THERMAL RADIATION THROUGH PERFORATED SCREENS

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Results of research of radiating heat exchange in a system of flat surfaces when there is a continuous screen or there is a perforated screen are described. The equations of the resulting radiant streams between surfaces are represented. It is established that at the certain radiating characteristics and geometrical characteristics the system of surfaces with the perforated screen radiates energy more, than similar system with the continuous screen.

NOMENCLATURE

q_i resulting radiant heat flux
ε total emissivity
$\dot{q}_{r,i}$ dimensionless radiant heat flux between surfaces i and j
β ratio of the total perforation area to the geometrical area (perforation degree)
σ Stefan-Boltzmann constant

INTRODUCTION

The control of radiation heat exchange in different media requires the examination of regularities of radiation heat exchange between different surfaces. Therefore intensification of radiation heat exchange with the help of shields there is an actual problem.
For examination of such problems, many different analytical and numerical methods are available [1]. In a recent paper for deriving the equations for an interchanging of energy we used the simplified zone method [2]. For the first time effect of magnification of a radiation flux was obtained in [3] for grid cylinders. Here we reduce the analysis of radiation which transits through a surface with perforation at different values β and ε.

ANALYSIS

We shall consider the system consisting of two parallel infinite surfaces between which the continuous thin screen (Fig.1) is located. We shall make the following assumptions: surfaces in system are Grey surfaces. Surfaces are homogeneous surfaces, and they have constant temperature. Environment is transparent, and the size of a flux of energy, transferable a gas layer convection or heat conductivity, is small. We neglect this size.
At the established thermal condition of all system $q_1 = q_3$. We can accept $T_2 = T_3 = T_s$, because the screen is thin also his material has the big heat conductivity.
In this case existence of the screen in system reduces a resulting flux of energy in 2 times as. However, if a emissivity of a surface 1 to accept $\varepsilon_1 = 1.0$, and the others $\varepsilon_i = \varepsilon$, then

$$T_s^4 = T_4^4 \frac{\varepsilon}{1-(1-\varepsilon)^2+\varepsilon} = T_4^4 \frac{1}{(3-\varepsilon)} \tag{1}$$

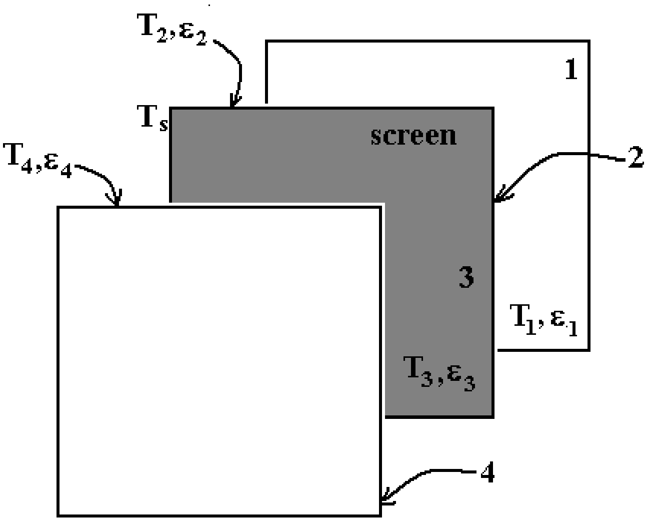

Fig.1. Radiating system

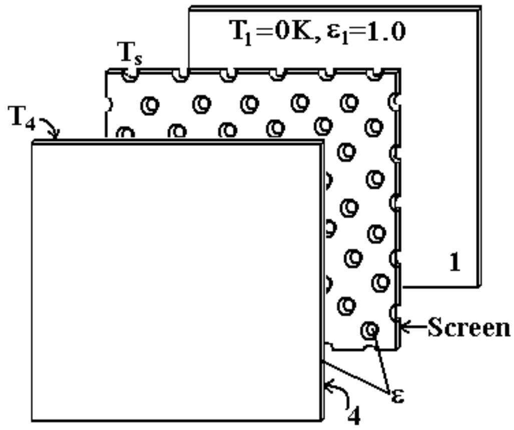

Fig. 2. Radiating system with perforations Screen

The resulting flux decreased not in 2 times, and in (3-ε) times when $\varepsilon_i = 1.0 = \varepsilon$

$$q_1''' = \sigma A_1 \left(T_4^4 \frac{\varepsilon}{3-\varepsilon} - T_1^4 \right) \tag{2}$$

as T_1 = 0K,

$$q_1''' = \sigma A_1 T_4^4 \frac{\varepsilon}{3-\varepsilon} \tag{3}$$

We can draw the following conclusions: if in system there is a continuous screen he reduces a resulting radiant flux, and this reduction is connected to radiating characteristics of the radiating surface accepting warmly to a surface and the continuous screen.

Now consider the same system of surfaces, as on Fig.1 but provided that the apertures punch the thin screen in regular intervals allocated on a surface of the screen (Fig.2). We shall find a resulting flux of energy, radiates the screen and a surface 4, at the set temperatures, optical properties and geometry of surfaces. We make the following assumptions: 1) surfaces infinite; 2) the continuous part of surfaces is sulfur, homogeneous; 3) all surfaces have in regular intervals allocated temperature, and $T_2 = T_3 = T_4 > 0$; 4) environment which fills in system, is environment transparent. The surface 1 - a black surface, ε_1 = 1.0, its temperature is T_1 = 0K.

We shall write down radiates a flux of energy from the screen and surfaces in a dimensionless kind in relation to a flux of energy which is radiated by a continuous surface with the same temperature and an emissivity ε

$$\dot{q}_{r1} = \frac{q_1}{\varepsilon \sigma T^4 A_0} \tag{4}$$

We shall receive the equation determining a dimensionless stream of energy from system

$$\dot{q}_{r1} = (1-\beta) + \frac{\beta\{1+(1-\varepsilon)(1-\beta)\}}{1-(1-\varepsilon)(1-\beta)} \tag{5}$$

Apparently from the figure, the system at any values ε and β radiates more, than the continuous surface with the same emissivity, and exists the maximal value $\dot{q}_{r1}$, dependent on a degree of perforation of the screen. Increase $\dot{q}_{r1}$ essential enough.

Thus, determining influence on position of a maximum of radiation $\dot{q}_{r1}$ bring a flux of radiation from the external perforated surface of the screen and a flux of energy through of punching of the screen from a continuous radiating surface, and to a lesser degree a flux of radiation from an internal surface of the screen, at reflection from a continuous surface of system. This flux of energy too has a maximum of radiation which does not coincide with a maximum of function $\beta_{max}(\dot{q}_{r2,4-1})$, but the size of a flux makes no more than 10 % from $\dot{q}_{r2,4-1}$ and consequently essential influence on a resulting flux of radiation $\dot{q}_{r1}$ does not render. Size $\beta_{max}(\dot{q}_{r3-1})$ is described by the following equation

$$\beta_{max}(\dot{q}_{r3-1}) = \frac{\sqrt{\varepsilon(2-\varepsilon)} - \varepsilon(2-\varepsilon)}{(1-\varepsilon)^2} \tag{6}$$

CONCLUSION

Thus, the phenomenon of perforated effect does not contradict the basic laws of radiating heat exchange and will well be coordinated to results of researches which were carried out at studying the radiant streams leaving cavities (models of absolutely black body) [1, 2, 3, 4, 5]. However, as we saw in the beginning of article, the continuous screen reduces radiation in 2 times, and the screen with aperture essentially increases this flux.

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