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Solution of leakage problem in a guarded hot plate device

Ali Can İspir*, Eren Dikeç, Seyhan Uygur Onbaşıoğlu

Faculty of Mechanical Engineering, Department of Mechanical Engineering, 34437 Istanbul, Turkey
**Corresponding author: Fax: +90 212 245 07 95 Email: ispir@itu.edu.tr*

Abstract

The conduction heat transfer coefficients of the fibrous insulation materials depend on temperature, especially under high temperature conditions. In this study, the device, called guarded hot plate (GHP), measuring the heat transfer performance of insulation materials under high temperature conditions is improved. Circulation of the cooling fluid inside aluminum cold plates is optimized by numerical results. To prevent leakage of the fluid, metal pipes are inserted into the conduits aiming the fluid to circulate throughout these pipes. Following the design, the cold plates are manufactured and the computational results are validated by the experimental ones. By the new designed cold plate, the system operates and achieves validated measurements for the thermal conductivity of the fibrous insulation materials, under high temperature conditions.

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Keywords: Heat Exchanger, Guarded Hot Plate, Computational Fluid Dynamics

Nomenclature

$\overline{uu}$	Reynolds stress, m^2/s^2
J	Radiosity, W/m^2

1. Introduction.

GHP device has two plate heat exchangers, a main plate heater and four heating wires contained in an enclosure. The main plate heater, hot plate, is located between two plate heat exchangers, namely, cold plates. Two identical samples of insulation materials are inserted between these plates and heat flux through the plates is read by an energy

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analyzer. By the means of the read heat flux value and the temperature measurements taken on the plate surfaces using thermocouples, heat conduction of the material can be calculated by Fourier heat conduction equation [1].

$$q'' = k\frac{\Delta T}{L} \quad (1)$$

Cold plates of the GHP device are two identical aluminum plates. Temperature distribution over the cold plates should be uniform. For this reason, conduits are inserted within the plates through which a fluid, a type of oil for the high temperature conditions, circulates. Temperature of the working fluid is held constant by a high temperature circulator unit pumping it to the cold plate. To supply a temperature field which varies within the interval of 1 K at most, the close loop circulation system must never allow the fluid to leak [2]. Different circulation constructions are used in cold plates to supply these conditions. Computational Fluid Dynamics was held to find the best circulation design. The best design according to results was manufactured and installed into the GHP device. After installation, the temperature on the cold plate surfaces were measured at different points and it was seen that the measurement data is consisted to the temperature field which had been obtained computationally.

2. Experimental setup

Experimental setup used in this study is shown Figure 1. This device is made up of 2 cold plates, 1 hot plate, 4 heating wires, various thermocouples (both cold plate, hot plate and heating wire surfaces); a data logger, an energy analyser, 2 power supplies, an oil bath and a controller respectively.

Fig. 1. View of experimental setup

Since it is critical to insure one-dimensional heat transfer phenomenon [1] in the device, placement of the resistances over the hot plate and channel design in cold plate are crucial.

2.1. Properties of cold plate: The size of the cold plate is 500 mm x 500 mm, its thickness is 30 mm and it is made up of aluminum [2]. Taking the technical specifications of the oil bath in account, the diameter of the channel to be opened is determined as 16 mm so that the hot oil in the plate circulates. As shown in Figure 2, there are five different thermocouple channels on measurement surface of each cold plate to take temperature measurements.

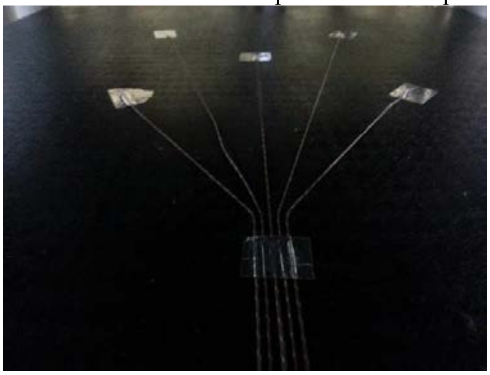

Fig. 2. Temperature measurement points of cold plate

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