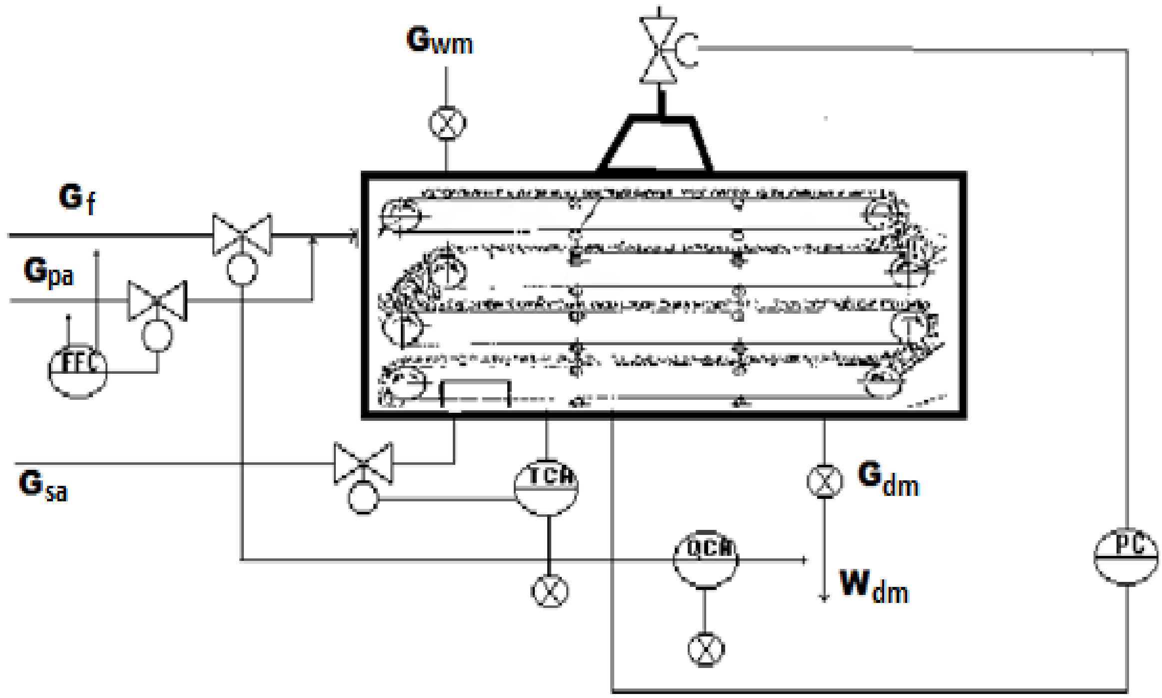

Figure 4. Scheme for automation of the drying process

- **Regulation**

• Regulation ω_{dm} with fuel supply G_f - as an indicator of the effectiveness of the drying process

• Regulation of the ratio of fuel consumption G_f and primary air G_{pa} for the supply of primary air -

$G_{pa} = \gamma * G_f$ to ensure the efficiency of fuel combustion.

• Regulation of the temperature of the drying agent θ_{da}^{in} at the entrance to the drum secondary air G_{sa}.

• Stabilization of the costs of wet and dry material G_{wm} and G_{dm} with automatic dispensers - to ensure material balance in the solid phase.

- **Control**

• Consumptions- G_f, G_{pa}, G_{sa}, G_{wm}, G_{dm};

• temperature - $\theta_{da}^{in}, \theta_{cada}^{out}, \theta_d$;

• Underpressure - P_d;

• humidity - ω_{dm} (ω_{given}).

- **Signaling**

• significant deviations ω_{dm} from ω_{given};

• significant increase in θ_{da}^{in};

• Unplanned shutdown of the drive, at the same time a signal "To protection circuit" is generated.[9]

- **Protection system**

At the signal "To the protection circuit" - stop the flow of material and fuel into the drying unit.

CONCLUSIONS

Amaranth has been gaining even more popularity in agriculture for more than twenty years. In the feed for livestock, its application takes place slowly. Nevertheless, now many farmers and peasants recognize that Amarant is much more useful than nutrient varieties wheat, soybeans, barley and other traditional cultures. Considering the above, we carried out an analysis of the drying process where the main parameter is the humidity of the product, using the black box method to automate the drying process. "Black box", which is considered as a belt dryer, portrays the relation between input (consumptions) and output (humidity, temperature) parameters. Material balance, in terms of the total amount of moisture in the drying process, substantiates these relations. Based on these interconnections on a black box, an automation functional scheme was built.

Abstract. The article describes the use of the "Black Box" method to automate the drying process in the technological system of producing granules based on amaranth. For this purpose, the correlation between the parameters involved in the drying process has been investigated and an information schematic illustrating these relationships is presented. Based on the given equations and information scheme, functional scheme of process automation is developed.

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