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СВОБОДНО-КОНВЕКТИВНОЕ ОХЛАЖДЕНИЕ ТЕПЛОВЫДЕЛЯЮЩЕЙ СФЕРЫ РАСПОЛОЖЕННОЙ В ЦИЛИНДРИЧЕСКОМ КАНАЛЕ

Проведено экспериментальное исследование свободно-конвекционного теплообмена сферического тепловыделяющего элемента, расположенного внутри вертикального цилиндра. Результаты проведенного параметрического исследования показывают, что теплопередача при фиксированном отношении диаметров сферы и канала (d / D = 0,77) в первую очередь зависит от чисел Грасгофа и Прандтля.

Ключевые слова: *свободная конвекция; шаровой элемент; коэффициент теплопередачи.*

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NATURAL CONVECTION HEAT TRANSFER FROM SOLID SPHERE LOCATED INSIDE CYLINDRICAL CHANNEL

An experimental study has been carried out on natural convection heat transfer over solid sphere located inside a vertical cylinder. Results of the parametric study conducted further reveal that the heat transfer with constant diameter ratio (d/D = 0.77) is primarily dependent on the Grashof and Prandtl number.

Keyword: *natural convection; solid sphere; heat transfer coefficient.*

Natural convection is the process of energy transfer between a heated solid surface and the adjacent fluids (gas or liquid) that is in motion and it includes the combined impacts of conduction and fluid motion. Some forms of natural convection take place in most processes where fluids are heated or cooled in a gravitational and buoyancy induced-natural force field. The natural convection heat transfer process can be divided into two major models, internal and external, depending on the boundary layer interaction and the working fluid in the adjacent region. In external models the adjacent region is assumed to be an infinitely large domain of uniform temperature homogeneous static fluid, independent of the boundary layer. In internal models, the adjacent fluid forms a substance that is slightly or fully enclosed by the boundary layer, resulting in a high coupling between the boundary layer and the substance region. Natural convection from sphere as a symmetric body has been investigated by a large number of researchers due to its fundamental significance in several industrial applications such as emergency cooling system of nuclear reactors, compact electronic components and cooling or heating of chemical reactors generating. Numerous experimental, numerical and analytical investigations have been performed on natural convection heat transfer from isothermal spheres. The relevant experimental studies of heat transfer by natural convection from a sphere are given by [1–4]. Numerical solution for the natural convection heat transfer over a solid sphere with air as working fluid was first presented by Geoola and Cornish [5].

They have showed the local and overall Nusselt numbers for range of Grashof number ($0.05<Gr<50$). In addition, temperature and streamline contours were also presented.

The present report is concerned primarily with investigate the phenomena of natural convection of solid sphere located inside a vertical cylinder using experimental methods.

The experimental apparatus is consists mainly of isolated channel with a circular cross-section of 50 mm outer diameter, 3 mm wall thickness. A copper sphere 34mm in diameter was used and independently heated using 100W – electrical heater with variac voltage regulator to

adjust the input power and to achieve the required heat flux. The schematic diagram of the experimental set-up is presented in Fig. 1.

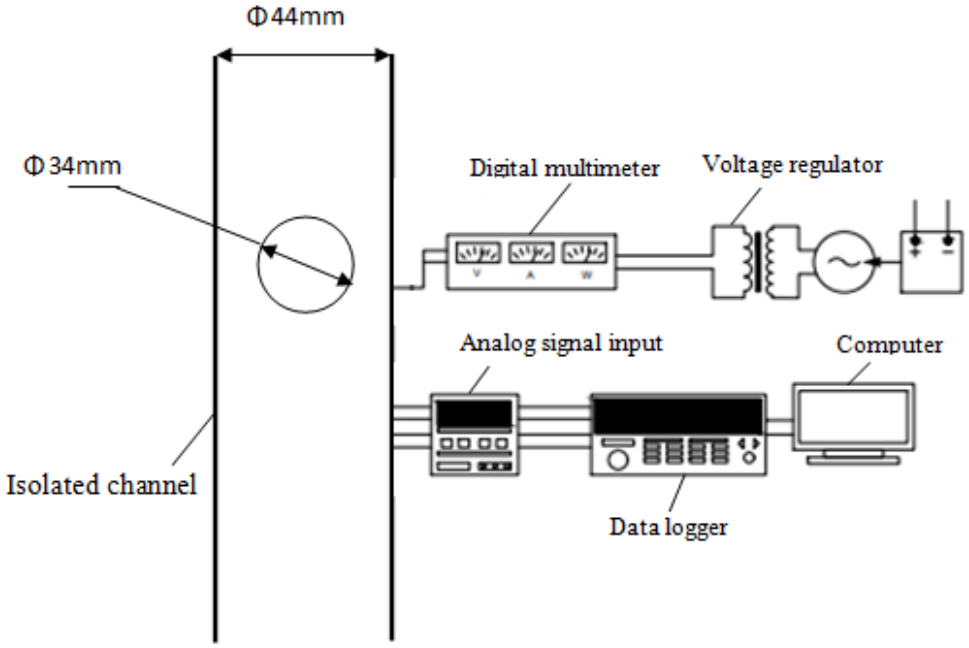

Fig. 1. Schematic diagram of the experimental test bench

$$Ra = Gr\,\mathrm{Pr} \tag{1}$$

$$Gr = \frac{d^3 \rho^2 g \Delta T \beta}{\mu^2} \tag{2}$$

$$\mathrm{Pr} = \frac{\mu C_p}{k} \tag{3}$$

$$Nu = 0.017 Ra^{0.58} \tag{4}$$

Whenever heat is transferred by natural convection from a solid sphere to a adjacent fluid it is usually, thought that a functional relationship exists between the Nusselt number and the ratio of the buoyancy to viscous force in the form of Rayleigh number as shown in Fig. 2. The experimental results of Nusselt number were correlated as shown below in Eq. (4).

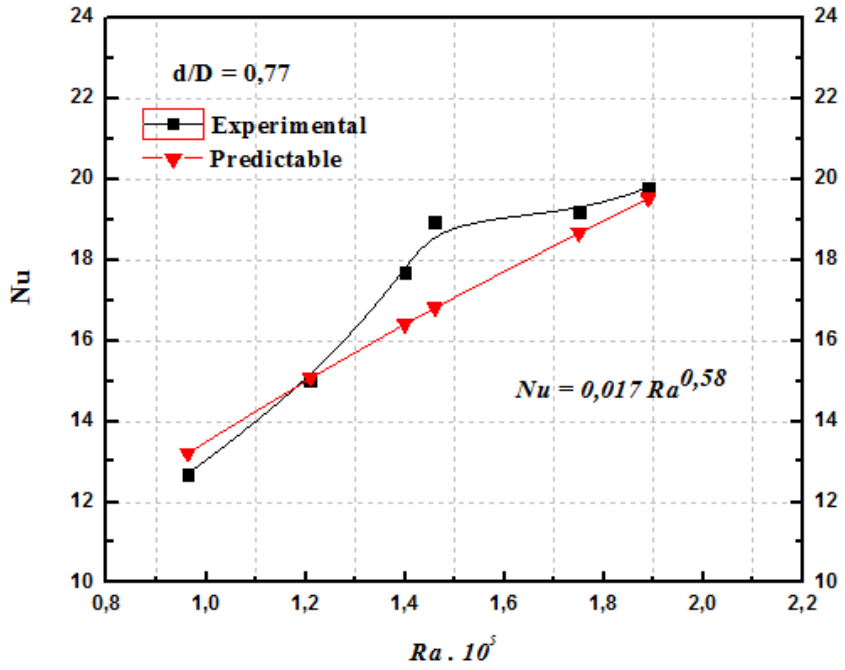

Fig. 2. Relation between heat transfer coefficient and Ra number

The absolute deviations between the experimental and predictions data are 8 %.

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