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Processes of Heat And Moisture Exchange of the Surface of a Heated Liquid in Direct Contact With the Environmental Air

Mansurova Sh. P. [1]

Abstract: The article examines and analyzes the temperature conditions of possible cases of evaporation of water and liquid vapors during unintended contact with the surrounding air.

Key words: heat exchange, mass exchange, evaporation process, liquid surface temperatures, heat content, moisture content.

The sensible heat coming to the surface of the liquid is completely spent on evaporation, thereby turning into latent heat. The liquid vapors formed during evaporation enter the surrounding air, increasing its moisture content. Since liquid vapors are a heat carrier, they transfer their heat to the surrounding air along with themselves, as a result of which the heat content of the air increases. The heat spent on evaporation, as well as the sensible and sensible heat given off by the surface of the liquid, in this case will enter the liquid from the specified special heater and be transferred to its surface due to the thermal conductivity of the liquid itself. As a result of the ongoing process of heat and mass exchange, the temperature, heat content and moisture content of the air will increase.

Let us consider and analyze the temperature conditions of possible cases of evaporation of water and liquid vapor entering the surrounding air, increasing its moisture content.

Case 1. Isothermal evaporation process ($t_c=t_p>t_m$). This process is characterized by the equality of the temperatures of the liquid surface and the surrounding air. If there are no bodies in the room with a temperature different from the liquid surface (or air), then the evaporation process will be caused by the finite value of the difference in partial pressures (p_{pp} - p_{po}) > 0 (where p_{pp} and p_{po} are, respectively, the partial pressures of vapors on the liquid surface and in the surrounding air). In this case, the heat expended on evaporation of the liquid $Q_B = G_p r$ (where G_p is the amount of evaporated liquid; r is the heat of evaporation), will be supplied to the surface due to the thermal conductivity of the liquid. It is assumed that the liquid receives this heat from some heater that maintains a constant surface temperature $t_p = t_c$ during the evaporation process. Thus, the steady-state evaporation process occurs under isothermal conditions. Since $t_p - t_c = 0$, the amount of exchangeable sensible heat Q_y between the liquid surface and the environment is also equal to 0. As a result of the ongoing heat and mass exchange process, Q_p kg of steam and Q_c enter the air. G_p i kcal of heat (where i is the heat content of steam), as a result of which the heat content and moisture content of the air will increase while its temperature remains unchanged.

Case 2. Adiabatic process ($t_с > t_п = t_м$). From the above it is known that at $t_п = t_м$ an adiabatic evaporation process will occur, which is characterized by equality between the amount of heat received by the liquid surface from the surrounding air and the amount of heat spent on evaporation. At $t_с > t_п$ the flow of sensible heat $Q_я$ will be directed from the surrounding air to the liquid surface. The sensible heat arriving at the liquid surface is completely spent on evaporation, thereby turning into latent heat (vapors of the evaporated liquid $G_п$ r). However, this increase occurs only due to the initial heat content of the evaporated liquid, equal to $G_п$ t_m and usually representing a very small share of the total heat content of water vapor, as a result of which it is practically accepted that $Q_c = G_п i \approx G_п r = Q_я$. Thus, this approximation allows us to consider the process under consideration as adiabatic. A characteristic feature of this process is that Q_{in} =0.

[1] Jizzakh Polytechnic Institute

Case 3. Non-isothermal process ($t_c<t_п>t_м$). Under such temperature conditions, the flow of sensible heat $Q_я$will be directed from the surface of the liquid to the environment. It is assumed that maintaining a constant temperature of the surface of the liquid is ensured by a special heater. Since $p_{пт}–p_{po}>0$, then evaporation will occur simultaneously with the release of sensible heat from the surface of the liquid. The amount of heat supplied to the surface of the liquid from the heater in this case will be equal to$Q_в = G_п i + Q_{я.}$

Case 4. Non-isothermal process ($t_p>t_p<t_c$). Since the surface temperature is lower than the ambient temperature, the sensible heat flux Q s will be directed from the environment to the liquid surface. The mass flow of substance G_p will also be directed from the surrounding air to the liquid surface, since under the temperature conditions under consideration the partial pressure of vapors in the air is higher than their partial pressure directly above the liquid surface (since $t_p < t_p$, where t_p is the dew point temperature). When moist air comes into contact with the liquid surface, condensation of water vapor will occur, accompanied by the release of heat of evaporation (G_p r). Thus, heat in the amount of will enter the liquid from the environment $Q_в = Q_{я.} + G_п r$. It is assumed that maintaining a constant liquid surface temperature in this case is ensured by a special cooler. As a result of this process, the temperature, heat content and moisture content of the air decrease. Similar processes are often encountered in air conditioning systems when cooling and drying it is required.

Case 5. Temperature conditions of the process ($t_c > t_п < t_м$) and $t_п > t_p$. Since $t_м > t_п$ and $t_п > t_p$, the value of $Q_я$ will be greater than the value $G_п i$as a result of which the difference $Q_я$ - $G_п i$will express the amount of heat entering the water. The rays of change in the state of air in such processes are located within the angle between the lines I = const and d = const .

Case 6. Temperature conditions of the process $t_c > t_п > t_м$. Changes in the state of air under such temperature conditions are depicted by rays lying within the angle formed by the lines t = const and I = const (except for the purely adiabatic process considered in the 2nd case). In this case, the flow of sensible heat is directed from air to water, since $t_c > t_п$, and the flow of steam is from water to air. In this case, the heat transferred to the air by steam $G_п i$, will be greater than the sensible heat given off by the air Q_I , as a result of which the amount of heat given off by the air Q_I as a result of which the amount of heat equal to $G_п i$- Q_I will come from the heat source maintaining constant temperature conditions of the water.

This means that the temperature of the water will increase due to the influx of this heat, and the temperature and heat content of the air will decrease. Thus, this process of interaction between water and air allows for the cooling of the air with a simultaneous increase in its moisture content with a corresponding decrease in heat content due to the apparent heat given off by the air to the water.

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