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A study on the cooling of electronic component by a flat heat pipe

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Abstract. A three dimensional numerical model for the cooling of an electronic component by using a flat heat pipe (vapor chamber) is presented. The heat pipe consists of two copper flat walls, two copper water wicks and a vapor region sandwiched between the heat pipe wicks. In this paper, a three dimensional hydrodynamic model of the wicks and vapor regions coupled with a three dimensional thermal model of the heat pipe is presented. The hydrodynamic model of the wick and vapor region is obtained by solving numerically the mass, momentum and liquid vapor interface conditions in a three dimensional form. The temperature of the model is obtained by coupling the energy equation in a three dimensional form with the hydrodynamic model. The model are solved numerically by using finite difference method. The results illustrate well the function of the heat pipe and the circulation of the working fluid inside the wick regions. They also shows that ,for power input 107 W, the maximum liquid velocity is about 4.35×10^{-4} m/s

Key words

Flat heat pipe, Electronic component, Cooling, Hydrodynamic model, Thermal model

Nomenclatures

acc	accommodation coefficient	
CE	Ergun's coefficient	
CP	specific heat	$J.kg^{-1}.K^{-1}$
h	heat transfer coefficient	W.m-2.K
hfg	latent heat	$J.kg^{-1}$
K	permeability	m^2
L	model length	m
$\dot{m}$	mass flow rate per unit area	$kg.m^{-2}\,s^{-1}$
M	molecular Weight	$kg.mol^{-1}$
Max	Maximum	
n	normal direction	
p	pressure	Pa
q''	heat flux	$W.m^{-2}$
r_{eff}	effective pore radius	m
T	temperature	K
u	velocity component at x direction	$m.s^{-1}$
v	velocity component at y direction	$m.s^{-1}$
V	total velocity	$m.s^{-1}$
w	velocity component at z direction	$m.s^{-1}$
W	model width	m

Greek Symbols

μ	dynamic viscosity	Pa.s
ε	porosity	
ρ	density	$kg.m^{-3}$
λ	thermal conductivity	$W.m^{-1}.K^{-1}$
σ	Stefan Boltzmann constant	$W.m^{-2}K^{-4}$

Subscripts

b	base plate
c	capillary
H	heater
in	interface
l	liquid
max	maximum
w	wick
sat	saturation
v	vapor
∞	cooling fluid

1. Introduction

A flat plate heat pipe founds many applications such as cooling of high power semiconductor chips, electronic equipment and applications in spacecraft radiator segments due to its high thermal conductivity, reliability and low weight penalty [1]. A heat pipe is an evaporation–condensation device for transferring heat in which the latent heat of vaporization is exploited to transport heat over a distance with a corresponding small temperature difference. The heat transport is realized by means of evaporating a liquid in the heat inlet region (called the evaporator) and subsequently condensing the vapor in a heat rejection region (called the condenser). Closed circulation of the working fluid is maintained by capillary action and/or bulk forces. There are two types of flat heat pipe construction; one is transferring heat