RADIATION HEAT TRANSFER IN MANUFACTURING AND MATERIALS PROCESSING

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ABSTRACT. This review discusses radiation heat transfer which occurs in conjunction with a variety of manufacturing and materials processing applications. Practical needs in manufacturing and materials processing thermal analysis are noted, and the role of radiation heat transfer in meeting these requirements is discussed. Specifically, different types of radiative heating strategies are categorized, radiation sources commonly used are described, and issues which are somewhat unique to radiation heat transfer in manufacturing and materials processing operations, such as matching the spectral characteristics of the source and load, are identified. The need for development of robust inverse analysis tools for process and equipment design, as well as thermal process control is noted throughout the review.

Surface radiation heat transfer, although fairly well understood in principle, is used in many manufacturing operations (such as in electronics manufacturing) and needs for improved understanding and development of new analysis techniques are discussed. Specific topics include i) the practical need for improved surface exchange analysis techniques in complex geometries and/or in systems involving moving materials, ii) coupled macro- and microscale radiation heat transfer for process analysis, thermal control and inspection, and iii) forward analysis and identification of dimensionless parameters describing highly coupled and multiple mode heat transfer operations.

Volumetric radiative transfer in semitransparent materials at high temperature, important in a number of specific operations, such as fabrication of composite epoxy-fiber structures, crystal growth and glass manufacturing, is described. Here, the examples are selected to illustrate i) the importance of matching source and load spectral characteristics, ii) combined volumetric radiative and surface convective heating utilizing flames and other high temperature sources, and iii) the relevance and impact of dependent scattering phenomena.

Finally, needs and challenges in radiation thermometry in practical systems involving, for example, i) moving materials, ii) materials of high purity, or iii) radiatively participating process and/or plant gases are discussed, and recent advances in radiation thermometry theory and applications are reviewed.