Component sizing of a power-split hybrid electric vehicle using a hybrid algorithm

Key words: sizing, hybrid electric vehicle, hybrid algorithm

Topic group: Advanced hybrid electric vehicle

Research objective

Genetic algorithms (GA) [1-7] are proved well suited for component size optimisation of hybrid electric vehicles (HEV). But, GA is required very high convergence time to find optimal value. The hybrid algorithm [8] combining both the GA and the particle swarm optimisation (PSO) is found suitable to reduce convergence time and to improve optimal value for multi-modal functions, but no study is done for practical application. This paper investigates the hybrid algorithm for component size optimisation of a power-split HEV to get better fuel consumption with less convergence time compared to the GA.

Methodology

A Toyota Prius hybrid-1.5L SI engine of maximum power 43 kW, electric motor of maximum power 30 kW and NiMH battery of maximum capacity 6 Ah are used as baseline components. The Toyota Prius hybrid-1.5L vehicle performance is considered as constraints for optimisation. The most widely used electric assist charge sustaining supervisory control strategy is considered for the study. The vehicle simulation model is developed on the WARPSTAR [9] which is developed by the University of Warwick, UK. A hybrid algorithm, combining the GA and the PSO, is used for optimisation. The hybrid algorithm combines the standard velocity and position update rules of the PSO and with the ideas of selection, crossover and mutation from the GA. An additional parameter, the breeding ratio determines the proportion of the population which undergoes breeding in the current generation. Internal combustion engine, electric motor and battery sizes are optimised for minimum fuel consumption without sacrificing vehicle performance such as acceleration, maximum speed and gradeability.

Results

Convergence times required to find optimum fuel consumption for different drive cycles are compared using both the genetic algorithm and the hybrid algorithm. The hybrid algorithm is required less convergence time and finds better optimal value compared to the GA.

Limitations of this study

Only fuel consumption is considered for the optimisation. Exhaust emissions and component cost are not taken into consideration.

What does the paper offer that is new in the field including in comparison to other work by the authors?

The application of the hybrid algorithm for component sizing of HEV is new and the algorithm can be used in place of the GA to find better optimal value in less convergence time.

Conclusions

1. The hybrid algorithm reduces convergence time compared to the genetic algorithm for component sizing of HEV
2. The hybrid algorithm shows better optimal value in terms of fuel economy compared to the genetic algorithm.
3. The hybrid algorithm can be used in place of the genetic algorithm for component size optimisation of HEV.
Reference: