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OPTIMUM PERFORMANCE AND DESIGN OF A RECTANGULAR FIN

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ABSTRACT−A rectangular fin with a fluid in the inside wall is analyzed and optimized using a two-dimensional analytical method. The influence of the fluid convection characteristic number in the inside wall and the fin base thickness on the fin base temperature is listed. For the fixed fin volumes, the maximum heat loss and the corresponding optimum fin effectiveness and dimensions as a function of the fin base thickness, convection characteristic numbers ratio, convection characteristic number over the fin, fluid convection characteristic number in the inside wall, and the fin volume are represented. One of the results shows that both the optimum heat loss and the corresponding fin effectiveness increase as the fin base thickness decreases.

KEY WORDS : Analytical method, Heat loss, Optimization, Convection characteristic number

NOMENCLATURE

Bi	: Biot number, $(h\, l_h)/k$
h	: heat transfer coefficient over the fin [W/m^2°C]
h_e	: fin tip heat transfer coefficient [W/m^2°C]
h_f	: heat transfer coefficient in the inside wall [W/m^2°C]
k	: thermal conductivity [W/m°C]
l_b	: fin base length [m]
L_b	: dimensionless fin base length, l_b/l_c
l_c	: characteristic length [m]
l_e	: fin tip length [m]
L_e	: dimensionless fin tip length, l_e/l_c
l_h	: one half fin height [m]
L_h	: dimensionless one half fin height, l_e/l_c
l_w	: fin width [m]
M	: convection characteristic number over the fin surface, $hl_c/k=\{(h\, l_h)/k\}(l_c/l_h)=Bi/L_h$
M_e	: convection characteristic number at the fin tip, $(h_e\, l_c)/k$
M_f	: fluid convection characteristic number in the inside wall, $(h_f\, l_c)/k$
q	: heat loss from the fin [W]
Q	: dimensionless heat loss from the fin, $q/(k\Phi_f\, l_w)$
q_w	: heat loss from the bare wall [W]
Q_w	: dimensionless heat loss from the bare wall, $q_w/(k\Phi_f\, l_w)$
T	: fin temperature [°C]
T_b	: fin base temperature [°C]
T_f	: fluid temperature in the inside wall [°C]
T	: ambient temperature [°C]
U^*	: symbol for optimum heat loss or effectiveness
v	: fin volume [m^3]
V	: dimensionless fin volume, $v/(l_c^2\, l_w)$
W^*	: symbol for optimum fin tip length or fin height
x	: length directional variable [m]
X	: dimensionless length directional variable, x/l_c
y	: height directional variable [m]
Y	: dimensionless height directional variable, y/l_c
β	: ratio of convection characteristic numbers, M_e/M
ε	: fin effectiveness
θ	: dimensionless temperature, $(T-T_\infty)/(T_f-T_\infty)$
λ_n	: eigenvalues (n=1, 2, 3, ···)
Φ_f	: adjusted inside fluid temperature [°C], (T_f-T_∞)

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1. INTRODUCTION

Heat transfer is one of the important phenomena in the automotive technology. For studies about this heat transfer, the influence of gases thermodynamic properties on gross heat release has been esteemed (Lanzafame and Messina, 2003). The surface heat flux and combustion characteristics of premixed propane mixture in a constant volume chamber are investigated (Park, 2005).

The extended surfaces or fins are well known to be a simple and effective means of increasing heat dissipation in many engineering and industrial applications such as the cooling of combustion engines, electronic equipments, many kinds of heat exchangers, and so on. Various shapes of fins have been used and the profile of the rectangular fin is one of the widely used profiles in actual industrial areas. Performances of the rectangular profile