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Development of High-Efficient Calorifier for Systems of Air Conditioning

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Abstract: The values of the optimal height of the fins on the surface of the calorifier tube were detected. The criterial dependence for calculating of the heat transfer in a channel located at the angle of 90 degrees to the horizon with rectangular bars with free air convection was obtained.

Key words: Experimental setup · Rectangular rod · Free-convection flow · Heat transfer coefficient · Calorifier

INTRODUCTION

Air conditioning is designed to create a working area of the space of optimal parameters of microclimate (temperature, relative humidity, purity and velocity) at a given level in order to ensure that the conditions most favourable to the health of people, management of technological process, ensuring the preservation of cultural values and the maintenance of comfortable conditions of stay of cattle [1, 2].

The air conditioning system automatically maintains the air coming into the room (temperature, relative humidity, purity and motion speed near jobs) at a certain level in order to ensure optimal meteorological conditions [3, 4].

Thus, the conditioning system allows qualitatively and quantitatively to adjust the parameters of the air entering the premises in accordance with the specified thermal and humidity conditions of the building. The quality of cleaning ventilation air from coarse and fine dust is achieved by passing it through an air filter, the degree of heating of the air depends on the power of the radiator (heat exchanger) and the degree of hydration depends on the curing inlet air in the chamber irrigation.

The Main Part: The air supplied to the premises and used as the working fluid for the Central and local air conditioning systems, prepared in air (Figure 1).

As supply in air conditioning systems used inside or outside air or a mixture thereof. Depending on the condition of the air it needs either cool and moist or dry or combine these processes.

The heaters are devices having a large area of the outer heat-transfer surface and used for heating air in air conditioning systems, ventilation and standby heating.

The outer surface of the tubes of the air heater can be developed by means of plates or fins (roughness). The most common water, steam and electric heaters.

Electric heaters are available air capacity from 10 up to 40 thousand m^3/h and their heat output can vary in the range from 10 to 200 kW. Electric heaters can switch to supply current to the voltage of 220 and 380 V.

Figure 2 shows the electric air heater with tubular heating elements.

Tube heating elements orebrenie aluminum to increase the surface area of heating. The heating elements allow to adjust the degree of heating of the air.

To increase the average coefficient of convective heat transfer in the heaters with tubular heating elements can be used on the outer surface of the tubes of a ring with rectangular fins, which are set at the same distance from each other. The presence of rings with rectangular fins increases the heat transfer surface and increases the speed of the coolant, which in turn leads to an increase in the convection coefficient.

The author proposed a design of the heat exchanger, on the inner surface of which is at the same distance from each other mounted rectangular bars.

The purpose of these studies was the determination of empirical equations in a dimensionless form for the calculation of average convection coefficient in the channel located in the space under the angle of 90 degrees to the horizon, under free air convection. Also to the objectives of this study were to identify the impact of the installation step on the inner surface of the channel of rectangular rods for the average convection coefficient.

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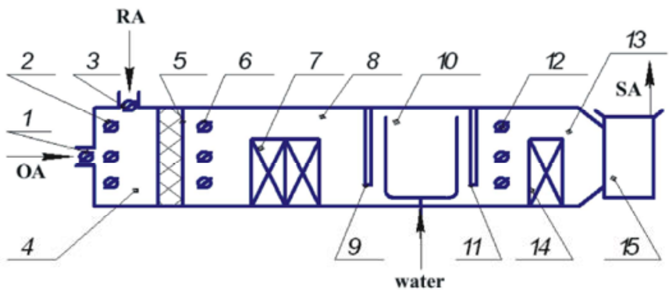

Fig. 1: Scheme of conditioning outside air with recirculation
1 - louvered grille; 2, 3, 6, 12 valves; 4 - mixing chamber, 5 - filter; 7 - heater of the first stage; 8,13 - guide channels; 9, 11 - separator; 10 - chamber irrigation; 14 - heater of the second stage; 15 - fan; arrows indicate consumption of outdoor air (OA), recycling air (RA) and supply air (SA)

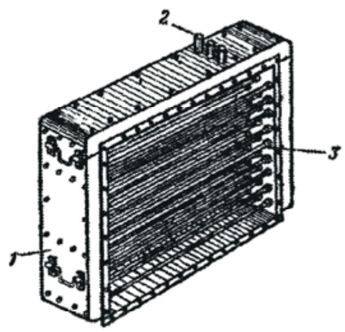

Fig. 2: Electric Heater. 1 – body; 2 – inlet wiring; 3 – heating elements

For this there were two experimental working area.

The first studies of heat transfer were conducted in a rectangular channel without rods, which was located in space at an angle of 90 degrees to the horizontal and had a length L = 1.0 m and width b = 0.36 m. the Experiments were performed in channels with height of 15 mm, 30 mm, 45 mm and 60 mm.

The main parameters changed in the range: the product of the number Grashof on Prandtl number $Gr_B \Pr\left(\frac{B}{L}\right)=\frac{g\beta\mu c_p B^4\Delta T}{L\lambda\nu^2}=\frac{g\beta\mu c_p B^4 q_w B}{L\lambda\left(\frac{\mu^2}{\rho^2}\right)\lambda}=\frac{g\beta q_w\rho^2 c_p B^5}{\mu L\lambda^2}=13...1,3\cdot10^6$; Prandtl number Pr = 0,7; the heat flux density q_w = 4...460 W/m^2; temperature difference: $\overline{t_w}-t_o$ = 7...54 °C, где $\overline{t_w}$ – the average temperature of the channel wall; the average air velocity in the channel $\overline{w}=0,28...0,56$ m/s.

The flow regime of the coolant was determined by visualizing the flow at the exit of the channel. Throughout the range were visually observed laminar flow regime of the coolant.

In addition, studies have been conducted in the channel of length L = 1.0 m, width b = 0.36 m rectangular rods made of aluminum with a height of H = 4.1 mm, which were installed along its entire length, at first at a distance of 41 mm from each other, then at the distance of 82 mm, then at a distance of 164 mm and end at a distance of 328 mm. the Experiments were performed in channels with height of 15 mm, 30 mm, 45 mm and 60 mm.

In the experiments realized heating at a constant heat flux from the wall (q_w = const).

The main parameters changed in the range: the product of the number Grashof on Prandtl number $Gr_B \Pr\left(\frac{B}{L}\right)=\frac{g\beta\mu c_p B^4\Delta T}{L\lambda\nu^2}=\frac{g\beta\mu c_p B^4 q_w B}{L\lambda\left(\frac{\mu^2}{\rho^2}\right)\lambda}=\frac{g\beta q_w\rho^2 c_p B^5}{\mu L\lambda^2}=20...1,4\cdot10^6$; Prandtl number Pr = 0,7; the heat flux density q_w 7...502 W/m^2; simplex $\frac{T}{H}=10...80$; simplex $\frac{H}{B}=0,07...0,27$; the temperature difference between the: $\overline{t_w}-t_o=$ 6...50°C, where $\overline{t_w}$ – the average temperature of the channel wall.; the average air velocity in the channel $\overline{w}=0,28...0,56$ m/c.

The flow regime of the coolant was determined by visualizing the flow at the exit of the channel. Throughout the range were visually observed laminar flow regime of the coolant.

As rectangular rods were made of duralumin, in the calculation of the coefficients of convective heat transfer were taken into account the increase of the heat-transfer surface area for given surface area of the two side faces of each rectangular rod.

Processing of empirical data is made in the form of criteria dependence $\overline{Nu}_B = c(Gr_B \Pr\left(\frac{B}{L}\right))^k\left(\frac{T}{H}\right)^m\left(\frac{H}{B}\right)^n$.

In this relationship the characteristic linear size was used the height of the channel and defining the temperature was the ambient temperature t_0, which was equal to the temperature at the inlet of the channel located in the space under the angle of 90 degrees to the horizon.

The result has been obtained the criteria dependence, which is a power function and describes the results of the study, the average heat transfer in a channel with rectangular cores in the investigated range in conditions of free convection of the coolant flow:

$$\overline{\mathrm{Nu}}_{\mathrm{B}} = 0{,}15(\mathrm{Gr_B\,Pr}\left(\frac{B}{L}\right))^{0,2}\left(\frac{T}{H}\right)^{0,35}\left(\frac{H}{B}\right)^{-0,34}, \qquad (1)$$

where $\overline{\mathrm{Nu}}_{\mathrm{B}} = \frac{\overline{\alpha} B}{\lambda}$;

$\mathrm{Gr_B\,Pr}\left(\frac{B}{L}\right) = \frac{g\beta q_w \rho^2 c_p B^5}{\mu L \lambda^2} = 10^2 ... 10^6$;

$\mathrm{Pr} = 0{,}7$;

$\frac{T}{H} = 10...80$;

$\frac{H}{B} = 0{,}07...0{,}27$;

The criterion relation (1) describes the empirical data with a relative error ± 20 % with confidence 0, 95.

CONCLUSION

Thus, it was found that the installation of rectangular rods with a pitch of 164 mm in the channel located under an angle of 90 degrees to the horizon, leads to an increase in the average convection coefficient up to 300 % compared to the canal, where there are no rods. It is obtained that the geometric simplices $\frac{T}{H}$ and $\frac{H}{B}$ act as individual parameters affecting the average coefficient of convective heat transfer in a channel with rectangular rods.

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