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Experimental and Numerical Investigations of Impingement Air Jet for a Heat Sink

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Abstract

In this study, impingement air jet heat and flow characteristics of hexagonal finned heat sink which was named as OHS-2 were determined experimentally and analysed numerically by Ansys-Fluent CFD programme. The heat sink was optimized by using Taguchi method in the wind tunnel according to $L_{18}(2^1\times3^7)$ orthogonal array in earlier study [1]. Therefore, the optimized heat sink was used instead of another heat sink. Six of most commonly used turbulence models in the numerical analysis of heat and mass transfer with impinging jets were examined and k-ε reliable turbulence model was chosen the most suitable for experimental study. The experimental and numerical studies were carried out for a heat sink with a nozzle diameter, two different Y/d distances, 6 different flow rates and 3 different fin heights. The variations of the Nu-Re and $Cp_{x,y}$- $l/(l_0/2)$ were analysed and compared. Finally, heat transfer correlations were produced from experimental and numerical results of impingement jet heat transfer. Also the numerical and experimental results were observed to be in a good agreement.

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Keywords: heat transfer, impingement jet, turbulent model, experimental analysis, numerical analysis, Computational Fluid Dynamics

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Nomenclature

A	area (m^2)
C_p	pressure coefficient
d	nozzle diameter (m)
D_h	hydraulic diameter (m)
ε	dissipation rate
h	convection coefficient (W/m^2K)
h_k	fin height (m)
I	current (A)
k	conduction coefficient (W/mK)
l	station distance (m)
L	length of the base plate (m)
N	total number of fins
Nu	Nusselt number (=hL/k)
P	pressure (Pa)
Pr	Prandtl number (=$C_p\mu/k$)
Re	Reynolds number (=$\rho uL/\mu$)
R	resistance (Ω)
T	temperature (K)
U	velocity (m/s)
V	voltage (V)
W	width of the base plate (m)
μ	dynamic viscosity (Pas)
ν	kinematic viscosity (m^2/s)
ρ	density (kg/m^3)
Y	distance between nozzle and heat sink.

Subscripts

a	air
ave	average
cond	conduction
conv	convection
in	inlet
k	fin
out	outlet
rad	radiation
s	surface
tot	total
C	further nomenclature continues down the page inside the text box

1. Introduction

Today, the rapid growth of energy consumption and costs has made efficient energy use mandatory. Therefore the importance of heat transfer in daily life and industrial applications has increased still further. In the studies to improve the heat transfer, transferring the heat efficiently has just not been enough, downsizing of the elements used, increased mass production and rising costs have resulted in additional problems. As a result of the studies, heat and mass transfer by impinging jet is determined to be an efficient and economical method which is fast and can be applied to small surface areas.