

## The peculiar features of the drying process in the heat pump drying installation

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*The regular mode in HPDY comes at the very beginning of the process and keeps on during the whole drying process. The experiment demonstrate that self setting of air parameters in HPDY keep regular mode of fish drying process due to gradual temperature rise and relative air moisture drop at slowing down the speed of moisture removal from the product. It cuts considerably the time of the process.*

Key words: drying, drying rate, regular mode, heat pump installation.

Fish drying is a non-stationary and non-reversible process, going on at the alternating (decreasing) speed, so calculation of kinetics process presents considerable difficulty. Fish muscle tissues refer to moist, colloid, capillary-porous bodies and moving forces of removing moisture at low temperature drying of such bodies is a moisture possession gradient. The drying process is characterized by the drying speed decreasing due to over drying of the fish upper layer. This is explained by its thickening and increasing resistance of moisture diffusion to the surface.

The kinetics of the inner mass transference at low temperature fish drying may be described in general case by equation of moisture change speed at any body point [2]:

$$\partial U / \partial \tau = \alpha_m \nabla^2 U + \alpha_m \delta \nabla^2 \Theta + k_p / \rho_0 \nabla^2 p, \quad (1)$$

where:  $U$  – body moisture content;  $\Theta$  – temperature drop,  $p$  – general pressure of moist air,  $\alpha_m$  – diffusion coefficient,  $\delta$  – relative thermo diffusion coefficient,  $k_p$  – molar filtering moisture transference coefficient,  $\rho_0$  – anhydrous body density,  $\nabla^2$  – Laplas operator.

It has been experimentally established that fish tissues heating in the process of drying to the drying agent temperature lasts from 0,1 to 0,8 hour depending on the fish thickness and this accounts for a comparatively small value of general drying duration (fig.1).

During that time the temperature levels off and keeps constant at different points throughout the fish thickness, i.e. temperature gradient tends to zero.

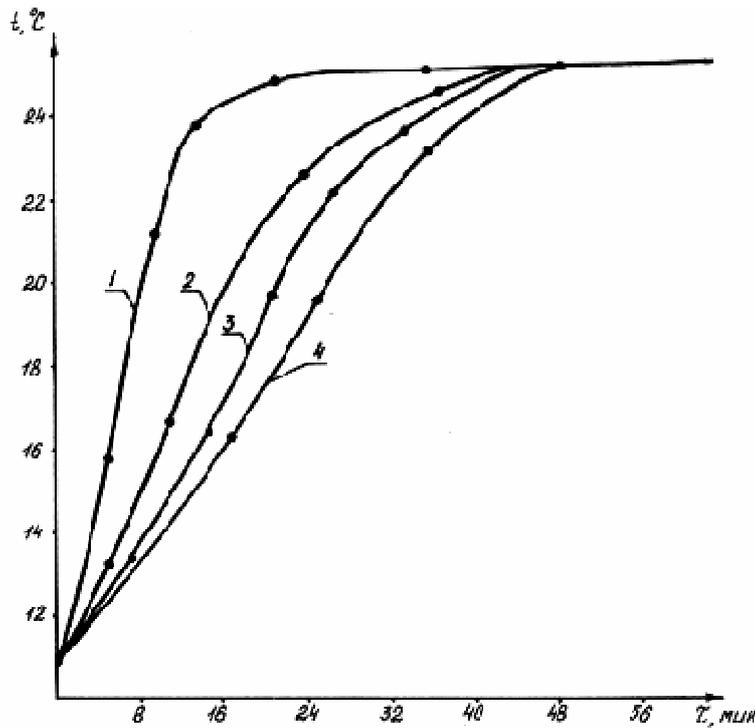


Fig 1. The dependence of temperature in a fish body on the time of drying  
 1 – on the surface of fish; 2, 3 – in a fish body; 4 – in the centre of fish body

It is known that mass transference reaches considerable values under the general pressure of moist air at the temperature of product close to 100°C. At such a temperature alongside with the pressure increasing due to specific volume rising of moisture in pores and capillaries we observe intensive vapor creation throughout the whole moist body volume, which is characteristic to such processes as frying, drying by means of high frequency electric current and others. Since the process of fish drying takes place at temperatures not higher than 35°C the influence of no relaxing pressure gradient is not of considerable value and it may be neglected.

So, mass transference at dry curing and cold smoking of fish may be described by the first equation component (1):

$$\frac{\partial U}{\partial \tau} = \alpha_m \nabla^2 U \quad (2)$$

Equation solution is known from the heat transference theory. It is obvious that just like in heat transference the regular mode occurs in the process of drying at a certain moment, which is defined by the drying rates:

$$\frac{\partial U}{\partial \tau} = -m = \text{const} \quad (3)$$

When the regular mode occurs the drying rate keeps constant in all the points of fish body and it characterizes relative speed of changing moisture content in fish body and depends only on its physical properties, parameters of moisture evaporation process on its surface, form and size, of fish.

If we experimentally determine the change of moisture content of fish thought time, then drying rate at regular mode can be defined by equation:

$$\ln U_1 - \ln U_2 / \tau_1 - \tau_2 = m = \text{const} \quad (4)$$

To support this hypothesis we have undertaken the fish drying experiment (bass, roach) in a special drying installation. It allowed to maintain constant air parameters (temperature, moisture and speed). Fish drying was carried out at  $t^\circ 20^\circ\text{C}$ , relative air moisture 50% and 70% and speed 1.5m/sec. Fish drying was done in a range from initial moisture to 50% of corresponding standard moisture of dried and cured fish product. Simultaneously were done fish drying experiments also in a heat pump drying installation. (HPDY).

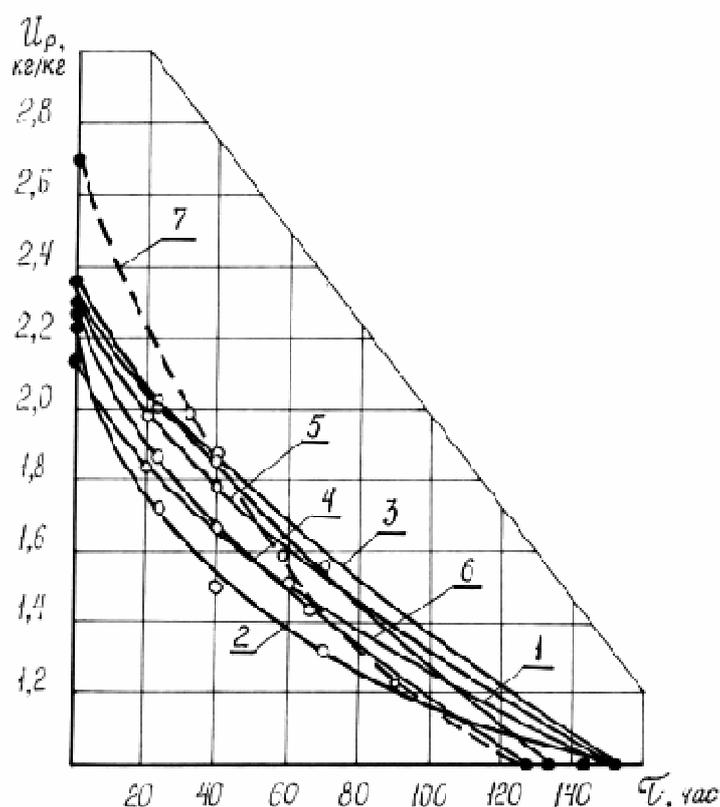


Fig. 2. Fish moisture change in the drying process.

1 – perch ( $\varphi = 50\%$ ), 2 – perch ( $\varphi = 70\%$ ), 3 – roach ( $\varphi = 50\%$ ),  
4 – roach ( $\varphi = 70\%$ ), 5 – safrefish ( $\varphi = 50\%$ ), 6 – safrefish ( $\varphi = 70\%$ ),  
7 – ban in HPDY

Drying curves are demonstrated at fig 2.

At the basis of experimental data the drying rate was calculated. Dependence of different fish drying on time is presented on fig.3.

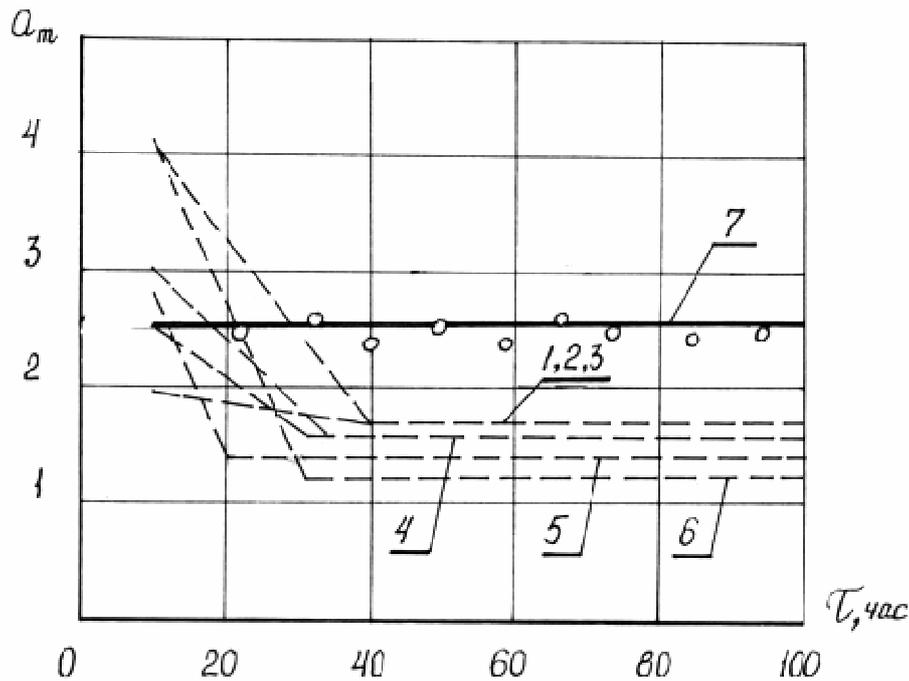


Fig. 3. Dependence of drying rate on time

1 – perch 50%, 2 – perch 70%, 3 – roach 50%, 4 – roach 70%,  
5 – safrfish 50%, 6 – safrfish 70%, 7 – perch in HPDY.

As it is seen from fig. 3 the drying rate at fixed air parameters gradually slows down and in 20 – 40 hours the regular mode comes.

The regular mode in HPDY comes at the very beginning of the process and keeps on during the whole drying process.

The experiment demonstrate that self setting of air parameters in HPDY keep regular mode of fish drying process due to gradual temperature rise and relative air moisture drop at slowing down the speed of moisture removal from the product. It cuts considerably the time of the process.

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# Специфические особенности процесса высухания в теплонасосной установке

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*В теплонасосной сушильной установке регулярный режим процесса сушки наступает уже в начале процесса и сохраняется в течение всего периода сушки. Результаты экспериментальных исследований показывают, что самоустановление параметров воздуха в теплонасосной сушильной установке сохраняют регулярный режим процесса сушки рыбы за счет постепенного повышения температуры и понижения относительной влажности воздуха при уменьшении скорости удаления влаги из продукта. При этом в значительной степени уменьшается время протекания процесса.*

Ключевые слова: высушивание, норма высухания, правильный способ, нагревает установку насоса.