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PROFESSOR SPALDING'S IMPACT ON THE NUMERICAL MODELING OF COMPLEX THERMAL PROCESSES

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ABSTRACT

Practical thermal processes and systems, in application areas such as energy, manufacturing, environmental control, heating/cooling, thermal management of electronics, and transportation, are generally complicated because of combined transport mechanisms and complex phenomena that are typically encountered. Common materials are frequently difficult to characterize and involve large property changes with temperature, concentration and pressure. Also, the boundary conditions are often unknown or not well defined. The configuration and the geometry are often quite complicated. However, in order to study, predict, control, design, and optimize most practical thermal processes, it is important to obtain accurate, realistic and dependable numerical results from the simulation. The mathematical and numerical models must be verified and validated to establish the accuracy of the simulation results if these are to be used for improving existing systems and developing new ones. This paper focuses on the main concerns that arise and approaches that may be adopted to obtain accurate numerical simulation results on practical thermal processes and systems. A fairly wide range of systems is considered, including those involved in materials processing, energy, heat removal and safety. Verification and validation, imposition of realistic boundary conditions, modelling of complex, multimode transport phenomena, multiple-scale modelling and time dependence of the processes are of particular interest. Additional effects such as viscous dissipation, surface tension, buoyancy and rarefaction that frequently arise in complicated systems are discussed. Uncertainties that arise in material properties and in boundary conditions are also important in design and optimization. The methodology to treat these is discussed. Large variations in the geometry and coupled multiple regions are also discussed. The methods that may be used to address these issues are discussed, along with typical results for a range of important processes. Future needs in this interesting and important area are also presented. In many of these studies, the work done by Spalding and his group has been of particular interest and value, since it guided many of the simplifications and approaches that were adopted.