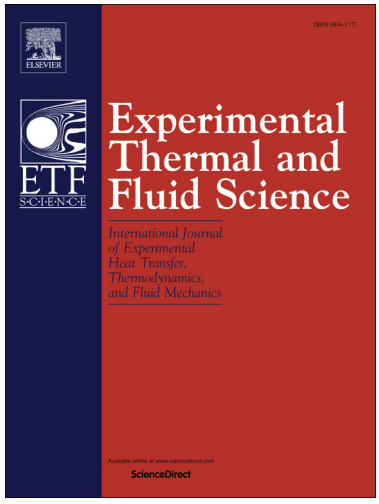

Experimental Investigation of Free Convection from Short Horizontal Cylinder to Newtonian and Power-Law Liquids of Large Prandtl Numbers

Hosny Abou-Ziyan, Abdulrheem Kalender, Mohamed Shedid, Hala Abdel-Hameed

PII: S0894-1777(17)30102-4
DOI: http://dx.doi.org/10.1016/j.expthermflusci.2017.04.004
Reference: ETF 9066

To appear in: *Experimental Thermal and Fluid Science*

Received Date: 24 October 2016
Revised Date: 23 March 2017
Accepted Date: 3 April 2017

Please cite this article as: H. Abou-Ziyan, A. Kalender, M. Shedid, H. Abdel-Hameed, Experimental Investigation of Free Convection from Short Horizontal Cylinder to Newtonian and Power-Law Liquids of Large Prandtl Numbers, *Experimental Thermal and Fluid Science* (2017), doi: http://dx.doi.org/10.1016/j.expthermflusci.2017.04.004

Experimental Investigation of Free Convection from Short Horizontal Cylinder to Newtonian and Power-Law Liquids of Large Prandtl Numbers

Hosny Abou-Ziyan[a,b*], Abdulrheem Kalender[a], Mohamed Shedid[b], Hala Abdel-Hameed[b]

Mechanical Power Engineering Department
[a] College of Technological Studies, PAAET, Kuwait
[b] Faculty of Engineering, Helwan University, Cairo, Egypt
[*] Corresponding author, hosnyaz@hotmail.com, +96599381336, fax +96522314224

Abstract

This paper reports the results of an experimental investigation of free convection from electrically-heated short horizontal circular cylinder of small aspect ratio (L/d=8) to five liquids of large Prandtl numbers. Three of these fluids are Newtonian and two are weakly power-law shear thinning fluids. Experiments are conducted, under constant heat flux, at various bulk temperatures (40-175°C) and heat fluxes (0.66-104 kW/m^2) that correspond to heat generation from about 0.7 to 113 MW/m^3. Effects of oil bulk temperatures, oil properties and heat generation parameter, on the free convection results, are investigated.

The results indicated that Newtonian fluids attain higher free convection heat transfer coefficient than the power-law fluids by 16% or more. Nusselt number (Nu=hd/k) of the laminar free convection data is correlated in terms of the power-law index and in classical and non-classical forms. Correlations cover Grashof number ($Gr^*=g\beta qd^4/k\upsilon^2$) from 33 to 1.68×10^7, Rayleigh number ($Ra^*=g\beta qd^4/k\upsilon\alpha$) from 6.1×10^4 to 6.88×10^8, Prandtl numbers (Pr=cpμ/k) from 30 to 1850, Prandtl numbers ratio (Pr_b/Pr_w) from 1.03 to 133 and heat generation parameter from 0.001 to 0.009. The developed non-classical correlation that is based on the presented experimental data is the first correlation to consider the heat generation parameter. It predicts the experimental Nu within ±5% whereas the classical form correlation predicts Nu with uncertainty over ±20%.

Keywords: *natural convection; horizontal cylinder; Nusselt number; non-Newtonian fluids; variable viscosity; heat generation effect*

1. INTRODUCTION

Free convection over vertical or horizontal cylinders is relevant to heat exchangers, passive solar collectors, heat treatments, manufacturing processes (such as hot rolling and extrusion, wire and fiber drawing, and casting) and cylindrical heating elements in many applications including cooling of electronics and some engine parts. Thus, heat transfer from horizontal cylinders has the most amount of literature out of all orientations [1]. Therefore, a complete survey of these literatures is impractical and the topic is already reviewed more than once [1-4]. However, selected papers are included here to discuss specific issues that associate with the present work such as horizontal and vertical confinement, analytical and numerical studies, related correlations and heat generation.