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On the natural convection heat transfer in a rectangular passage solar air heater

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Abstract

This paper presents and discusses the experimental measurements versus the results from the available correlations in the literature that are commonly used to predict the free convection heat transfer coefficient between the surfaces and the flowing air. The experimental investigations were accomplished using a rectangular duct comprising a flat plate-glass cover as the solar air heater with the following dimensions: 0.48-m width × 0.07-m depth × 2-m length. The absorber plate was made of 1-mm gauge of aluminium. The measurements were performed at inclination angles of 30°, 50°, and 70° to determine the optimum angle of the absorption-free convection mechanism in a solar air heater. The comparison is presented and discussed in terms of the Nusselt number. The optimum inclination angle to achieve the best collector performance was found to be 50°. The results of the present work can assist in resolving the issue of predicting the free convection in thermal passages.

Keywords: Natural convection; Rectangular conduit; Solar air heater; Solar absorber; Solar collector

1. Introduction

Solar air heaters that make use of flat-plate collectors have been widely utilised in the technology of low-temperature solar energy. The benefits of the use of solar air heaters include the rather simple design, the ease of operation, and the low capital costs. Solar air heaters may be used for space heating, drying and paint spraying operations (Kalogirou, 2004; Duffie and Beckman, 2006). The solar air heater occupies an important place among solar heating systems because of the minimal use of materials and the direct use of air as a working substance, which reduces the number of required system components (Yeh and Ho, 2009). The efficiency of these collectors in air heating is low due to the low convection heat transfer coefficients between the absorber and the flowing air that increases the absorber plate temperature, resulting in higher heat losses to the ambient atmosphere.

However, selecting a suitable equation to predict the free convection in a rectangular solar air heater remains unclear.

Maiti et al. (2011) designed and developed an indirect, natural convection batch-type solar dryer fitted with north–south reflectors. These reflectors enabled an enhancement of the collector efficiency. This enhancement ranged from 40% to 58.5%. This system was in India in the month of January under conditions of peak solar irradiation. The equation proposed by Tiwari (2002) was used

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