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Heat transfer and friction correlations and thermal performance analysis for a finned surface

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Abstract

In the present work, the heat transfer and friction loss characteristics were investigated experimentally, employing a finned heating surface kept at a constant temperature of 45°C in a rectangular channel through which air was passed as working fluid. The position of the cylindrical fins attached on the surface was arranged either in-line or staggered. The parameters for the study were chosen as Reynolds number (3700–30 000), depending on hydraulic diameter, the distance between fins in the flow direction ($S_y/D = 1.96$–4.41) and fin arrangement. The variation of Nusselt number with these parameters was determined and presented graphically. For both fin arrangements, it was found that increasing Reynolds number increased Nusselt number, and maximum heat transfer occurred at $S_y/D = 2.94$. Correlations for Nusselt number and friction factor were developed for both fin arrangements and smooth channel, and the thermal performances of the arrangements were also determined and compared with respect to heat transfer from the same surface without fins. With the staggered array, a heat transfer enhancement up to 33% at constant pumping power was achieved. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: Finned surfaces; Heat transfer enhancement; Thermal performance; Cylindrical fins; Performance analysis

1. Introduction

If the heat formed in a working machine is not removed at a sufficient rate, some problems, even breaking down, can take place in the machine due to over heating. Overcoming this sort of problem is only possible by a more effective heat transfer. Furthermore, considering that

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Nomenclature

A	heat transfer area
C_p	specific heat
D	fin diameter
D_e	hydraulic diameter of the channel $[2WH/(H+W)]$
f	friction factor
H	fin and channel height
h	mean heat transfer coefficient
k	conductivity of air
L	test surface length
m	air mass flow rate
N	the number of fins
Nu	Nusselt number for finned surface $(= hD/k)$
Nu_0	Nusselt number for smooth channel $(= hD_e/k)$
h	heat transfer coefficient
S	distance between adjacent fins (Fig. 2)
Re	Reynolds number based on hydraulic diameter $(= VD_e/v)$
T	steady state temperature
V	mean inlet velocity
$\dot{V}$	volumetric flow rate
W	channel width
ΔP	static pressure difference
η	performance efficiency
v	kinematic viscosity of air

Subscripts

a	finned
con	convection
los	losses
stag	staggered
in	inlet
out	out
rad	radiation
s	mean surface, smooth
tot	total
x, y	spanwise and streamwise direction, respectively (Fig. 2)

alternative energy resources have to be researched to replace the rapidly consumed present energy resources, the economic use of heat energy depends on the transfer of heat more efficiently. One of the ways of increasing the heat transfer rate is to attach fins on the heat transfer surface. This technique is widely used in applications, such as power stations, cooling engines, cooling systems,