Abbreviations

BP   brake power

BSFC   brake specific fuel consumption

CCFC   cross and counter flow configuration

CFD   computational fluid dynamics

CFR   coolant flow rate

EG   ethylene glycol

FP   friction power

HEX   heat exchanger

IP   indicated power

PG   propylene glycol

UDF   user defined function

Nomenclatures

A heat transfer area $[\text{m}^2]$

A_r aspect ratio

A_d area ratio of diffuser

C heat capacity rate $[\text{WK}^{-1}]$

c_p specific heat $[\text{Jkg}^{-1}\text{K}^{-1}]$

C^* heat capacity ratio

D_h hydraulic diameter $[\text{m}]$

ΔEx exergy gain or loss rate $[\text{W}]$

f friction factor

F_l fin length $[\text{m}]$

F_{th}	fin thickness [m]
F_h	fin height [mm]
F_p	fin pitch [mm]
G	mass velocity [$\text{kgm}^{-2}\text{s}^{-1}$]
H_c	Core height [m]
h	heat transfer coefficient [$\text{Wm}^{-2}\text{K}^{-1}$]
I	irreversibility [W]
j_a	colburn factor
k	thermal conductivity [$\text{Wm}^{-1}\text{K}^{-1}$]
L_a	louver angle [degree]
L_d	fin length [mm]
L_h	louver height [mm]
L_p	louver pitch [mm]
m	mass flow rate [kgs^{-1}]
NTU	number of heat transfer units
Nu	Nusselt number
N	engine speed [rev/s]
N_s	entropy generation number
P	pumping power [W]
Pr	Prandtl number
P_F	fan power [W]
PI	performance index
Δp	pressure drop [Pa]

p	pressure [Pa]
Q	heat transfer rate [W]
R	gas constant [J/kg K]
Re	Reynolds number
S_{gen}	entropy generation rate [W/K]
s1,s2	louvered fin zones
T	temperature [K]
T_w	width of the tube [mm]
T_0	dead state temperature [K]
u	fluid velocity $[ms^{-1}]$
U	overall heat transfer coefficient $[Wm^{-2}K^{-1}]$
UA	conductance $[WK^{-1}]$
V	volume flow rate [l/min.]
W	engine load [kg]
W_c	Core width [mm]
η_f	fin efficiency
η_o	total heat transfer surface effectiveness
η_{II}	second law efficiency
η_m	mechanical efficiency
η_{bth}	brake thermal efficiency
η_{ith}	indicated thermal efficiency
μ	fluid viscosity $[Nsm^{-2}]$
$\emptyset$	nanoparticle volume fraction

ρ	fluid density $[\text{kgm}^{-3}]$
ε	heat exchange effectiveness

Subscripts

a	air
bf	base fluid
c	coolant
f	fin, fluid
in	inlet
w	wall
nf	nanofluid
ext	exit
np	nanoparticle
hnf	hybrid nanofluid
l	louvered zone
o	overall