Chapter 12
Radiation Heat Transfer

Abstract

This chapter elucidates the basic physics of radiative heat transfer, as it is generated at the atomic level and can be transferred through a vacuum, as well as models for radiation heat transfer among surfaces in an enclosure. Real surfaces emit thermal radiation (part of the electromagnetic spectrum) as a function of temperature, wavelength, and direction. The total emissive heat flux is obtained by integration over all wavelengths and all directions. A surface also receives radiation from another source (irradiation), which may be reflected, from the surface, absorbed by the body, and/or transmitted through the body. Absorptivity, reflectivity, and transmissivity are properties of a surface that are fractions of irradiation absorbed, reflected, and transmitted. Radiosity is all radiation leaving a surface, either emitted or reflected. A black surface absorbs all irradiation and emits the maximum amount at any temperature. The spectral distribution of blackbody emission is Planck's distribution, integration of which over all wavelengths gives the Stefan-Boltzmann equation, which shows that the blackbody emissive power is proportional to the fourth power of absolute temperature. A real surfaces emit less than a blackbody, and can sometimes be modeled as having absorptivity and emissivity equal and independent of wavelength and direction. Such a surface is diffuse and gray. To model radiation exchange among surfaces, the first step is to quantify the fraction of one surface's field of view is taken up by another surface, which is the definition of the view factor. Radiation models for blackbody enclosures are simplified because the surface radiosities are simply the emissive powers. Gray surfaces may experience multiple reflections from and absorptions at all surfaces, so all radiosities are interdependent. Enclosure radiation exchange can be modeled by an electric analogy and several examples are provided.