GSM Based Industrial Security and Energy Conservation System

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Abstract: An intelligent control system was developed using simple control methodologies for a H_2- powered fuel cell scooter with the aid of a built-in microprocessor. This system increases the power input to drive a hydrogen fuel cell scooter, particularly during uphill conditions by running both the batteries and the fuel cell source in parallel. This system also improves the energy management of the scooter by recharging the battery using the fuel cell as well as automatic switching to the battery source when the hydrogen fuel cell is running low on hydrogen. This system was tested on a bench set simulating a 254 W hydrogen fuel cell stack equipped on a 200 W scooter. The entire operation was embedded in a PICAXE-18 microcontroller for automatic switching between the batteries and the fuel cell source. It has been shown that an increase in the DC motor efficiency by 6 %. The uphill angle of the scooter has been increased by 19.3 %, which means the scooter would be able to travel in more steeper hills.

Key words: Hydrogen Fuel Cell, Energy Management, Fuel Cell Scooter.

1. INTRODUCTION

Australia, a major producer and user of coal, has the highest per capita greenhouse gas emissions in the industrialized world [1]. The ultimate goal is clear: the introduction of a zero emissions transport fuel that can be made from a wide range or primary energy resources [2, 3]. This goal leads to companies to undertake various strategies to cut down on harmful emissions, one being the introduction of hydrogen as an alternative vehicle fuel. One of the methods is by using a fuel cell. Hydrogen fuel cells are being considered as ideal candidates for future vehicles, due to their high efficiency and near zero emissions [4].

Hydrogen is the most abundant element on the planet, and it is the cleanest burning fuel on the basis of carbons atoms per fuel molecule [5-6]. It anational Journal of Computer Science and Communication Mobile Computing, Vol.4 Issue.10,Nov - 2014, pg. 244-249

As fuel cells today becoming less expensive, plug-in hybrid vehicles are becoming more and more popular today. A PEM fuel cell costs are about $1100/kW when used with pure oxygen and about $2200/kW [9-10] when used with air. The costs are projected to be $650 - $1150 by 2010 .

The plug-in fuel cell hybrid vehicle relies on any number of combinations of fuel cells, batteries, capacitors and ICEs to power the vehicle [11, 12]. The plug-in aspect of this vehicle allows grid electricity or onboard charging of the batteries, during the night or when the vehicle is stagnant. About half the distance traveled by automobiles each day in the US are within the first 32 km traveled by each vehicle in a day . Renault introduced a commercial plug-in hybrid vehicle in 2003 [13,14].

Fuel cell and batteries can have a powerful combination. The combination of the two can provide better performance and lower cost than batteries alone of fuel cells alone [15].

One of the steps to reduce harmful emissions is to incorporate batteries to hydrogen fuel cells into scooters. Currently, there are over 400,000 motorcycles and scooters registered through out Australia [16]. Thus hydrogen fuel cell scooters are considered the way to go to lower emissions to move Australia to a cleaner environment.

Hydrogen fuel cell scooters are being developed, especially in Taiwan, China as well as India. This is because Numbers of scooters in use are high in Asia, and growth rates are also high. The People's Republic of China, for instance, had 500,000 motorcycles in 1980, and 10 million in 1994 - an annualized growth rate of 24%, faster than the 15-20% of Chinese urban vehicles in general [17]. India had an average annual growth rate of 16% for two-wheeled vehicles from 1981 to 1998 [18].

One of the problems that lie with the fuel cell scooters is that fuel cells encounter insufficient power densities and thus the power generated by fuel cell scooters are not enough for various conditions.

Take the uphill example for urban areas. For a scooter travelling uphill with one or possibly two people can pose a great challenge as well as a threat to the passengers if the power generated by the scooter is insufficient to travel over the uphill hurdle.[19-22]

In this paper, a regenerative energy control system. This system increases the power input to drive a hydrogen fuel cell scooter, particularly during uphill conditions by running both the batteries and the fuel cell source in parallel to increase the power input to the DC motor. This system also improves the energy management of the scooter by recharging the battery using the fuel cell as well as automatic switching to the battery source when the hydrogen fuel cell is running low on hydrogen. This was tested on a bench set simulating a 254 W hydrogen fuel cell stack equipped on a 200 W scooter. The entire operation was embedded in a PICAXE-18 microcontroller for automatic switching between the batteries and the fuel cell source

2. CONTROL METHODOLOGY

One of the methods is to incorporate rechargeable batteries to the hydrogen fuel cell scooter.
Fuel cell systems designed for applications that require fast start-up, such as back up or emergency power contain rechargeable batteries. This is usually also true for fuel cells applied to transportation, even without reformers. Batteries or super-capacitors are commonly installed in the system to mitigate the insufficient power density problem encountered by the existing fuel cells [19]. This hybrid technology can be seen in many fuel cell scooters today.

This method was incorporated and tested on bench set up simulating a 254 W hydrogen fuel cell stack equipped on a 200 W scooter, which was developed by the HART research team at the University of Tasmania. The current system developed originally runs on a fuel cell source. Once the hydrogen depletes, a flick of a switch will change the main source from the fuel cell to a set or batteries. Note that this two sources work independently.

A main problem faced by the University of Tasmania hydrogen fuel cell scooter is the need for more power especially during uphill conditions.

Thus a proposed new control system for the scooter was introduced. This control system is basically controlled by the micro controller by reading current levels and thus operates the 2 reed relay switches to either switch to modes to recharge the battery or runs the battery in parallel with the fuel cell source to increase the power input to the DC motor. Also, the current detector before the motor controller detects the availability of the hydrogen gas. If the metal hydride tank is running low on hydrogen, the power assist system will automatically switch for continuous running of the scooter, this time by using the rechargeable batteries.

3. EXPERIMENTAL SETUP

The proposed system was simulated on a bench. The three main goals to be demonstrated are:

- Developing a power assist system using the battery as a secondary cell to run in parallel with the fuel cell to enable the scooter to ascend steeper slopes.
- Developing a charging system that enables the fuel cell to recharge the batteries when the power assist is not needed (when traveling in a flat surface for example). This is to keep the batteries fully charged every time so that when the hydrogen depletes, the batteries can be used as the main power source.
- Automatic switching circuit to switch from fuel cell to batteries when hydrogen is running low.

All automatic switching circuit is done using a programmable microprocessor and the switching device used is a normal reed relay. The physical set up block diagram of the bench is shown in Figure

(1) A DC source of 24 V was used to mimic the fuel cells behavior.
(2) Two sealed lead acid batteries with each 12V are providing the extra current for the electric DC motor during the power assist operation. Lead acid batteries are chosen due to their high power density, reliability and ability to satisfy widely varying loads [8].
(3) The throttle, which is adjusted on the scooter handlebar, is used for chancing the DC motor speed and consequential scooter speed. The throttle was used to run different speeds from 500 rpm up to the maximum. It is based on the principal of a varying resistor.
(4) The scooter control system controls the speed, direction and optimizes energy conversion. It gets and regulates the voltage and current signals. The regulated signals goes into the DC motor.
(5) 24V DC motor is a permanent magnet motor using permanent magnets rather than electromagnetic windings in the stator. It has a relatively high maintenance because of its brushes but also a higher efficiency tan other DC motors due to the lack of stator field windings [8]. This is connected to a dynamometer.

(6) The battery charger is constructed using a LM371K voltage regulator. The output voltage is set to 28 V. This is to charge the 24 V batteries, which have a fully charged voltage of 28 V.

(7, 8) Hall effect current sensors are installed to sense the current levels and outputting a voltage level with respect to the current sensed. Two LOHET 650-554 sensors are installed, one is to detect the current drawn by the motor and one is to detect the current provided by the fuel cell source.

(9, 10) The reed relays used are OMRON's G2RL-1-E relays. The 4 modes of switching are:

Normal and charging mode (same as the same relay was used)

Power assist mode

Backup power mode

(11) The dynamometer works in these tests as a consumer or generator, because the power for turning the dynamometer shaft is supplied by the DC motor. It is a universal commutator motor with a necessary field voltage of 8 V DC and an armature voltage of 25 V DC. The dynamometer has two spring balances installed to measure the torque and load.

(12) The consumer load is a variable resistor (max 28.2 • with 4 A) that is connected in the electrical generator output circle.

(13) 8 V DC power source was used for generating the dynamometer field current. The field strength generates the resistance in the dynamometer.

(14) This variable resistor (max 32 • with 3.3 A) regulates the dynamometer field strength.

4. RESULTS

For the power assist system, as loading increases, the motor current reaches a maximum of 12 A. This is to protect the motor from burning as the rated motor current is just 11.5 A. An additional 4 A of current was supplied by the battery on top of the 8 A current from the DC source. At maximum loading, about 12 N, the maximum current for the original system (fuel cell only) is 8 A and the maximum current for the integrated system (fuel cell and battery in parallel) is 12 A. This will certainly increase the power input to the DC motor. The battery will start assisting the fuel cell when the current reaches about 7.5 A, with a maximum provided current of 4 A.

Also, at maximum loading, the efficiency achieved by the original system is 64% and the new system is 70%.

For the charging system, a constant current of 1.5 A at 28 V was supplied to the battery by the charger. The charging rate was calculated to about 11.67 hours to charge the batteries from flat until floating.

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5. CONCLUSION

This paper presents a study on plug-in hybrids on small-sized urban scooters. This is to improve the system efficiency and battery life with acceptable load capability.

All the system components above were tested to obtain the final results. The final results showed the efficiency before the new system was installed was 64 % and after incorporation, the efficiency is 70%. The current drawn by the DC motor reaches a maximum of 12 A, comparing to just 8 A on the old system. Finally, a battery charging process was incorporated as well as an automatic switching to battery source when the hydrogen runs out.

The final results show that with the incorporation of batteries to fuel cell scooters, the motor efficiency can be increased as well as building a market for future research on urban fuel cell scooters.

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