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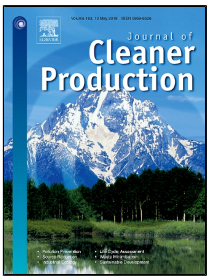

Parametric optimization of novel electric–hydraulic hybrid steering system based on a shuffled particle swarm optimization algorithm

Wanzhong Zhao, Zhongkai Luan, Chunyan Wang

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PARAMETRIC OPTIMIZATION OF NOVEL ELECTRIC–HYDRAULIC HYBRID STEERING SYSTEM BASED ON A SHUFFLED PARTICLE SWARM OPTIMIZATION ALGORITHM

Wanzhong Zhao*, Zhongkai Luan, Chunyan Wang

College of Energy and Power Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China

*Email: zwz@nuaa.edu.cn

Abstract

The on-board battery is the primary energy storage device of the electric vehicle that provides power to drive all actuators of the chassis, i.e., the energy consumption of each actuator has a direct impact on the vehicle's energy management system. To reduce energy consumption while steering and improve the handling stability of electric vehicles, a novel electric–hydraulic hybrid steering (E–HHPS) system with multiple steering modes is presented herein. The electric power mode is used to reduce the overall energy consumption of the system by adaptive intervention, whereas the hybrid power mode is responsible for the steering portability in conditions of increased steering torque. To further improve the performance of the E–HHPS system, the structural parameter optimization model of the E-HHPS system is established based on the consideration of the steering economy, steering road feeling, and steering sensitivity. To solve the multi-objective optimization problem with characteristics of increased dimensions, a shuffled particle swarm optimization algorithm (SPSO) is proposed to realize a combination of a local search and global information exchange. The simulation results demonstrate that compared with the EHPS system, the E–HHPS system has a better steering economy at low vehicular speeds. In addition, the E–HHPS system optimized by the SPSO algorithm can considerably reduce the steering energy consumption and noticeably improve the handling performance of the vehicle.

Keywords: Electric vehicles, Electric-hydraulic hybrid steering, Energy flow analysis, Parameter optimization, Multi-objective.

Highlights

A novel commercial EV steering (E–HHPS) system with multiple modes is presented

Energy consumption of the E–HHPS system is analyzed at different working conditions

Steering economy and handling performance are quantified by evaluating indices

A parameter optimization model is established with evaluation indices as objects

The effectiveness of the proposed SPSO algorithm is evaluated by the E–HHPS model

1 Introduction

With the intensification of the global energy crisis, the electric commercial vehicle has been extensively touted as a solution to cater to the increasing demand in efficiency and energy-saving requirements [1, 2]. The on-board battery is the main energy storage device of the electric vehicle that provides power to drive all the actuators of the chassis [3], i.e., the energy consumption of each actuator has a direct impact on the vehicle's energy management. Therefore, as an important part of the chassis, the energy consumption of the power steering system cannot be ignored.