

A New Technique for Characterizing Multi-Temperature Convection

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Heat transfer is normally formulated in terms of a driving temperature difference and a corresponding heat transfer coefficient. Nevertheless, many heat transfer problems involve more than two temperatures, i.e. more than one driving temperature difference. This class of problems is referred to as multi-temperature heat transfer. Heat transfer in an asymmetrically heated channel, cross flow over cylinders or spheres with different surface temperatures and enclosures with boundaries at different temperatures belongs to this class. The formulation of a multitemperature heat transfer problem in terms of some effective temperature difference and an overall heat transfer coefficient, as is traditionally done in the literature, is usually not a proper representation of the physics of the problem. Moreover it does not provide detailed information that may be needed for analysis and design purposes. Most notably, when convection is the dominant mode, the split of heat transfer between the different heat sources involved cannot be resolved based on these overall heat transfer coefficients. Paired heat transfer coefficients that designate both the source and sink of heat transfer are shown to be a suitable alternative, though they are proven impossible to obtain based on the knowledge of overall heat transfer rates at the sources. A new technique is proposed to overcome this difficulty. This technique entails a baseline solution of the full set of the governing equations and subsequent solutions of the energy equation with perturbed boundary conditions. An important application of the proposed technique is the computation of convective heat transfer coefficients of complex fenestration systems (fenestration systems with an attachment, e.g. a roller blind). This research is funded by the Smart Net-zero Energy Buildings strategic Research Network (SNEBRN) of the Natural Sciences and Engineering Research Council.