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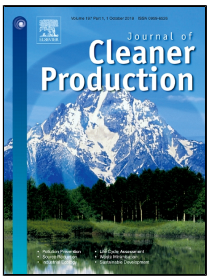

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Model Predictive Control Strategy for Energy Optimization of Series-parallel Hybrid Electric Vehicle

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Abstract: Series-parallel hybrid electric vehicle (SPHEV) is a compact and effective configuration of HEV, which has great potential to save fuel consumption. Because of multi power sources (one engine and two electric motors) and various driving conditions, it is difficult to design an optimal energy management strategy (EMS). To obtain better fuel economy, a novel particle swarm optimization based (PSO-based) nonlinear model predictive control (NMPC) strategy is proposed for EMS of SPHEV. First, a nonlinear model predictive control framework is designed. Then, a modified particle swarm optimization is used for receding horizon optimization. Next, in order to realize fast computing, a two-steps optimization method is adopted. Finally, the proposed strategy are verified by simulations based on the data of a real bus and a driving cycle. The results show that the fuel consumption of SPHEV is greatly decreased by more than 10% compared to that with CD-CS strategies.

Keywords: Series-parallel hybrid electric vehicle, model predictive control, modified particle swarm optimization, energy optimization

Nomenclature

A	Frontal area of vehicle (m^2)	T_{mi}	EMi torque (Nm)
b_e	Specific fuel consumption (g/kWh)	T_{mi}^*	Desired torque of EMi (Nm)
C_0, C_1, C_2	Weighting factors of PSO	$T_{mi\_\max}$	Max value of EMi torque (Nm)
C_D	Air resistance coefficient	$T_{mi\_\min}$	Min value of EMi torque (Nm)
F_f	Total resistance of vehicle (N)	ΔT_{mi}	Difference of EM torque (Nm/s)
f_r	Rolling resistance coefficient	$\Delta T_{m\_\max}$	Max difference of EM torque (Nm/s)
g	Gravity acceleration (m/s^2)	T_s	Sample time for discrete-time model (s)
i_0, i_g	Transmission ratio of final drive and AMT	T_w	Driving/braking torque on wheels (Nm)
m_{veh}	Vehicle mass (m/s)	V_{bat}	Open circuit voltage of battery (V)
$N_{\max}$	Max number of PSO generation	v_{veh}	Vehicle longitudinal velocity (m/s)
P_{bat}	Discharging/charging power of battery (W)	V_i^{now}	Particle speed of current generation
P_i	The best position of particle i	V_i^{next}	Particle speed of next generation
P_g	The best position of whole particle swarm	w	Weighting factor of PSO
Q_{bat}	Battery capacity (C)	$w_{\max}$	Max value of weighting factor
Q_g	Fuel consumption per second (L/s)	$w_{\min}$	Min value of weighting factor
R_{bat}	Internal resistance of battery (Ω)	X_i^{now}	Particle position of current generation
r_w	Wheel radius (m)	X_i^{next}	Particle position of next generation

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