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Heat Transfer Enhancement in Externally Finned Tubes and Internally Finned Tubes and Annuli

 Springer

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Nomenclature

Δp	Air-side pressure drop, Pa or lbf/ft ²
Δp_f	Pressure drop assignable to fin area in finned tube exchanger, Pa or lbf/ft ²
a	Major diameter for rectangular tube cross section, m or ft
A	Total heat transfer surface area (both primary and secondary, if any) on one side of a direct transfer type exchanger; total heat transfer surface area of a regenerator, m ² or ft ²
A_c	Flow cross-sectional area in minimum flow area, m ² or ft ²
A_f	Fin or extended surface area on one side of the exchanger, m ² or ft ²
A_{fa}	Actual flow area of an internally finned tube, $A_n(1 - 2e/d_i)^2$, m ² or ft ²
A_{fin}	Inter-fin flow area of an internally finned tube, $A_{fa} - A_{core}$, m ² or ft ²
A_{fr}	Heat exchanger frontal area, m ² or ft ²
A_n	Nominal flow area of an internally finned tube $\Pi d_i^2/4$, m ² or ft ²
AMTD	Arithmetic mean temperature difference K
B	Minor diameter for rectangular tube cross section, m or ft
D_{ab}	Diffusion coefficient for component a through component b, m ² /s
D_i	Internal diameter, m or ft
d_o	Outside diameter, m or ft
D_{vi}	Volume-based tube inner diameter, m or ft
eld	Rib height, dimensionless
f	Fanning friction factor $\Delta P \rho D_h / 2LG^2$, dimensionless
f_f	Friction factor of fins in Eq. 6.5 ($= 2 \Delta p \pm \rho A_c / A_f G^2$), dimensionless
f_t	Friction factor of tubes in Eq. 6.5 ($= 2 \Delta p \pm \rho A_c / A_t G^2$), where $A = A - A_f$, dimensionless
f_{tb}	Tube bank friction factor $= \Delta P \rho D_h / 2NG^2$, dimensionless
Gr	Grashof number $= g\beta\Delta TD_h^3 / \nu^2$, dimensionless
Gz	Graetz number $= \Pi d_i Re Pr / 4L$, dimensionless
j	$St Pr^{2/3}$ dimensionless
n_L	Number of louvers in airflow depth, dimensionless
Nu_{Dh}	Nusselt number $= hD_h / k$, dimensionless
p/d	Rib pitch, dimensionless

p_f	Fin pitch, center to center spacing, m or ft
p_w	Wave pitch of wavy fin, m or ft
$Re_{D_{vi}}$	Reynolds number based on D_{vi} , GD_{vi}/μ dimensionless
$Re_{D_{vo}}$	Reynolds number based on D_{vo} , GD_{vo}/μ dimensionless
s	Spacing between two fins = $p_f - t$, m or ft
S_f	Flow frontal area of heat exchanger, m^2 or ft^2
Sh	Sherwood number for mass transfer ($=K_m D_f / D_{ab}$), dimensionless
St	Stanton number = $h / G c_p$ dimensionless
u^*	Friction velocity = $(\tau_w / \rho)^{1/2}$, m/s or ft/s
u_m	Fluid mean axial velocity at the minimum free flow area, m/s or ft/s
V_m	Heat exchanger tube material volume, m^3 or ft^3
w_{fin}	Weight of fins in heat exchanger, kg or lbm
w_s	Width of segmented fin (Fig. 6.20), m or ft
W_{tot}	Weight of tubes and fins in heat exchanger, kg or lbm
w_{tub}	Weight of tubes in heat exchanger, kg or lbm
X^+	$x / D_h RePr$, dimensionless
X_{DV}^+	$RePr D_v / L$, dimensionless

Greek Symbols

2θ	Included angle of fin cross section normal to flow, radians, or degrees
α	Helix angle relative to tube axis radians or degrees
β	Helix angle
γ	Reciprocal of fin pitch, m or ft
δ	Liquid film thickness
Δp	Pressure drop
ΔT	Temperature difference
ϵ	Permittivity
η_f	Fin efficiency or temperature effectiveness of the fin, dimensionless
η_o	Surface efficiency of finned surface = $1 - (1 - \eta_f) A_f / A$, dimensionless
μ	Dynamic viscosity
θ	Louver angle for louver fin, radians
ρ	Density
σ	Surface tension
τ_w	Wall shear stress, Pa or lbf/ft ²

Subscripts

ave	Average
deff	Effective diameter
ev	Evaporation
fd	Fully developed flow

H1	Heat flux boundary condition
i	Inner
il	Inline tube arrangement
in	Inlet
L	Liquid
m	Average value over flow length
o	Outer
o	Outside (air-side) surface
p	Plain tube or surface
s	Saturated
st	Staggered tube arrangement
sub	Subcooled
v	Vapor
w	Evaluated at wall temperature
x	Local value