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Modeling the operating modes of the refrigerating machine and the heat pump when drying fish

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Research Objective:

The design of air conditioning systems for production is a complex and responsible event, which includes a synthesis of engineering solutions and modern design methods. Analysis of the schemes and modes of air conditioning systems for the production of dried fish at the design stage will improve its energy efficiency and increase environmental and energy safety, as well as the availability of products for the consumer. The use of a heat pump in the SCR for drying and drying fish allows you to reduce energy consumption for the drying process and reduce the temperature required for drying.

Diagram of an air conditioning system for drying fish with a heat pump and a refrigeration machine

For the implementation of the technological process, various equipment is used, primarily refrigerating machines and heat pumps operating under certain conditions. The design of SCR for drying and drying fish is based on the choice of equipment and modeling of the parameters of the technological process. Thermal calculations of drying plants primarily relate to the determination of heat consumption for drying at the values of the drying agent parameters recommended by the technological instructions.

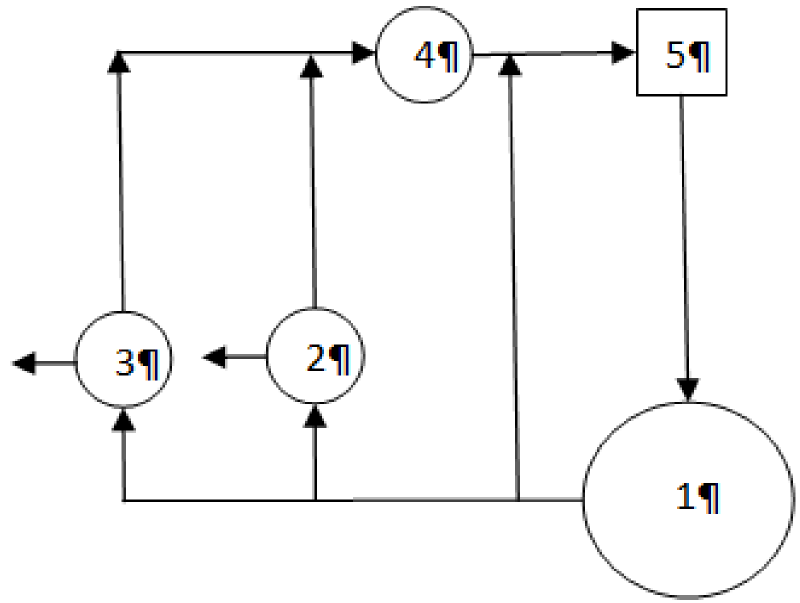

Diagram of air conditioning systems for drying fish: 1 - fish drying chamber, 2 - air cooler of the refrigerating machine, 3 - air cooler of the heat pump, 4 - condenser of the heat pump, 5 - circulation fan

Equipment used

For the simulation example, the configuration pair outdoor unit - indoor unit from Daikin was selected. In the simulated SCR, 2 heat pumps and 1 refrigeration machine were used for drying and drying fish.

Name	Dimension	The quantity
Outdoor unit model		RZQ250C7Y1B
Indoor unit model		FDQ250B8V3B
Indoor units		
Cooling Standard	kW	24.1
Heating Standard	kW	26.4
Input power		
Cooling Standard	kW	8.58
Heating Standard	kW	8.22
EER Cooling		2.81
COP Heating		3.21

Cooling capacities are based on the following conditions: Evaporator: 12 ° C / 7 ° C; condenser: 30 ° C / 35 ° C

Approximation of parameters for a refrigeration machine

To obtain a Daikin chiller model RZQ250C7Y1B with an FDQ250B8V3B indoor unit. The approximation of the parameters of the operating mode of the refrigerating machine in the cooling mode from two parameters is carried out - the temperature in the room and the temperature of the outside air. The equation for the total thermal power has the form:

$$Q_{\text{х.м.}} = 0{,}684 \cdot x - 0{,}131 \cdot y - 0{,}004424 \cdot x \cdot y + 18{,}62$$

$$Corr = 0{,}9999,$$

where x is the temperature of the refrigerated room, ° C; y is the outside air temperature, ° C.The refrigeration coefficient of the refrigerating machine is determined by the equation:

$$\varepsilon = \frac{Q_{\text{хм}}}{N_{\text{хм}}}$$

The capacitor power is determined by the equation:

$$Q_{\text{к\_хм}} = Q_{\text{хм}+} N_{\text{хм}}$$

Power consumption equation:

$$N = 0{,}051 \cdot x + 0{,}142 \cdot y - 0{,}001254 \cdot x^2 + 0{,}001513 \cdot x \cdot y + 2{,}116$$

$$Corr = 0.9996$$

Parameter approximation for a heat pump

The approximation of the parameters for the mode of operation of the refrigerating machine in the heating mode from two parameters is carried out - the temperature in the room and the temperature of the outside air.

The equation for the total thermal power has the form:

- $Q_{\text{т.н.}} = -0.185x + 0.649y + 0.002232x^2 + 0.0003125y^2 - 0.003625xy + 25.7$

Corr= 0,9998

, where x is the temperature of the heated room, ° C; y - outdoor air temperature, ° C For power consumption, kW:

$$N = 0.164x + 0.123y + 4.192$$
$$Corr = 0.9999$$

Compressor parameters

To calculate the wall temperature in the evaporator and to determine the outlet air temperature in the moist air diagram, it is necessary to determine the evaporating temperature and condensing temperature. As a first approximation, we take the boiling and condensation temperatures:

- for the refrigerating machine: to_хм = tкам_вых-Δto;   tк_хм=tнар+ Δtк,

- for a heat pump: to_тн = tкам_вых-Δto; tк_тн=tисп_вых+ Δtк .

Determine the boiling pressure Po and the condensing pressure Pк for the refrigerant R410A according to the equation P (tsat). Determine the pressure ratio π= $P_к / P_o$. We determine the adiabatic efficiency for a scroll compressor according to the equation obtained in [2]:

$$\eta = 0{,}0515 \cdot \pi^3 - 0{,}4998 \cdot \pi^2 + 1{,}6094 \cdot \pi - 0{,}9729$$

where η is the efficiency, π is the degree of pressure increase Pc / Po.

Finding air parameters

Then, using the CoolPack program, based on the calculation of a one-stage refrigeration cycle in terms of refrigerating capacity, compressor power, adiabatic efficiency and coefficient of performance, we obtain to and tк. The equations for the chiller and heat pump are similar. We solve the system of equations for finding the air parameters at the outlet from the evaporator $I_{\text{воз\_вых}}$ и $d_{\text{воз\_вых}}$

$$Q = G(I(t_{\text{воз\_вх}}, \varphi_{\text{воз\_вх}}) - I_{\text{воз\_вых}})$$

$$\frac{I(t_{\text{воз\_вх}}, \varphi_{\text{воз\_вх}}) - I_{\text{воз\_вых}}}{I(t_{\text{воз\_вх}}, \varphi_{\text{воз\_вх}}) - I(t_{\text{ст}}, \varphi_{\text{ст}})} = \frac{d(t_{\text{воз\_вх}}, \varphi_{\text{воз\_вх}}) - d_{\text{воз\_вых}}}{d(t_{\text{воз\_вх}}, \varphi_{\text{воз\_вх}}) - d(t_{\text{ст}}, \varphi_{\text{ст}})}$$

To determine the air temperature, we decide:

$$I_{\text{воз\_вых}} = I(t_{\text{воз\_вых}}, \varphi_{\text{воз\_вых}})$$

$$d_{\text{воз\_вых}} = d(t_{\text{воз\_вых}}, \varphi_{\text{воз\_вых}})$$

If during the solution $\varphi_{\text{воз\_вых}} > 100$ is obtained, this means that the point of the air state fell into the region below the saturated air line and it is necessary to solve the following system of equations to determine the temperature$t_{\text{воз_вых}}$

$$I_{\text{воз\_вых}} = I\left(t_{\text{воз}_{\text{вых}}}, \varphi_{\text{воз}_{\text{вых}}}\right)$$

$$\varphi_{\text{воз\_вых}} = 100.$$

To determine the temperature of the air from the condenser, we solve:

$$Q_{\text{к}} = G_{\text{к\_воз}}(I(t_{\text{к\_воз\_вых}}, \varphi_{\text{к\_воз\_вых}}) - I(t_{\text{к\_воз\_вх}}, \varphi_{\text{к\_воз\_вх}}))$$

$$d(t_{\text{к\_воз\_вых}}, \varphi_{\text{к\_воз\_вых}}) = d(t_{\text{к\_воз\_вх}}, \varphi_{\text{к\_воз\_вх}})$$

The flow rate of water condensate in the air cooler is determined by the equation:

$$G_{\text{влаг}} = G_{\text{воз}}(d(t_{\text{воз\_вх}}, \varphi_{\text{воз\_вх}}) - d(t_{\text{воз\_вых}}, \varphi_{\text{воз\_вых}}))$$

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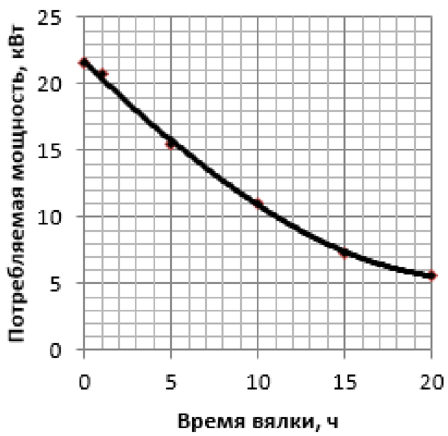
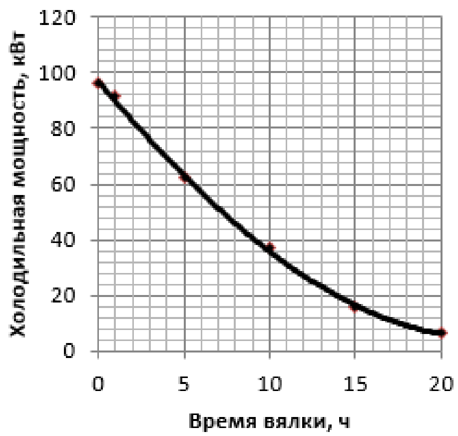
Results

The calculation according to the mathematical model was carried out when the drying chamber was operating with a loading of 1000 kg of cut fish and the consumption of moisture removed from the product in accordance with the drying kinetics. The analysis was carried out with air supply to the drying chamber with a temperature of 25 ° C and a relative humidity of 55%. The air consumption in the drying chamber is taken in the amount of 40,000 m3 / h. Based on the presented calculation and analysis of the scheme with a heat pump, we can say that this drying method is more efficient and economical compared to other methods.





composition СКВ	Time	Qo_{XM}	Qo_{TH}	Nэл	Gвл
	h	kW	kW	kW	kg/h
ХМ+ТН	0	51	45	21,55	74,58
ХМ+ТН	1	49,5	42	20,75	67,92
ХМ+ТН	5	33	29,1	15,53	44,58
ХМ+ТН	10	21,9	15	11,05	22,9
ХМ+ТН	15	10,5	5,4	7,32	9,63
ХМ+ТН	20	5,4	0,9	5,62	4,82

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Conclusions

In general, it can be concluded that modeling the process of drying and drying fish and finding its main parameters, i.e. temperatures at the inlet and outlet of the air cooler, humidity, the amount of moisture removed during dehumidification, wall temperatures of evaporators, boiling and condensing temperatures, allows you to design a system and simulate its operating mode. The mathematical model, the approximation of the equipment characteristics and the found boiling and condensation temperatures make it possible to fully describe and analyze the operation of the SCR system under the conditions of the technological process, which is important in the design and selection of equipment. To solve the presented problem, an analytical and graphic-analytical method is used, which makes it possible to build a model of the air conditioning process for drying and drying fish. The method, using a mathematical model of equipment, allows you to solve a system of equations and calculate the parameters of the technological process, air parameters - temperature and humidity at specified points, primarily at the inlet and outlet of air coolers and condensers. The presented mathematical method makes it possible to analyze the design work and select the most rational schemes and equipment that are most effective for the developed technological process.

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Thank you for your attention!

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