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APPLICATION OF PSEUDO-THREE-DIMENSIONAL HEAT EXCHANGER MODEL IN THE ONE-DIMENSIONAL SIMULATION OF THE VEHICLE COOLING SYSTEM UNDER THE FTP-72 DRIVING SCHEDULE

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ABSTRACT–In designing the heat exchanger model, the existing epsilon-number of transfer units (NTU) method cannot reflect factors inside the heat exchanger, such as the local flow rate changes. Furthermore, it is difficult to apply a three-dimensional model to a one-dimensional analysis since high computational power is required. In contrast, a pseudo-three-dimensional heat exchanger model which has higher accuracy than the existing epsilon-NTU method and has faster speed for application in one-dimensional analysis. However, pseudo-three-dimensional model has still improvements in the simulation time as the mesh counts increase. In this study, the improved pseudo-three-dimensional heat exchanger model was developed and integrated within a one-dimensional analysis loop capable of simulating vehicle driving and the cooling system. The integrated model calculated the change in the energy consumption of the entire cooling system with the change in the aspect ratio of the heat exchanger. Also, the optimal operation strategy of the cooling system, which incorporated a proportional integral derivative controller of the three-way valve, was determined to reduce the parasitic losses. As a result, parasitic loss of the cooling system decreased by 14.1 % as aspect ratio increased by 46 % under FTP-72 (UDDS) driving schedule and simulation time was reduced 90.1 % while accuracy degrades only 2.7 %.

KEY WORDS : Dymola, Modelica, Pseudo-three-dimensional heat exchanger model, Single-zone combustion analysis, Staggered grid analysis, Three-way valve

NOMENCLATURE

A	: area, m^2
B	: coefficient of friction of the motor
C	: specific heat, J/K
E	: power, W
F	: force, N
G	: volume flow rate, m^3/s
I	: moment of inertia, $kg.m^2$
J	: moment of inertia, $kg.m^2$
K	: motor constant
L	: inductance, H
N	: gear level
Q	: heat, J
R	: ideal gas constant, J/kg.K
T	: temperature, K
U	: internal energy, J
V	: volume, m^3
a	: coefficient of fin shape
b	: shape factor of the engine
c	: constant for the ram air effect
g	: gravitational acceleration, m/s^2
h	: heat transfer coefficient, $W/m^2.K$
i	: current, A
j	: factor
k	: ratio of specific heat
l	: length, m
m	: mass, kg
p	: pressure, Pa
r	: resistance, Ω
t	: time, s
u	: specific internal energy, J/kg
v	: voltage, V
w	: rotational acceleration, rad/s^2
x	: fraction
Re	: Reynolds number
Nu	: Nusselt number
η	: efficiency
ρ	: density, kg/m^3
α	: quality of combustion
θ	: angle, °
τ	: torque, J

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