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STUDY OF AIR PRESSURE TRANSMISSION THROUGH SHELL LAYERS DURING COCOON DRYING

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Annotation

The article studied the thermodynamic processes that occur during the drying of the cocoon, and found that the main amount of moisture (humidity 200-280%) is in the chrysalis, and 160-180% - in the cocoon. It was revealed that the main resistance to drying falls on the cocoon shell, pupae without shell dry 2.5 times faster. Relations describing the mass conduction fluxes for cocoon layers are given, and a differential equation for air permeability under pulsating pressure is derived.

Keywords. Living cocoon, humidity, free moisture, cocoon drying, pupa, temperature.

Introduction

The cocoon consists of heterogeneous bodies - a silk shell and a chrysalis. Moisture in living cocoons can be chemically bound, hygroscopic and free. Chemically bound moisture is involved in the construction of substance molecules in a cocoon. Its removal leads to irreversible changes, that is, the substance is destroyed.

Therefore, chemically bound moisture is not removed during the primary processing of the cocoon. Hygroscopic humidity depends on the temperature and humidity of the environment. Excessive removal of hygroscopic moisture changes the physicochemical properties of the cocoon, therefore, during drying, hygroscopic moisture remains in the range of 8-12%. Free moisture is mainly in the chrysalis and needs to be removed.

A characteristic feature of living cocoons is high humidity, which on average reaches 160-180%. This moisture is unevenly distributed among the individual components of the cocoon. The moisture content of the cocoon is 12-

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16%, the moisture content of the pupa reaches 200-280% in relation to the dry mass.

The intensity of the drying process is mainly determined by the intensity of mass conduction through the cocoon shell layer. The course of the drying process depends on the amount of moisture in the material and the environment, as well as on the nature of the moisture in relation to the cocoon. During drying, it is necessary to remove free moisture mechanically retained by the body of the pupa.

The drying process involves the movement of moisture within the material, the creation of steam and its transfer from the material to the environment. During the drying of the cocoon, the pupa releases its moisture into the environment by diffusion from the air space and the cocoon shell [1-4].

Purpose and method of research.

During the drying process, the pupa releases its moisture to the shell through the layer of air in the cocoon, and not directly into the atmosphere surrounding the cocoon. The temperature gradient is directed from the outside through the shell into the cocoon, and the humidity gradient is directed from the pupa outward through the air space in the cocoon and the wall of the shell. The pupa is in contact with a small part of the shell. Most of the pupa is surrounded by air. The part of the pupa that comes into contact with the shell directly provides it with moisture, and the remaining part enters the living cocoon through the air space.

If Wc=Wvp=Wjk, then the cocoon can be considered dried.

Here: Wc –cocoon moisture; Wvp- humidity of the air layer inside the cocoon, Wjk- humidity of the living cocoon.

To ensure the maximum yield of raw silk, drying of the cocoon should not lead to dehydration of the cocoon shell, i.e. the following equality must hold:

$$Wc - Wjk = 0 \quad (1)$$

This can be provided that all the moisture evaporating from the shell is completely covered by the moisture it receives from the pupa, or the cocoons are dried in air at a sufficiently high humidity.

During drying, moisture is removed from the capillary-porous material sequentially, first through large pores, then through medium and smaller pores. In this case, there is a clear relationship between the moisture content of the material and the small radius of holes filled with liquid, according to [5] established by the following relationship:

$$P_в = \int_{r_0}^{r_{max}} f_v(r)dr \qquad (2)$$

Here: $P_в$ - porosity of the body:

$$P_в = \frac{\rho_0 W}{b_i \rho_j} \qquad (3)$$

Here: b_i –liquid filling of pores; W- humidity; p_0- dry body density; p_j —wet body density.

Hence the amount of moisture

$$W = \frac{\rho_j}{\rho_0} \int_{r_0}^{r_{max}} f_v(r)dr \qquad (4)$$

The above equations determine the porosity of the body, which depends on the rate of movement of moisture in the material (mass conductivity), which determines the need to study the mass conductivity of the cocoon and its air permeability, which characterizes the porosity of the shell. Technological processes during the primary processing of silkworm cocoons are closely related to thermodynamic processes, along with mechanical and chemical effects on them. Without knowing the theoretical foundations of air permeability, moisture permeability, thermal conductivity and other thermodynamic parameters of the cocoon shell, it is difficult to determine the optimal modes of drying silk cocoons with a pulsating pressure change. If we consider it as a dense mass, then the permeability of the mass is mainly determined by the air permeability and moisture permeability of the material. Its value is determined by the thickness of the material, the driving force of the transferability and the speed of the external air flow [6].

The results obtained and their discussion. The cocoon wall consists of many layers (Fig. 1). If the thickness of each layer is denoted by h, then the total thickness of the cocoon shell can be determined as:

$$l_i = h_1 + h_2 + h_3 + ... + h_n = \sum_{i=1}^{n} n_i h_i \qquad (5)$$

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As air passes through the cocoon, the pressure Pn(t) acting on the outer wall of the cocoon decreases. In this case, the movement of air through the layers of the shell can be determined by the differential equation:

$$\frac{dP_n(t\cdot l_i)}{dt}=\frac{\lambda}{c}\cdot\frac{d^2P_в(t\cdot l_i)}{dl^2} \qquad (6)$$

Here λ - coefficient of air permeability of the cocoon shell; c - cocoon shell porosity; l_i - cocoon shell thickness; P_n- air pressure in the outer layer of the shell; $P_в$ - air pressure in the inner layer

If $P_i(t)=V_i(t)$

in that

$$\frac{dV_i(t)}{dt}=\mu\left[V_{i+1}(t)-2V_i(t)+V_{i-1}(t)\right] \qquad (7)$$

Here $\mu=\frac{\lambda}{ch^2}$

Specific derivative $\frac{d^2P_в(t\cdot l_i)}{dl^2}$ P(t) can be approximated by the starting index of the coordinate. It has two adjacent points i+1 and i-1

$$\frac{d^2P\,(t_1\cdot l_i)}{dl^2}=\frac{1}{n^2}\left[P_{i+1}(t)-2P_i(t)+P_{i-1}(t)\right] \qquad (8)$$

Here

$$P_{i+1}(t)=P(t_1,l_{i+1}), \qquad P_{i-1}(t)=P(t_1,l_{i-1}) \qquad (9)$$

Taking these expressions into account, formula 8 turns into a first-order differential equation:

$$\frac{d\ P_i(t)}{dt}=\mu\left[P_{i+1}(t)-2P_i(t)+P_{i-1}(t)\right] \qquad (10)$$

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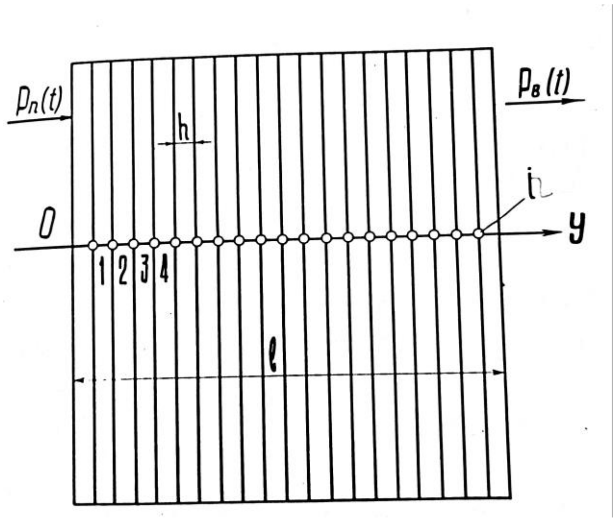

Fig.1. The passage of air pressure through the layers of the shell. l- is the thickness of the cocoon shell; h- is the thickness of one layer; i -number of layers.

The number of these equations corresponds to the number of layers of the cocoon shell. If the number of layers is "n", then all the equations together form a system of "n" ordinary differential equations.

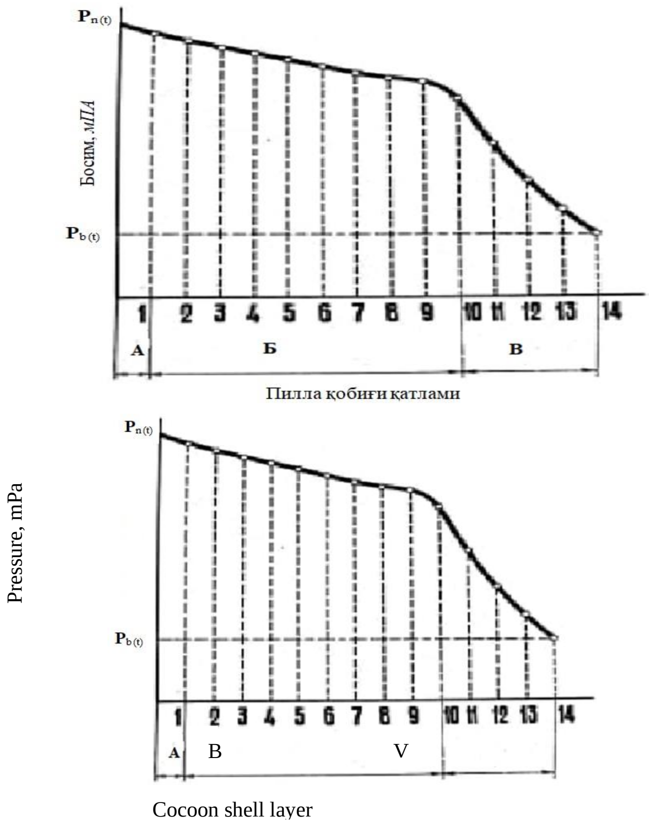

Fig.2 - Graph of changes in air pressure passing through the layers of the cocoon shell. A-top layer (sdir); B-middle main layer (silk); V-inner layer (film)

When scaling variables, it should be taken into account that the air pressure in the inner layers does not always exceed the value of the outer layer. Figure 2 shows that the rate of passage of air pressure through the layers of the cocoon shell is not the same. It is sharply reduced in the lower layers of the shell (film).

Conclusion

The ratios describing the process of mass transfer for the layers of the cocoon shell are given, and the differential equation of air permeability under pulsating pressure is obtained.

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