

PERFORMANCE ESTIMATION OF NEW VEHICLE THERMAL MANAGEMENT SYSTEM FOR AN UNMANNED MILITARY GROUND VEHICLE USING INTEGRATED SIMULATION MODEL

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ABSTRACT–The Hybrid Electric Vehicles (HEVs) have additional powertrain components compared with conventional vehicles. Thus, to design a Vehicle Thermal Management System (VTMS) architecture and control strategy for a new HEV powertrain, it is necessary to analyze the energy balance in the vehicle powertrain under various driving cycles and environmental conditions. In this study, a 1-D numerical model for an unmanned military ground vehicle powertrain including VTMS is developed and cycle simulations under military operation driving schedule with three different environmental temperatures are conducted to evaluate the cooling/heating performance of the VTMS and the performance of the vehicle. The simulation results showed that the integrated simulation of the VTMS and the powertrain is useful for the estimation of the performance of the new concept of VTMS architecture for a new vehicle platform. This study also suggests that the integrated system model can supply various information for the system design and optimization in the early stage of system design process.

KEY WORDS : Vehicle Thermal Management System (VTMS), Battery Thermal Management System (BTMS), Energy balance, HEV fuel economy, Vehicle simulation, Unmanned military vehicle

NOMENCLATURE

A : area, m^2
 Ah : ampere hour, An
 C : thermal capacity rate, W/K
 c : C_{min}/C_{max}
 Cp : heat capacity, $J/kg\cdot K$
 D : depth, m
 d : diameter, m
 f : friction factor
 g : gravity, m^2/s
 h : convective heat transfer coefficient, $W/m^2\cdot K$
 I : current, A
 j : correlation factor
 k : thermal conductivity, $K\cdot m/W$
 L : length, m
 M : mass, kg
 $\dot{m}$: mass flow rate, kg/s
 NTU : number of heat transfer unit
 Nu : Nusselt number
 P : pressure, Pa

p : pitch, m
 Pr : Prandtl number
 $\dot{Q}$: volume flow rate, m^3/s
 $\dot{Q}$: heat rejection rate, J/s
 R : resistance, Ω
 Re : Reynolds number
 T : temperature, C
 t : thickness, m
 U : overall heat transfer coefficient, $W/m^2\cdot K$
 V : voltage, V
 W : work, J/s

GREEK SYMBOLS

ε : effectiveness
 η : efficiency
 θ : theta, degree
 μ : dynamic viscosity, $kg/m\cdot s$
 v : velocity, m/s
 ζ : roughness, m
 ρ : density, kg/m^3
 τ : torque, Nm
 ω : angular velocity, rad/s

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