Trial Construction of a Small Electric Vehicle Using a Fuel Cell

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Abstract

This paper proposes the introduction of a small, light-weight electric vehicle with a single-passenger (Economy-Running EV) operating at minimum power. Driving power source in the trial electric vehicle using a fuel cell with a 24V, 200W is aided by hydrogen storage material filled-up to 1.5MPa instead of a battery. At present, running characteristics of Economy-Running EV using a brushless dc motor as the drive system measures the current and voltage supplied to it, and investigates the mileage when that is run at a specific speed using a filled-up fuel cell. As a result, at a speed of 23km/h, generating current and voltage of fuel cell are 4.5A and 22.5V, respectively. That is, generated output of fuel cell is 101W, and mileage is about 62.5mile (100km).

Keywords

electric vehicle, economy-running EV, fuel cell, metallic alloys for hydrogen storage, brushless dc motor, environmental protection

1. INTRODUCTION

Recently, there have been many proposals and countermeasures for the purpose of the global environmental protection. Introduction of the low-pollution automobile is one of such countermeasures. In the field of electric automobile, various models have already been produced by automobile industries and they will spread more and more as the regular vehicle of the environment conscious people in the future. However, there is no recognized standard for batteries or solar generators used in electric vehicles at present, and various batteries and solar cells are adopted as power drive sources of electric vehicles including fuel cells [Tamura et al, 2000].

We have reported previously with respect to running characteristics of electric kart using an induction motor (IM) as the drive system measures the energy supplied to IM and regenerates energy for battery, respectively. As a result, in the speed control method of electric kart, supply energy in the slip frequency control system was decreased about 30% compared to V/F control system [Yamaguchi et al, 2001, Yamaguchi et al, 2003].

This paper proposes the introduction of a small, single-passenger light-weight electric vehicle named Economy-Running EV, operating at minimum power [Hattori et al, 2003, Hattori et al, 2003]. Driving power source in the trial electric vehicle using a fuel cell is aided by conventional hydrogen storage material instead of a battery. Running characteristics of Economy-Running EV using a brushless dc motor as the drive system measures the current and voltage supplied to it, and investigates the mileage when that is run at a specific speed using a filled-up fuel cell.

2. DRIVING SYSTEM

The block diagram of an Economy-Running EV using a fuel cell instead of battery is shown in Figure 1. Power source with a 24V, 200W of fuel cell is generated by chemical reaction between H_2 and O_2 when passing through a proton exchange menbrane (PEM). Pressure of H_2 gas is adjusted to 1.5MPa using a gas regulator, and H_2 gas is charged in the hydrogen storage material for about 30 minutes. A blower is used to send O_2 in air into the fuel cell, the amount of air is adjusted automatically corresponding to generated output. Gas pressure of H_2 send to fuel cell is adjusted to 0.03MPa. A drive motor is used as brushless dc motor rating 24V, 200W. Generating current and voltage of fuel cell are monitored by using voltmeter and ampere meter of analog type.

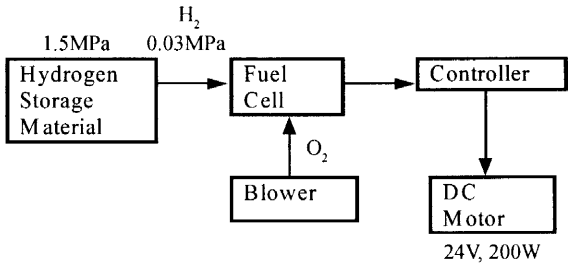


Fig. 1 Block diagram of a small electric vehicle using a fuel cell

Rating of drive system for the Economy-Running EV is shown as follows.

(1) Drive motor: brushless dc motor 24V, 200W using a frequency control system.
(2) Power source: polymer electrolyte fuel cell (PEFC) 24V, 200W, 0.03MPa, 2.6kg.
(3) Hydrogen storage material: metallic alloys for hydrogen storage 500L, 1.5MPa, 5.6kg.
(4) Blower: 18V, 1A, 5000rpm.

3. GENERAL VIEW OF ECONOMY-RUNNING EV

The rear side view of a constructed Economy- Running EV is shown in Figure 2. The body is constructed of three layers of materials using a carbon, core-mat and carbon. The weight of the body is about 18kg. The size of the body is 267cm x 71cm x 46cm. Hydrogen storage material is mounted on the rear side of the body. The Economy-Running EV is constructed having two front wheels and a single rear wheel using a rear wheel-drive. There is a built-in fuel cell in the rear side of the body.

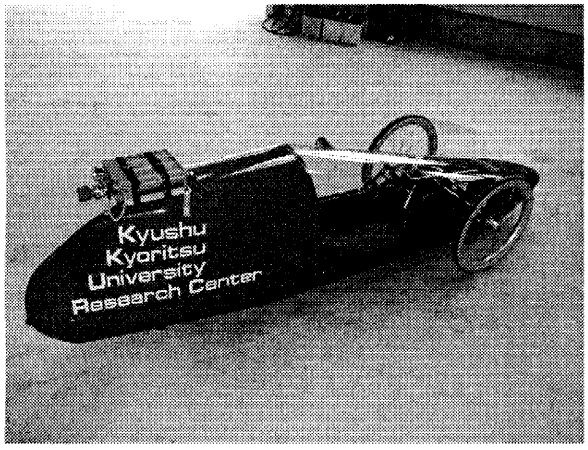


Fig. 2 General view of Economy-Running EV

Cockpit of the Economy-Running EV is shown in Figure 3. Ampere meter is mounted in the center of the cockpit. Power switch, variable resistor corresponding to accelerator and speed meter with a digital indicator are fitted on both sides of the ampere meter. Further, voltmeter is fitted in the right side in front of handle bar. Rear wheel is braking is done by using a handle-brake fixed on the left side of the handle bar in the cockpit. Tires used for the wheels are size (44-406) of Marathon Shell tires made by MICHELIN. Measurement of speed and mileage are carried out by counting the digital signal generated in proportion to the number of rotations of a tire. Digital signal is obtained by on-off of lead switch operating the magnetic field of magnet set on the spokes of the right front wheel.

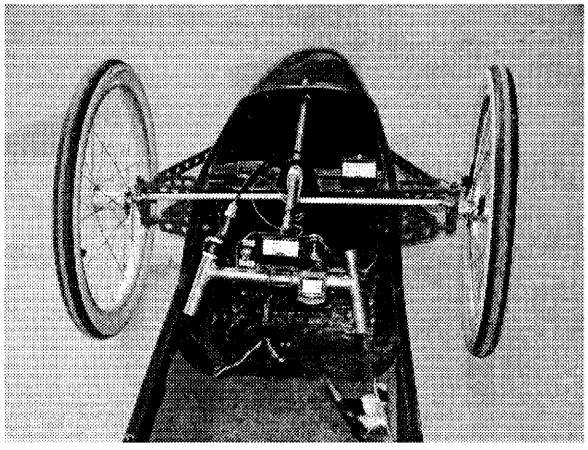


Fig. 3 State of cockpit

The rear view of a trial constructed Economy-Running EV is shown in Figure 4. Metallic alloys for hydrogen storage used as hydrogen storage material is shown mounted on the rear side of the Economy-Running EV. Size and weight of the metallic alloys is 188mm x 241mm x 77mm and 5.6kg, respectively. Gas pressure of H_2 is adjusted to the rate of 0.02-0.03MPa, and it is charged to fuel cell . Metallic alloys for hydrogen storage must be cooled using a fan or water when the H_2 gas is charged by the radiation of heat.

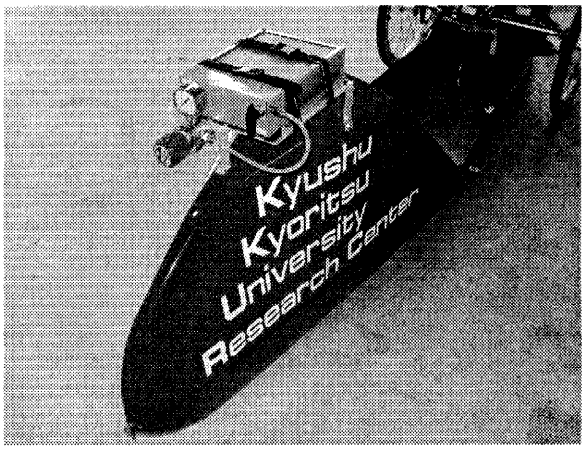
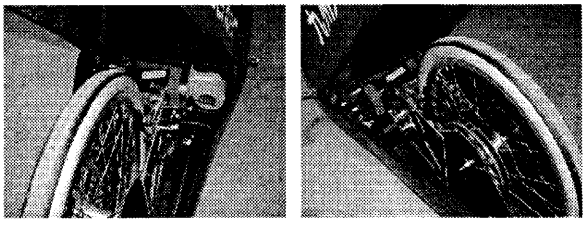


Fig. 4 Appearance of hydrogen storage material

Figure 5 (a) and Figure 5 (b) show the left side view and the right side view of the drive system when opened the rear side of Economy-Running EV. In Figure 5 (a), the fuel cell, brushless dc motor and rear tire are shown mounted on the body. Further, super torque timing belt



(a) (b)

Fig. 5 Left and right side views of drive system

is used to connect the dc motor with the rear wheel. Gear ratio (N_2/N_1) between shaft (N_1) of dc motor and sprocket (N2) of rear wheel is 120/15. Figure 5 (b) shows a blower that is used to send O_2 in the air into the fuel cell. Size and weight of fuel cell is 129mm x 382mm x 85mm and 2.6kg, respectively. The procedure of power generation using a fuel cell is shown as follows.

(1) First: H_2 gas is charged to fuel cell.
(2) Second: the cock of a gas outlet of the fuel cell is opened to exhaust the air out.
(3) Third: the cock of a gas outlet is closed.

4. DCHARACTERISTICS OF ECONOMY -RUNNING EV

Measurement of supplying current is done by a terminal voltage of current sensitive resistor with a value of 50mV/15A that is installed between the fuel cell and driving system of brushless dc motor. The terminal voltage is supplied to Memory Hi-Corder while the Economy-Running EV is running and the data obtained is downloaded to floppy disk (FD). Then, the data of FD are processed by using a personal computer, and their characteristics are printed by the printer.

4.1 Characteristics of supplying current and generating voltage while running

Characteristics of supplying current *Is* and generating voltage E_G while running a mileage of about 0.13mile (210m) on flat ground is shown in Figure 6. Figure 6 shows the voltage generated by the fuel cell at a stop state of the Economy-Running EV which is about 35V of 1.5 times compared with 24V of rated voltage while running. Variable resistor corresponding to accelerator is set at maximum at the same time of the start. 16 seconds after the start, burshless dc motor is operated to nearly steady state. Output power ($E_G Is$) of brushless dc motor is decreased corresponding to the time proceeds, speed of Economy-Running EV is increased. The output power is 101W (22.5V x 4.5A) while covering the distance of 0.13mile (210m) at a maximum speed of 23km/h.

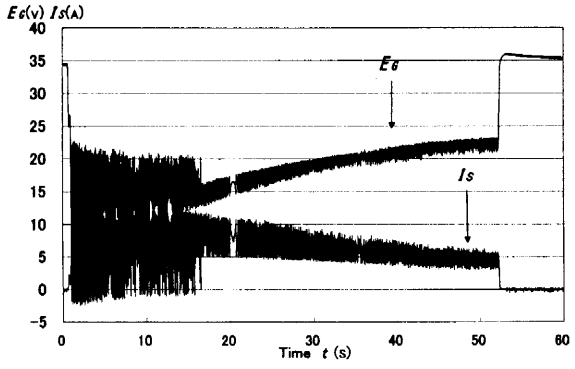


Fig. 6 Characteristics of supplying current *Is* and generating voltage E_G at a running

4.2 Characteristics of the mileage using a filled-up fuel cell

Characteristics of the mileage using a filled-up fuel cell is measured set at 22.5V, 4.5A corresponding to 23km/h by connecting a load in a laboratory.

Pressure of H_2 gas in metallic alloys for hydrogen storage is charged to 1.5MPa, gas pressure of H_2 sent to fuel cell is adjusted to 0.03MPa. Characteristics of the mileage is shown in Figure 7. Figure 7 shows that fuel could retain power until 260 minutes. This is corresponding to a mileage of about 62.5mile (100km). Characteristics of the output power for a fuel cell is such that the power suddenly stopped without prediction compared to a battery.

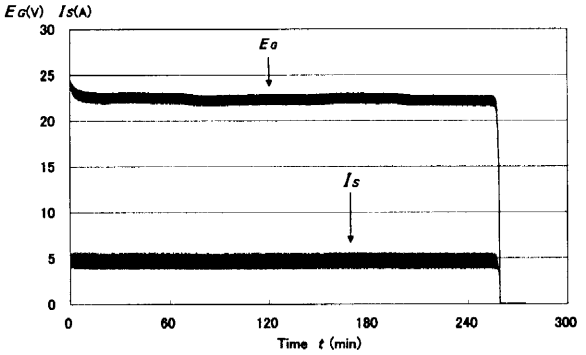


Fig. 7 Characteristics of the mileage using a filled-up fuel cell

5. CONCLUSION

This paper has proposed the introduction of a small, lightweight electric vehicle with a single-passenger (Economy-Running EV) operating at minimum power. Driving power source in the trial electric vehicle using a fuel cell with a 24V, 200W is aided by hydrogen storage material filled-up to 1.5MPa instead of a battery.

At a speed of 23km/h, generated output of fuel cell is 101W, and mileage is about 62.5mile (100km).

It is possible that if the distance covered is increased much higher speed can be achieved with less power consumption.

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