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Influence of Fluid Distribution in Heat Absorbing Body on Nonuniformity of Surface Temperature of Heat Sink

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Abstract

In this paper, the physical model of the flow passage structure of endothermic body is established by abstract simplification,In the heat conduction, convection and resistance analysis, velocity analysis and heat transfer characteristics and other aspects of the establishment of the mathematical model of the flow and heat transfer parameters, get the corresponding theoretical values, provides a theoretical basis and specific theoretical analysis for future research.The experimental research on the flow and heat transfer process of the working fluid in the flow channel is carried out. The scheme of the experiment platform, the related system of the experiment and the data processing are described.

Keywords:*channel heat,absorbing body, thermal boundary layer, heat transfer characteristics.*

1. Introduction

At present solar energy utilization, solar water heating system technology mature, cost-effective, the most widely used, the fastest development and large-scale industrial production. Solar water heating system is a kind of device which uses solar collector to collect solar energy for heating water. Solar collector is the core device of solar water heating system, which absorbs solar energy to produce heat energy and transfers heat energy to heat transfer working medium.

Flat plate solar collector absorber is a collector solar radiation energy into heat and passed to the key parts, working medium therefore, thermal conductivity of absorber directly affects the collector efficiency, its performance and the material thermal conductivity, structure and form with the radiation characteristics of surface coatings have a great relationship.The structure of absorber must consider and use conditions, materials, processing technology and cost factors. Flat plate solar collector absorber materials now mostly use copper material, copper material prices have been in high level, but the copper resources are scarce, in recent years the price of copper has been a rising trend, which undoubtedly increases the cost of manufacturing, the collector of copper material in addition, processing cost is relatively high also, processing more difficult.Therefore, the material can be changed into the pot material, the material cost is low, the processing is easy, and the processing cost is low.Components with complex structures can be machined at a lower cost.

2. Theoretical Analysis of Flow Heat Convection

Thermal convection refers to the phenomenon of heat transfer due to the macroscopic movement of fluid and the relative displacement of fluid at different temperatures. Thermal convection occurs only in the fluid, and this process must be accompanied by the irregular thermal motion of the fluid molecules. When the fluid flows through a solid surface, because the fluid is viscous, so attached to the solid surface is a thin layer of fluid is stationary, and away from the solid surface normal direction, the velocity of the fluid flow velocity increases gradually coming,This layer of thin, low velocity fluid called boundary layer.In the boundary layer between the fluid and solid heat transfer, heat convection boundary layer and the outer layer of the adhesive interaction of boundary layer fluid thermal static to the solid surface of the two basic heat transfer results, the heat transfer phenomenon in heat is called convection heat transfer.

2.1 Newton cooling formula

The heat transfer process in the direct contact between fluid and solid surface is called convection heat transfer,It includes two basic heat transfer modes: heat convection through solid surface and heat conduction close to solid wall surface,The heat exchange can be calculated by Newton cooling formula.

$$\phi = hA(T_w - T) \quad (1)$$

If the heat flux density is used to represent，as follows:

$$q = h(T_w - T) \quad (2)$$

2.2Convection heat transfer differential equations

For a convection heat transfer coefficient, must know the fluid temperature gradient at the wall, also is to know the temperature of the fluid inside, and the temperature field and the velocity of the fluid is closely related to the distribution, which is determined by the energy equation.In

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order to obtain the temperature field, the velocity field must be solved first, and the velocity field is obtained from the continuity differential equation and the momentum differential equation. Therefore, the convection heat transfer problem involves solving simultaneous differential equation, momentum equation differential equation and energy differential equation. These three differential equations constitute the differential equations of convection heat transfer.

The continuous differential equation is derived from the law of conservation of mass. Any flow problem must satisfy the mass conservation equation, that is, the continuity equation. There is no limit to the applicability of the continuity equation,Both compressible or incompressible fluids, viscous or inviscid fluids, steady or unsteady flow of fluids are applicable.Its differential form in Cartesian coordinates is as follows:

$$\frac{\partial \rho}{\partial t}+\frac{\partial(\rho u_x)}{\partial x}+\frac{\partial(\rho u_y)}{\partial y}+\frac{\partial(\rho u_z)}{\partial z}=0 \qquad (3)$$

For steady flow, the density does not change with time, the formula (3) becomes:

$$\frac{\partial(\rho u_x)}{\partial x}+\frac{\partial(\rho u_y)}{\partial y}+\frac{\partial(\rho u_z)}{\partial z}=0 \qquad (4)$$

For a steady incompressible flow, the density is constant, the formula (4) becomes:

$$\frac{\partial u_x}{\partial x}+\frac{\partial u_y}{\partial y}+\frac{\partial u_z}{\partial z}=0 \qquad (5)$$

2.3 thermal boundary layer and heat transfer characteristics

When the convective heat transfer process occurs between the fluid and the solid surface, the temperature difference exists between the fluid and the solid surface, similar to the flow boundary layer.There is a large temperature gradient in a thin layer near the solid surface,The fluid temperature near the solid surface is almost the temperature of the solid wall, which is the thermal boundary layer or the temperature boundary layer.It is similar to the division of flow boundary layer, the temperature field in the channel can be divided into two regions in the mainstream area and thermal boundary layer, the temperature changes in the mainstream region in the fluid rate can be regarded as zero, so the heat transfer in the thermal boundary layer within the main area,As shown in Figure 1, after a distance, the fluid eventually reaches the fully developed state of heat. The distribution of the temperature field is shown in Figure 1, and the final temperature distribution is related to the wall temperature boundary condition.

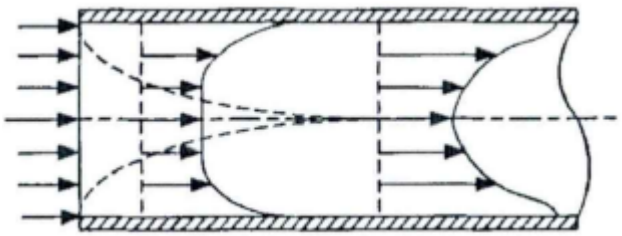

Fig. 1 Temperature distribution in the channel

In heat transfer, an important index of heat convection intensity with the convection heat transfer coefficient and Nusselt number, there is a certain relation between them, mathematic expressions are as follows:

$$h=\frac{\lambda Nu}{l} \qquad (6)$$

l is the characteristic length of the endothermic body flow channel, which is the hydraulic diameter of the endothermic body flow passage, λ is the flow of heat conduction coefficient.

3. Experiment

Flat plate solar collector is non condensing type solar heat collector, a heat absorber surface is a flat plate shape. Flat plate solar collector has the advantages of simple structure, convenient installation, low cost, easy to realize the integration of the building, with respect to the condensing type solar heat collector, can not only absorb the solar direct radiation, can absorb solar radiation scattering jurisdiction.At present, domestic solar hot water systems, large public solar hot water systems, air conditioning, building heating, refrigeration and drying are widely used flat solar collector. On the other hand, flat solar collector can absorb the direct blessing and scattering blessing, but because of no condensing function, the energy density and working temperature are relatively low.At the same time, flat solar collector in high temperature (low efficiency, surface heat loss, poor performance in winter antifreeze).

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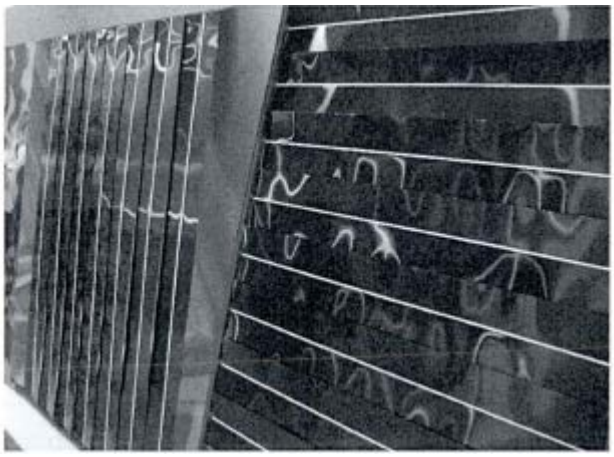

Fig. 2 Heat absorbing body figure of flat plate solar heat collector

Figure 3 is a diagram of the absorber channel experiment system.The experimental system consists of a power part, heating part and data acquisition part of the three major functional blocks, mainly comprises a power part and a water storage tank and a circulating pump, valve and throttle valve; the heating part includes electric heating, power meter, a thermometer, voltage regulator, voltage regulator and heat insulation cotton;Data acquisition includes data acquisition module, host computer, handheld ultrasonic flowmeter, pressure sensor and temperature sensor.

Fig. 3 The endothermic body flow experimental system physical map

The heat source of the heating part of the experimental system is arranged on the heat absorbing plate,absorbing plate is heat by electric heating belt ,Heat absorbing plate transfers heat to working fluid channel.The electric heating belt is connected with the power meter, the power meter is connected with the voltage regulator, and the voltage regulator is connected with the voltage stabilizing power supply. In the work process, regulated power supply provides a constant voltage regulator can change the input voltage is connected with the electric heating belt can be adjusted by the power value, power meter can display the total power of electric heating value, handheld thermometer can observe the absorber plate temperature,Insulation cotton insulation effect can make the temperature of the absorber plate is constant,also can make the temperature sensor measured temperature channel temperature is more accurate.In the experiment, the electric heating belt is adopted, the heat absorbing plate is selected as an adjustable group and is connected with the voltage regulator, and the other groups are directly connected with the voltage stabilizing power supply.Figure 4 is electrical heating belt layout of the physical map.Through the convenient adjustable group can achieve change range, which is directly connected with the power supply group of electric heating belt can be determined according to the actual needs of the strobe, thus the total heating power supplied to the system can be adjusted.

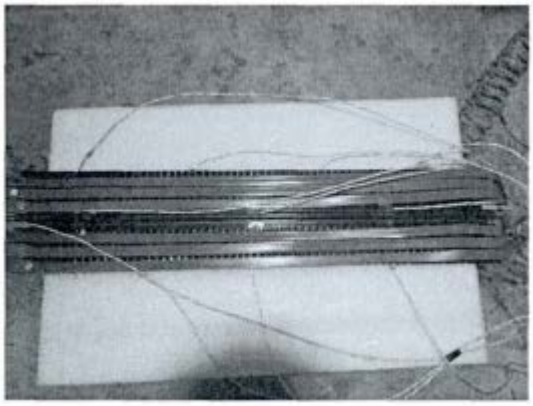

Fig. 4 Arrangement of electric heating tape and temperature sensor on test piece

The indirect quantity of this experiment can be obtained from the measured direct quantity and the corresponding formula.If the experiment verifies the results of temperature value, pressure drop value and velocity value, then the corresponding relation of the corresponding calculation formula,The results of other indirect quantities can also be confirmed,The following are the experimental results of temperature, pressure drop and velocity values of four single channels, which are single circle, single rectangle, porous rectangle and single rectangle with triangular fins on the inner wall.The temperatures of the outlet of runner obtained experimentally are shown in the table 1,

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Table 1 The temperatures of the outlet

Inlet velocity	0.1	0.2	0.3	0.4
Single round outlet temperature(K)	301.66	298.12	296.35	295.65
Single rectangular outlet temperature(K)	304.69	299.32	297.61	295.99
Temperature of porous rectangular outlet(K)	304.55	300.42	298.63	297.89
Delta fin outlet temperature(K)	304.02	300.87	298.32	296.93

4.Conclusions

The influence of various flow channel structures on the flow and heat transfer characteristics of the working fluid in the channel,Some rules of the influence of flow passage cross-section on the flow and heat transfer characteristics of the working fluid are further verified. From the heat transfer characteristics,four channels inside the smooth wall,the best heat transfer effect of porous rectangular channel,the heat transfer effect of the inner wall with fins is better than that of the smooth channel,and the heat transfer effect of triangle inner wing is best.From the flow characteristics, when the material flow cross-sectional area and cross-sectional area are equal, the resistance loss of smooth wall channel overall than the inner wall of finned channel is small, and the resistance loss of single circular runner is minimum; the reason is that when the material section area and discharge section area are equal, if the resistance increases flow area by a hole wall is a porous fin increased or when, the velocity of working fluid decreases, heat transfer time increases, the heat transfer effect is better.

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