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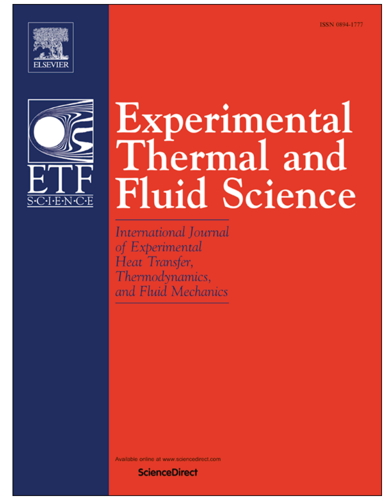

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S.M. Hosseinalipour, H.R. Shahbazian, Bengt Sunden

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Experimental Investigations and Correlation Development of Convective Heat Transfer in a Rotating Smooth Channel

S.M. Hosseinalipour [1]†, H.R. Shahbazian[1] and Bengt Sunden[2]

[1]Department of Mechanical Engineering, Iran University of Science and Technology, Narmak, Tehran, Iran
[2]Department of Energy Sciences, Lund University, Sweden
† Corresponding author: Seyed.m.alipour@gmail.com

ABSTRACT:

An experimental study has been carried out to investigate the effects of Coriolis force and centrifugal buoyancy force on convective heat transfer in a smooth cooling channel under rotating condition in a new rotation facility. The main motivation behind this work is to obtain required data for developing heat transfer correlations based on rotating state. In accordance with the open literature, four parameters, i.e.s Reynolds number, Rotation number, coolant Density Ratio and main flow direction were selected to study the influence on local heat transfer coefficient. Therefore, the investigation considered Reynolds number (Re) ranging from 5,000 to 12,000, Rotation number (Ro) in the range of 0 to 0.15, Inlet Density Ratio (DR) between 0.04 to 0.1 and at the entry developing region of a square smooth channel in a new rotation test bench. Comprehensive experiment have been conducted to collect data on the local Nusselt number at the leading and trailing walls. The results show that the local heat transfer rate is enhanced by rotation on the trailing surface and reduced on the leading surface in outward flow due to symmetrical secondary vortex generated by Coriolis force. The Centrifugal Buoyancy effect is favorable to the heat transfer enhancement on both walls. Also, by utilizing the extensive experimental data, correlations for the local Nusselt number have been updated for the leading and trailing walls in ranges of the mentioned flow parameters, which can be used as an internal cooling boundary condition for numerical analysis of thermal stresses and cooling efficiency maximization for gas turbine blades.

Keywords: Rotating heat transfer, Coriolis force, Centrifugal Buoyancy, Square channel, Correlation development

NOMENCLATURE

A	area (m^2)
Bu	rotational Buoyancy number
C_p	specific heat (J kg^{-1} K^{-1})
D_h	channel hydraulic diameter (m)
DR	density ratio
f	friction factor
f_0	friction factor from Blasius equation
h	heat transfer coefficient (W m^{-2} K^{-1})
I	electrical current
L	channel length (m)
Nu	local Nusselt number
Nu_0	Nusselt number from Dittus-Boelter equation
ΔP	pressure drop (Pa)
Pr	Prandtl number
Q	volumetric Flow Rate (m^3/hr)
q	heat energy (W)
r	rotating radius (m)
Re	Reynolds number
Ro	Rotation number
T	temperature (K)
T_w	air bulk temperature (K)
T_b	wall temperature (K)

x	streamwise coordinate
y	widthwise coordinate
x	span-wise coordinate
V	Voltage (V)
	Greek symbols
α, β, γ, θ	correlation coefficient
μ	fluid dynamic viscosity (Pa.s)
ρ	fluid density (kg/m^3)
λ	Thermal conductivity (W/m.K)
Ω	Rotational speed (r.s^{-1})
	Subscripts
amb	Ambient
b	Bulk
i	the number of the measured point in x direction
w	wall
in	inlet
loss	loss
out	Outlet
	Abbreviations
LE	Leading Edge
Stn	Stationary Condition
TE	Trailing Edge