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Effect of Control Strategy on the Performance of a Fuel Cell Hybrid Electric Auto Rickshaw

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ABSTRACT

The basis for this paper is a project whose objective is to examine the feasibility of converting a diesel powered auto rickshaw to fuel cell/battery hybrid electric operation. One of the most important factors that influences the performance of hybrid vehicles is the energy management and power distribution between the different energy sources. This paper examines the impact of the control strategy on performance. The optimization of the energy management system is a supervisory control problem. One of the most popular cost functions for optimization involves the sum of fuel consumption and equivalent fuel consumption from the battery state of charge (SOC), commonly referred to as the equivalent consumption minimization strategy (ECMS). In this paper, a modified ECMS is tested together with three different management control strategies on a model of a fuel cell hybrid electric rickshaw using a realistic drive cycle. The 1 st tested was a fuel cell load following strategy in which the power of the fuel cell tracked the demanded power and the role of the battery was to supplement power when demand exceeded the capacity of the fuel cell. The 2 nd tested was a battery load following strategy in which the fuel cell shuts down when the SOC is above a given threshold, and turns on when the SOC is below a given threshold. The 3rd tested was an optimized fuel cell strategy in which fuel cell operation was restricted to its most efficient region. The strategies are documented via flow charts. A performance comparison of the different strategies is presented, where the main performance measures are given by distance traveled, fuel economy and speed tracking error.

INTRODUCTION

Alternative energy solutions have received a great deal of attention in the last decade due to increasing demands for sustainable and environmental friendly energy sources. The main pollutant source in urban areas is emissions from internal combustion engine (ICE) driven vehicles [1]. Increased concerns over global and local pollution, depletion of fossil fuels, and higher gas prices have motivated ambitious plans for new vehicle types with alternative power sources. Hybrid vehicles that combine the advantages of two power sources (eg. combustion engine with an electric motor) have been the focus of attention. ICE/battery hybrid vehicles are available commercially and are becoming increasingly popular due to high fuel prices and increased concerns over the environment. Fuel cell (FC) hybrid vehicles are another promising alternative technology. FC hybrid vehicles have been proposed as the next vehicle generation as they promise cleaner performance and higher energy efficiency than conventional vehicles.

Auto rickshaws are one of the most popular vehicles in developing Asian countries where they are used as taxis and to transport goods. In India alone there are about 2.5 millions rickshaws currently on the road and 250,000 new vehicles are sold each year [2]. Figure 1 shows a typical three-wheel auto rickshaw. Due to their small size and maneuverability, they