Solar Flux and Absorptivity Measurements: A Design Experiment in Undergraduate Heat Transfer

W. Roy Penney, Kendal J. Brown, Joel D. Vincent and Edgar C. Clausen

Ralph E. Martin Department of Chemical Engineering
University of Arkansas

Introduction

A number of methods have been developed for enhancing student learning including multimedia developments[1,2], active, problem-based learning[3], collaborative learning[4,5], and participation in cooperative education[6]. Several papers have specifically addressed methods for improving or supplementing the teaching of heat transfer including the use of spreadsheets to solve two-dimensional heat transfer problems[7], the use of a transport approach in teaching turbulent thermal convection[8], the use of computers to evaluate view factors in thermal radiation[9], implementation of a computational method for teaching free convection[10], and the use of an integrated experimental/analytical/numerical approach that brings the excitement of discovery to the classroom[11]. Supplemental heat transfer experiments for use in the laboratory or classroom have also been presented, including rather novel experiments such as the drying of a towel[12] and the cooking of French fry-shaped potatoes[13]. Suggestions for the integration of heat transfer course material into the laboratory and classroom were described by Penney and Clausen[14-19], who presented a number of simple hands on heat transfer experiments that can be constructed from materials present in most engineering departments. This cross-course integration of course material has been shown to be a very effective learning tool that causes students to think beyond the content of each individual course[20], and will be the subject of this paper.

As part of the requirements for CHEG 3143, Heat Transport, junior level chemical engineering students at the University of Arkansas were required to execute design project assignments which illustrate a concept from the course. One of these experiments required a student group of two students to:

- measure the solar flux at various angles of incidence on a black (painted) aluminum plate and compare the result with data from the National Weather Service, and
- using the solar flux, measure the absorptivity of unpainted aluminum

The group was required to write a fully documented TK (Tool Kit) computer program to perform the design calculations, and to write a formal report that fully details the experimental work.

The purpose of this paper is to describe the required apparatus and procedures for this relatively simple experiment, and to present results from calculations used in obtaining the solar fluxes as a function of the angle of incidence and the absorptivity. Exercises such as this are effective in urging the students to apply the principles of heat transfer to actual physical systems, and thus to better visualize physical applications of classroom principles.