

On heat transfer through a solid slab heated uniformly and periodically: determination of thermal properties

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Abstract

In this paper, some heat transfer characteristics through a sample that is uniformly heated on one of its surfaces by a power density modulated by a periodical square wave are discussed. The solution of this problem has two contributions, comprising a transient term and an oscillatory term, superposed to it. The analytical solution is compared to the experimental results obtained by using the approach first proposed by Ångström, which has become a well-known thermal wave experimental procedure used for the determination of thermal diffusivity. A number of conclusions are drawn from this comparison, which highlight the need to carefully consider the experimental setup employed when carrying out this type of measurement. The results may be of interest to those dealing with heat transfer problems, thermal characterization techniques and/or involved in the teaching of partial differential equations at undergraduate or graduate level.

1. Introduction

Heat transfer problems are of considerable importance due to their relevance in daily life and scientific research. Therefore, it becomes very important to deal with them in introductory as well as advanced courses on physics and engineering. A physical situation often encountered is transient heating of a solid slab by a continuous heat source placed on one of its surfaces. This situation has been discussed recently in this journal [1, 2]. Another interesting example is that of a sample subjected to periodical harmonic uniform heating. This type of heating appears, for example, in the field of photothermal (PT) and related techniques [3], a group of well established methods that are useful, among other things, for the thermal characterization of materials. They are based on measurements of the harmonic temperature oscillations (the