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RADIATIVE HEAT TRANSFER IN HIGH-TEMPERATURE SOLAR THERMAL APPLICATIONS

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ABSTRACT. High-flux solar irradiation obtained with optical concentrators is an excellent source of clean process heat for high-temperature physical and chemical processing. Solar thermal power, the area that has traditionally driven developments in concentrating solar technologies, experiences renewed research interests, primarily in the context of large-scale dispatchable power generation. The area of solar thermochemistry aims at direct thermochemical production of chemical fuels and commodity materials. Radiative heat transfer problems of solar thermal and thermochemical systems are inherently transient and multi-scale. The basic approach to modelling coupled heat and mass transfer in high-temperature solar thermal systems involves simultaneous solutions of the radiative transfer equation (RTE) along with the mass, momentum, and energy conservation equations. In solar thermochemistry, interactions between thermal radiation and chemical kinetics are of special interest. Transient variations of radiative properties and temperature of reacting media require determination of the radiative contribution to the energy equation at any instant of the solution, leading to high computational cost. The complexity of analysis further increases for systems with significant gas radiation effects, requiring application of accurate but computationally expensive spectral methods. This presentation reviews the progress, challenges and opportunities in radiative and combined thermal transport research as applied to high-temperature solar energy conversion systems. Selected pertinent areas such as radiative characterization of heterogeneous media, radiative and combined thermal transport modeling, and optical, radiative and thermal measurements in high-temperature solar thermal applications are reviewed.