A RADIATOR SYSTEM FOR COOLING A SHORT CYLINDRICAL BODY

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A solution is given for the heat loss and optimal design of radial cones (solid and hollow) that lie in the same plane.

We have given [1] a solution for the design and optimization of a system of radial cones diverging from an isothermal sphere.

These relationships [1] represent a particular case of a short cylinder when the cones diverge in a plane instead of three dimensions (Fig. 1). In this case the length of the cylinder equals the base diameter of a cone, while the radius is determined by the condition of contact between the bases of the cones.

Figure 2 shows computer results from the equation of [1] for the system of Fig. 1 when the surfaces are black. The performance θ of the system in Fig. 2 is the ratio of the actual radiated flux to the limiting flux Q_{lim} that would be emitted if the cones had infinite thermal conductivity and if there were no radiative exchange between the cones:

$$Q_{lim} = n\pi \operatorname{tg}\frac{\alpha}{2}\,\sigma T_0^4 L^2.$$

These results are correct also for hollow cones lacking heat transfer between the internal surfaces and having a wall thickness δ that varies as follows along the axis:

$$\frac{(L-x)\operatorname{tg}\frac{\alpha}{2}-\delta}{(L-x)\operatorname{tg}\frac{\alpha}{2}} = \varphi = \text{const.}$$

In this case N must be replaced by $N/(1-\varphi^2)$ in order to use the relationships of Fig. 2.

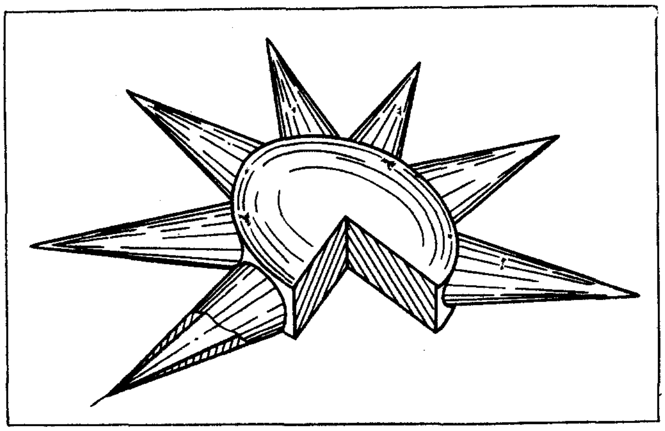

Fig. 1. Radiation system with cooling cones.

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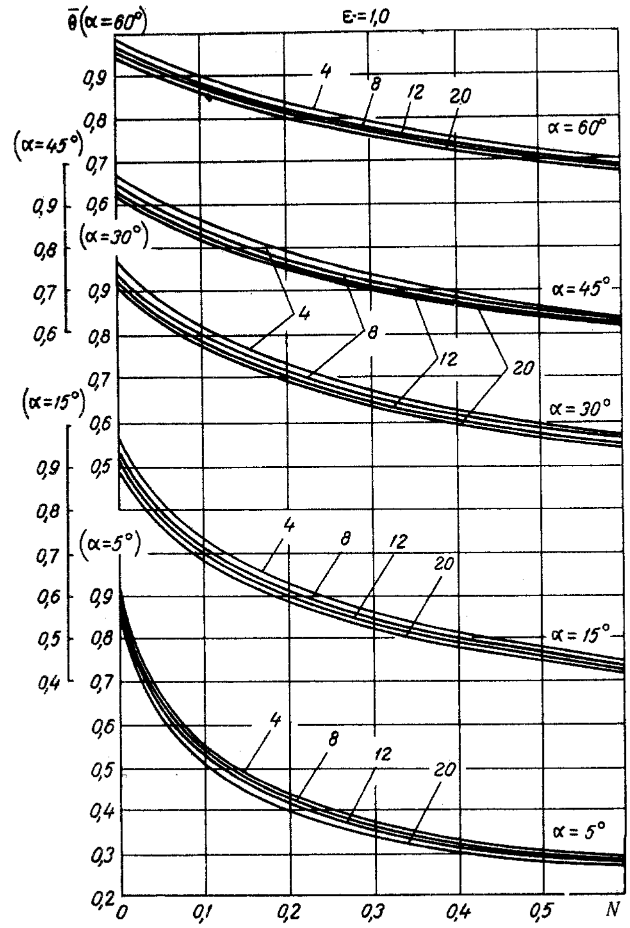

Fig. 2. Efficiency of radiation system versus α and N for different numbers of cones with $\varepsilon = 1$ (figures near curves are values of n).

The curves of Fig. 2 allow one not only to determine the heat flux from the sizes of the cones (together with T_0 and λ) but also to optimize the system of Fig. 1, which with hollow cones can sometimes be considerably better than the normal annular fin [2].

NOTATION

ε is the emissivity of surface;
σ is the Stefan–Boltzmann radiation constant;
λ is the thermal conductivity of material;
L is the length of cone;
α is the angle at the cone vertex;
n is the number of cones;
T_0 is the temperature of cooled body surface;
δ is the thickness of hollow cone wall at distance x from its base;
θ is the efficiency of heat-removing system;
N is the cone thermal-conductivity parameter ($N = 2\sigma T_0^3 L/\lambda$).

LITERATURE CITED

1. Yu. G. Zhulev and Yu. F. Potapov, Inzh.-Fiz. Zh., 14, No. 2 (1968).
2. G. L. Grodzovskii and Z. V. Pasechnik, Prikl. Mat. Tekh. Fiz., No. 3 (1967).