CONCEPTUAL DESIGN AND MODELING OF A FUEL CELL SCOOTER FOR URBAN ASIA

by

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abstract

Air pollution is of serious concern in many Asian countries, especially in densely-populated cities with many highly-polluting two-stroke engine vehicles.The present value of health effects have been estimated at hundreds of dollars or more, over each vehicle's lifetime, for a reasonably wealthy country like Taiwan. Four-stroke engines and electric battery-powered scooters are often proposed as alternatives, but a fuel cell scooter would be superior to both by offering both zero tailpipe emissions and combustion-scooter class range (200 km).

Unlike 50 kW automobile-sized fuel cell stacks, the vehicular 5 kW fuel cell needed here has not received much attention. This niche is examined here with a conceptual design and consideration of the issues of water, heat, and gas management. The application is extremely sensitive to size, weight, and cost, so a proton exchange membrane fuel cell using hydrogen stored in a metal hydride is best. Hydrides also act as sinks for waste heat due to the endothermic hydrogen desorption process. Pressurized operation is found to be ineffective due to high parasitic power demands and low efficiencies at the low powers involved.

A computer simulation is developed to examine overall vehicle design. Vehicle characteristics (weight, drag, rolling resistance), fuel cell polarization curves, and a Taiwanese urban driving cycle are specified as inputs. Transient power requirements reach 5.9 kW due to the rapid accelerations, suggesting a large fuel cell. However, average power is only 600 W: a hybrid vehicle with a small fuel cell and peaking batteries could also handle the load. Results show that hybrid vehicles do not significantly improve mileage, but are certain to precede pure fuel cell scooters while fuel cells are still more expensive than peaking batteries.

System size is approximately the same as current electric scooters, at 43 L and 61 kg for the fuel cell, hydrogen storage, and electric motor / controller. Manufacturing costs of fuel cell scooters are expected to decrease to under $1,300 in the long term, with per-km fuel costs half of those for gasoline scooters. Hybrid zinc-air scooters offer similar performance at slightly lower vehicle price, but the fuel infrastructure costs may be prohibitive.

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