Angular Distribution of Thermal Radiation from a Cylindrical Particle Cloud

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Theme

INVESTIGATES a simplified model of a metalized rocket exhaust plume to determine the importance of anisotropic scattering and searchlight effect on the angular distribution of thermal radiation.

Content

The Monte Carlo Method was applied to a finite cylindrical cloud (Fig. 1) of particles to calculate the fraction of monochromatic energy emitted which leaves the cloud as a function of the polar angle between the line of sight and the axis of the cloud (energy ratio). The observer is considered to be remote enough so that the cloud appears as a point source (Fig. 2). Emission is either uniformly distributed in the cloud or from a black surface at the base of the cloud (searchlight effect). Scattering is either isotropic or highly anisotropic, characteristic of aluminum oxide particles. The particles are considered to be uniformly distributed.

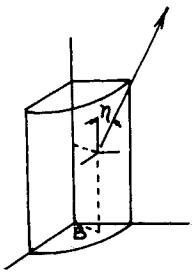

Fig. 1 The basic model.

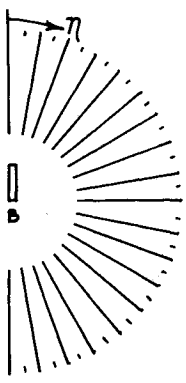

Fig. 2 The cloud as a point source.

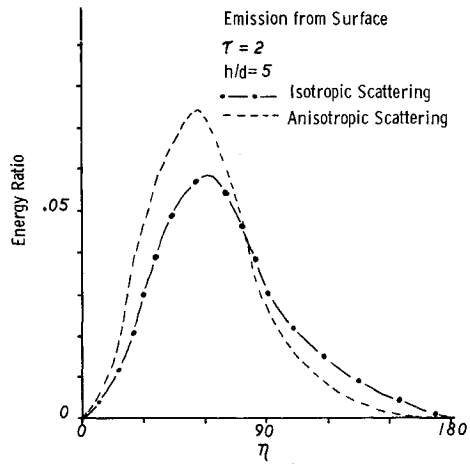

Fig. 3 Scattering comparison, $\tau = 2$.

Table 1 Apparent particle spectral emissivity

Wavelength scattering	0.87 μ		1.74 μ	
	Iso	Aniso	Iso	Aniso
$\eta = 30°$	0.65	0.98	0.071	0.108
$\eta = 90°$	0.18	0.16	0.020	0.018
$\eta = 120°$	0.11	0.063	0.012	0.0069

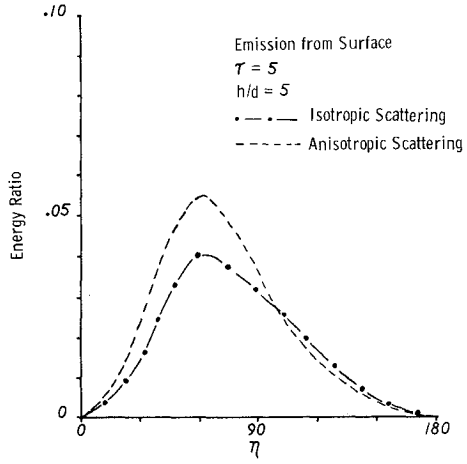

Fig. 4 Scattering comparison, $\tau = 5$.

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The only variables are the type of scattering, the height to diameter ratio of the cloud h/d, the emission source, and the optical scattering diameter τ of the cloud.

Results show no observable effect on the distribution when emission takes place in the cloud. There is a significant difference between results using isotropic and anisotropic scattering with searchlight effect (Figs. 3 and 4).

A sample problem is examined in which an apparent particle spectral emissivity is calculated to account for the searchlight emission. The parameters are combustion temperature = 6000°R, particle temperature = 3000°R, the particle absorption efficiency factor = 0.02, $h/d = 5$, $\tau = 2$ and nozzle expansion ratio = 10. The results are shown in Table 1.

We conclude that insofar as the angular distribution of radiation is concerned, searchlight effect and anisotropic scattering can be important contributors and must be shown to be negligible before being dropped from consideration.