

CHALLENGES IN THE ACCURATE NUMERICAL SIMULATION OF PRACTICAL THERMAL PROCESSES AND SYSTEMS

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ABSTRACT

The numerical simulation of practical thermal processes is generally complicated because of multiple transport mechanisms and complex phenomena that commonly arise. In addition, the materials encountered are often not easily characterized and typically involve large property changes over the ranges of interest. The boundary conditions may not be properly defined and may be unknown or complex. The geometry and interactions between different components are also often quite complicated. However, it is important to obtain accurate and dependable numerical results from the simulation in order to design, control and optimize most practical thermal processes of current and future interest. The models employed must be validated and the accuracy of the simulation results satisfactorily ensured if the simulation is to form the basis for improving existing systems and developing new ones for applications in areas such as energy, manufacturing, environmental control, electronics cooling, transportation and thermal processing. This paper focuses on the main challenges that are encountered in obtaining accurate numerical simulation results on practical thermal processes and systems. It considers a wide variety of systems, ranging from materials processing to energy and cooling. Of particular interest are concerns like verification and validation, determination and imposition of appropriate boundary conditions, and modelling of complex, multimode transport phenomena. Additional effects such as viscous dissipation, surface tension, buoyancy and rarefaction that could arise in practical processes and complicate the modelling are discussed. The challenges that arise due to large and complex material property changes, large variations in the geometry and coupled multiple regions are also discussed. The methods that may be used to meet these challenges are discussed, along with typical results for a range of important processes. Future needs in this interesting and challenging area are also outlined.