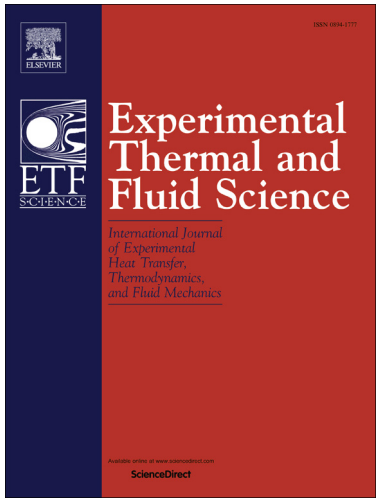

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PII: S0894-1777(16)30320-X
DOI: http://dx.doi.org/10.1016/j.expthermflusci.2016.11.012
Reference: ETF 8934

To appear in: *Experimental Thermal and Fluid Science*

Received Date: 15 July 2015
Revised Date: 9 November 2016
Accepted Date: 14 November 2016

Please cite this article as: K. Kumar, D.R. Prajapati, S. Samir, Heat Transfer and Friction Factor Correlations Development for Solar Air Heater Duct Artificially Roughened with 'S' Shape Ribs, *Experimental Thermal and Fluid Science* (2016), doi: http://dx.doi.org/10.1016/j.expthermflusci.2016.11.012

Heat Transfer and Friction Factor Correlations Development for Solar Air Heater Duct Artificially Roughened with 'S' Shape Ribs

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Abstract

This paper presents the experimental investigation for heat transfer and friction factor for an artificially roughened solar air heater duct with an aspect ratio of 12. Arc shape wire ribs arranged in 'S' shape having roughness parameters as relative roughness pitch (p/e) in the range of 4-16, relative roughness height (e/D_h) in the range of 0.022-0.054, arc angle (α) of 30°-75°, relative roughness width (W/w) of 1-4 and Reynolds number (Re) ranges from 2400 to 20000. It was found that performance of roughened solar air heater duct is better than the performance of smooth duct for the range of roughness parameters investigated. Experimental results shows that maximum enhancement in Nusselt number (Nu) and friction factor (f) found to be at relative roughness width (W/w) value of 3, relative roughness (p/e) value of 8, arc angle (α) value of 60° and relative roughness height (e/D_h) value of 0.043. Based on the data collected from the test runs for roughened duct for various combinations of the roughness parameters correlations were also developed for heat transfer and friction factor in terms of roughness parameters and operating parameter (Reynolds number).

Keywords

Solar air heater, artificial roughness, heat transfer, friction factor.

Nomenclature

A_c	surface area of absorber plate (m^2)	v	mean flow velocity in duct (m/s)
A_o	area of orifice meter (m^2)	h	heat transfer coefficient (W/m^2 K)
C_p	specific heat of air (J/kg K)	Nu	Nusselt number
C_d	coefficient of discharge	Re	Reynolds number
D_h	hydraulic diameter (m)	ΔP_o	pressure drop across orifice plate
W	width of duct (m)	$(\Delta P)_d$	pressure drop across test section in duct
H	height of duct (m)	m	mass flow rate of air (kg/s)
W/H	aspect ratio of duct	Q_u	useful heat gain (W)
L	length of test section in duct (m)	T_o	air outlet temperature (K)
e	Roughness element height (m)	T_i	air inlet temperature (K)
e/D_h	relative roughness height	T_{pm}	mean temperature of absorber plate (K)
p	pitch (m)	T_{am}	Mean temperature of air (K)
p/e	relative roughness pitch	Greek Symbols	
f	friction factor	α	arc angle (°)
k	thermal conductivity (W/m K)	$\alpha/90$	relative arc angle

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