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NASA TECH BRIEF

Directional Control of Radiant Heat

The usual assumption in radiant heat transfer between surfaces is that the emission from any surface is diffuse. This is seldom true. If the surface were grooved, for instance, the emission would be large to surfaces "viewing" the interior of the groove, and small in other directions.

If surfaces could be designed so that the surface radiative properties were strongly directional, the radiant energy transfer could be controlled to some extent. For example, a heat sink for radiant energy would have a larger net energy gain if it had a high absorptivity in the direction of a heat source and a low emissivity in the direction of a cold environment. A poor heat sink could be obtained by interchanging these characteristics. Similarly, a heat source could be designed to emit strongly to an absorber but weakly to the environment.

A "perfect" emitter could be considered as a surface with an emissivity of one in a desired direction and an emissivity of zero in all other directions. Analytically, such a surface is designed by the use of grooves having flat bases. The walls of the grooves are considered to be specularly reflecting with a reflectivity of one, while the base is assumed optically black. Based on these assumptions, an infinitely long specular symmetric groove with a flat black horizontal element at an arbitrary depth within the groove is analyzed for directional emissivity. These emissivities are calculated for various angles of groove opening and various depths of placement of the black surface. The results are then used in the calculation of radiant interchange between surfaces. Since the grooved surfaces absorb and emit directionally, they can be designed to control the equilibrium temperature of the groove base over a wide range.

The results show that the configuration analyzed gives directional emissivities and absorptivities that can be made to approximate a perfect directional surface, i.e., a surface which has an emissivity or absorptivity of one over a prescribed range of angles, and zero over the remaining angles. The radiant energy can then be transferred in desired directions, which results in more efficient energy absorbers and emitters. This property should prove very useful in the transfer of radiant heat from a single source to multiple or remote locations. It should also find use in directed nonvisible beams for security or counting purposes.

Note:

Requests for further information may be directed to:

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Patent status:

This invention has been patented by NASA (U.S. Patent No. 3,229,682), and royalty-free license rights will be granted for its commercial development. Inquiries about obtaining a license should be addressed to NASA, Code GP, Washington, D.C. 20546.

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