Application of Evolutionary Algorithm for Triobjective Optimization: Electric Vehicle

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ABSTRACT

For Electric Vehicles (EVs), Weight and losses reduction are important factors not only in reducing the energy consumption and cost but also in increasing autonomy. This paper describes the application of an evolutionary algorithm for multiobjective optimization in the traction chain (TC) of pure EV. In this study, the optimization algorithm is based on the Strength Pareto Evolutionary Algorithm (SPEA-II) and the fitness function is defined so as to minimize the electric vehicle cost (EVC), the electric vehicle weight (EVW) and the losses in the electric vehicle (EVL). Also, in this study, different requirements are considered as constraints like the efficiency of the permanent magnets engine, the number of conductor in the slots, the winding temperature... The simulation results show the effectiveness of the approach and reduction in EVC, EVW and EVL while ensuring that the electric vehicle performance is not sacrificed.

Keywords: Autonomy, Cost, Electric Vehicle, Evolutionary, Losses, Optimization, Permanent Magnets Engine

1. INTRODUCTION

The EV has all the characteristics of a complex system, with multi field, also it consists of heterogeneous components interacting with each other, where elements are coupled together with their environment, such as road, the driver and the speed profile (Figure 1).

Thus, we see that the cycles of vehicle circulation have a huge impact on technological choices and the design of such systems (Ben-Hadj, 2011; Regnier, 2003; Feferman, 2002). As for example, it is interesting to see the types of batteries whose characteristics are specifically adapted for use in urban, mixed... Different interactions presented in the Figure 1 are:

- Interactions between different areas such as the mechanical, electrical, chemical, thermal and power electronics.

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Interactions between the mission of the vehicle and determining the chain propulsion, the power converter, and other elements of the system.

Interactions between the management board energy (energy recovery, brakes), the control strategy of the machine and operating conditions actuator (voltage, frequency of rotation).

EVs represent a promising approach to reduce vehicle fuel consumption and exhaust emissions of CO₂. EVs have several advantages over vehicles with internal combustion engines (ICEs). EVs allow an efficient energy, also their electric motors provide quiet, smooth operation and stronger acceleration and require less maintenance than ICEs.

EVs do, however, face significant battery-related challenges like the driving range, the recharge time and the battery cost.

Many researches are working on improved battery technologies to increase driving range and decrease recharging time, weight, and cost. These factors will ultimately determine the pure EVs future.

In this context, we propose an evolutionary algorithm (EA) based on the SPEA-II which allows to design the traction chain of EVs, taking into account a number of criteria and respecting a number of constraints (Fodorean, 2005).

Then apply this algorithm to optimize simultaneously the EVC, the EVW and the EVL.

In this paper, section 2 presents the studied traction chain of pure EVs. In Section 3, the formulation of the optimization problem is represented. Section 4 covers application of the Evolutionary Algorithm in the optimization of the traction chain. In section 5, the simulation results are presented and discussed. Finally, a conclusion is given in Section 6.
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