Trial Construction of a Pipe Electric Vehicle Using a Fuel Cell

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Abstract

This paper proposes the introduction of a small, light-weight and slow speed electric vehicle named Pipe EV with a single-passenger operating at minimum power. Driving power source in the trial electric vehicle using a fuel cell with a 24V, 300W is aided by hydrogen storage material filled-up to 1.5MPa instead of a battery. At present, running characteristics of Pipe EV using a 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 30 km/h, generating current and voltage of fuel cell are 7A and 16V, respectively. That is, generated output of fuel cell is 112W, and mileage is about 75mile (120km).

Keywords

electric vehicle, pipe EV, fuel cell, metallic alloys for hydrogen storage, 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. Lithium-ion battery and fuel cell are adopted as power drive sources of electric vehicles at present [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 [Yamaguchi et al, 2001; Yamaguchi et al, 2003]. Secondly, we have reported with respect to running characteristics of Economy-Running EV using a fuel cell with a 24V, 200W instead of a battery [Yamaguchi et al, 2004]. This paper proposes the introduction of a small, light-weight and slow speed electric vehicle named Pipe EV with a single-passenger operating at minimum power. Driving electric source used in the trial electric vehicle is a fuel cell aided by hydrogen storage material.

Running characteristics of Pipe EV aided by EDLC (Electric Double Layer Capacitor) to fuel cell using a 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 a Pipe EV using a fuel cell aided by EDLC instead of battery is shown in Figure 1.

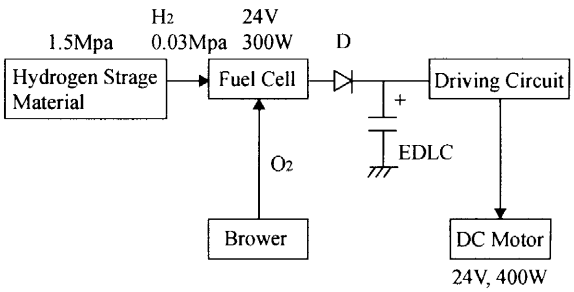

Fig. 1 Block diagram of a pipe electric vehicle (pipe EV) using a fuel cell aided by EDLC

Driving electric source with a 24V, 300W 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 15 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 power. Gas pressure of H_2 send to fuel cell is adjusted to 0.03MPa. A driving motor is used as DC motor rating 24V, 400W. Generating voltage of fuel cell and supplying current to drive system including a DC motor are monitored by using voltmeter and ampere meter of ana-

log type.
Rating of drive system for the Pipe EV is shown as follows.

(1) Driving motor: DC motor 24V, 400W.
(2) Driving electric source: polymer electrolyte fuel cell (PEFC) 24V, 300W, 0.03MPa, 2.6kg.
(3) EDLC: Electric Double Layer Capacitor with 30F, 50V.
(4) Hydrogen storage material: metallic alloys for hydrogen storage 500L, 1.5MPa, 5.6kg.
(5) Blower: frequency control type 18V, 1A, 5000rpm.

3. GENERAL VIEW OF PIPE EV

The front view of a constructed Pipe EV is shown in Figure 2. The body frame is constructed of iron/steel and aluminum pipes having 20ϕ, 30ϕ and 33ϕ in diameter, using bending and welding techniques. The weight of fuel cell and hydrogen storage material excluding the body is about 35kg. The size of the body is 1575mm x 950mm x 830mm. Hydrogen storage material is mounted on the rear of the body. The Pipe EV is constructed having four wheels with a rear wheel-drive systems. There is a built-in fuel cell in the left side of the body.

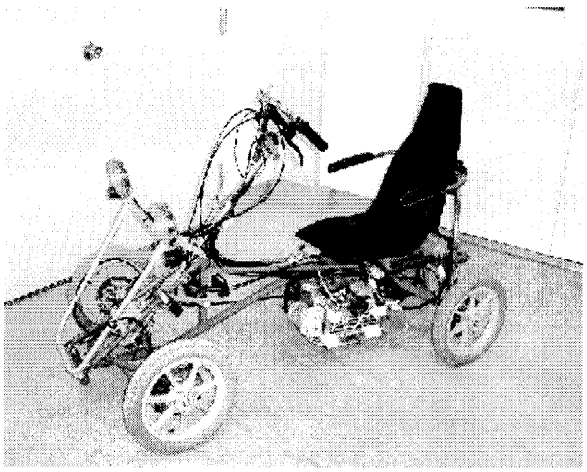

Fig. 2 General view of Pipe EV

Cockpit of the Pipe EV is shown in Figure 3. Speed meter with a digital indicator (Sanpet BC-168-4) is mounted in the center of the cockpit. Steering of the Pipe EV is done by the handlebar mounted on the cockpit. Right handlebar consists of the accelerator which also has the front brake lever. Rear wheel braking is done by using the brake lever fixed on the left handlebar. Tires used for the wheels are size (14 x 2.125) which is used in electric wheelchair. Measurement of speed and mileage are carried out by counting the digital signal generated in proportion to the number of rotations of the wheel. Digital signal is obtained by on-off of lead switch operating by magnet set on the left front wheel.

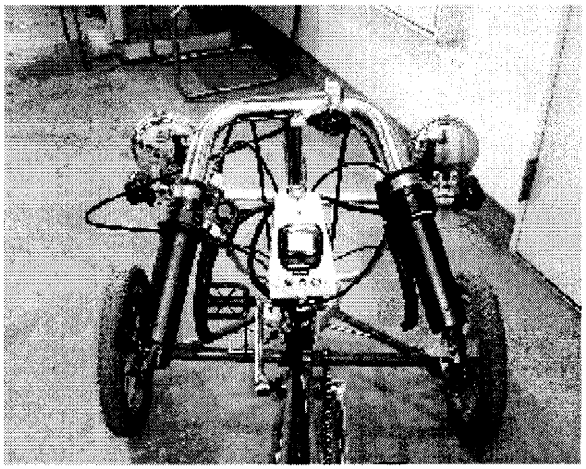

Fig. 3 State of cockpit

The rear view of a trial constructed Pipe 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 Pipe EV. Size and weight of the metallic alloys for hydrogen storage 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. The DC motor is mounted on the pipe frame between the right rear wheel and the chain drive. Chain 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 (N_2) of rear wheel is 60/11. Further, Pipe EV can be run by human power using the pedal. Figure 5 and Figure 6 show the left side view and the right side view of the Pipe EV. In Figure 5, frequency controlled the blower, fuel cell and diode (D) are shown mounted on the body. The blower is used to send O_2 in the air into the fuel cell. Size and weight of fuel cell is about 145mm x 400mm x 120mm and 2.6kg, respectively. Figure 6 shows the EDLC in an acryl case set on the metal tray fixed on the pipe frame. The capacity 30F/

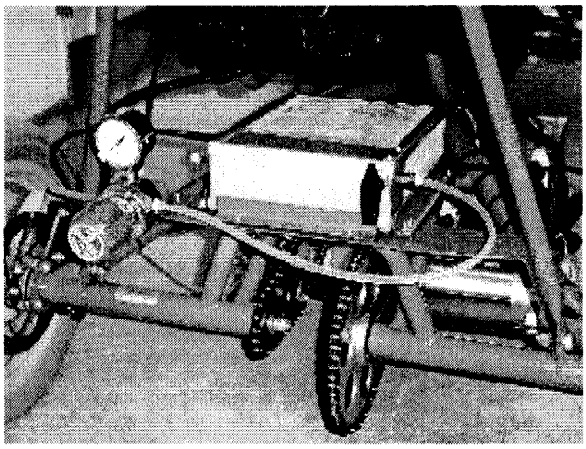

Fig. 4 Appearance of hydrogen storage material

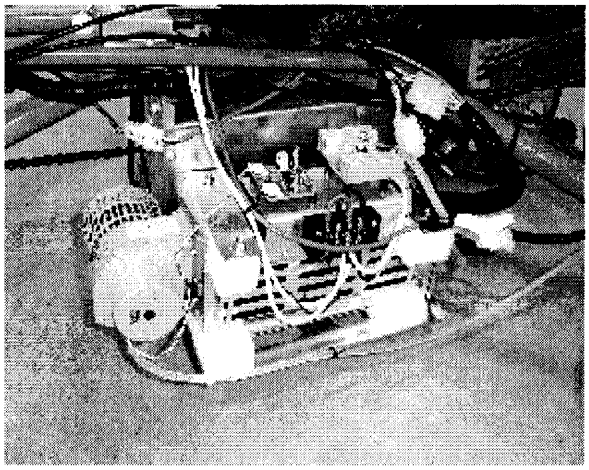

Fig. 5 Left side view of Pipe EV

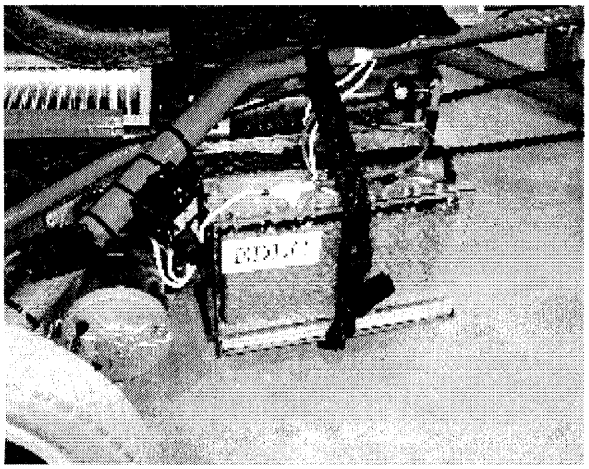

Fig. 6 Right side view of Pipe EV

50V EDLC set in acryl case consists of 20 series, each with the capacity of 600F with the working voltage of 2.5V.
Size of acryl case is about 135mm x 265mm x 140mm.

4. CHARACTERISTICS OF PIPE EV

Measurement of supplying current is done by a terminal voltage of current sensitive resistor with a value of 50mV/50A that is installed between the fuel cell and driving system of DC motor. The terminal voltage is supplied to Memory Hi-Corder while the Pipe EV is running and the data obtained is downloaded to flash card. Then, the data of flash card are processed by using a personal computer, and their characteristics are printed out.

4.1 Characteristics of supplying current and generating voltage while running

Characteristics of supplying current I_S and generating voltage E_G while running a mileage of about 0.13mile (210m) on flat ground at the speed of 20km/h is shown

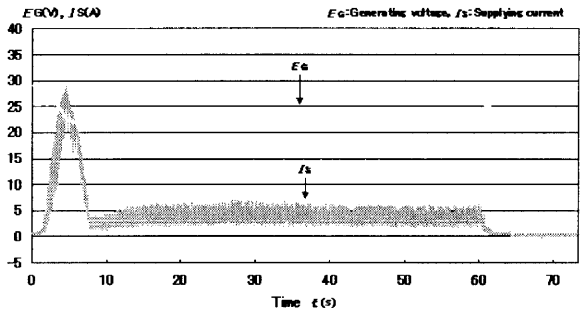

Fig. 7 Characteristics of supplying current *Is* and generating voltage at a running speed of 20km/h

in Figure 7. Figure 7 shows the voltage generated by the fuel cell at an idling state of the Pipe EV which is about 28.5V corresponding to 1.2 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. Supplying current to DC motor of 2-8 seconds after the start is about 28A corresponding to 6.2 times compared with 4.5A at speed of 20km/h. That is, EDLC with capacity of 30F contributes to the accelerating speed at start. Further, 10 seconds after the start, DC power ($E_G I_S$) of DC motor is measured at constant value corresponding to the time proceeds, and the speed of Pipe EV is kept at 20km/h. The output power is 112W (16V x 7A) while covering the distance of 210m at running speed of 30km/h.

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

Characteristics of the mileage is measured with the filled-up fuel cell set at 112W (27.5V x 4.1A) corresponding to 30km/h by connecting to a load consists of variable resistor and lamp in a laboratory.
Pressure of H_2 gas in metallic alloys for hydrogen storage is charged to 1.5MPa, and gas pressure of H_2 sent to fuel cell is adjusted to 0.03MPa. Characteristics of the mileage is shown in Figure 8. The Figure 8 shows that fuel could retain power until 240 minutes. This is cor-

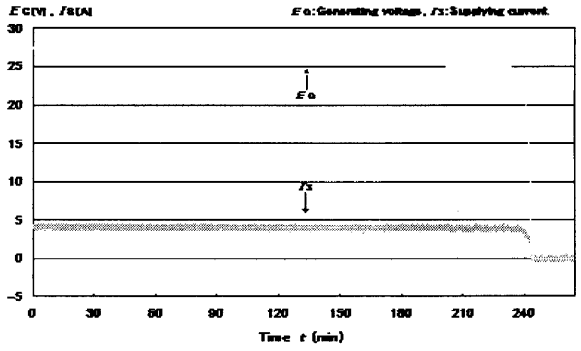

Fig. 8 Characteristics of the mileage corresponding to speed of 30km/h using a filled-up fuel cell

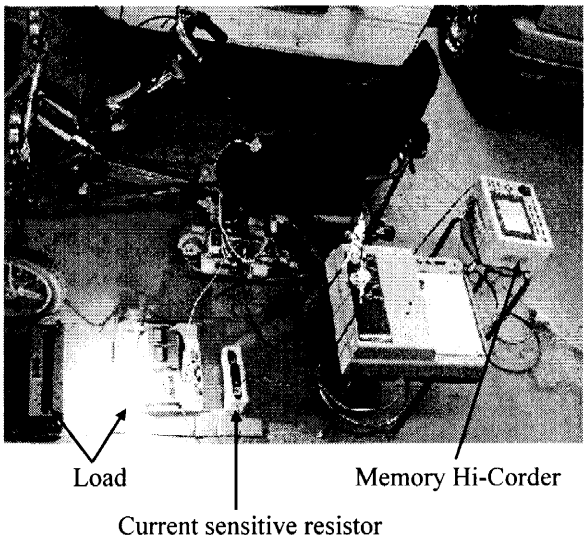

Fig. 9 Measurement view of characteristics for the mileage in laboratory

responding to a mileage of about 75mile (120km). Characteristics of the output power for a fuel cell is such that the power suddenly stops without prediction compared to a battery. Measurement view of characteristics for mileage is showed in Figure 9. Memory Hi-Corder is used to measuring the mileage.

5. CONCLUSION

This paper has proposed the introduction of a small, lightweight and slow speed electric vehicle named Pipe EV with a single-passenger operating at minimum power. Driving power source in the trial electric vehicle (Pipe EV) using a fuel cell (24V, 300W) with EDLC (30F) is aided by hydrogen storage material filled-up to 1.5MPa instead of a battery.

As a result, we have obtained the following.

(1) At a speed of 30km/h, generated output of fuel cell is 112W, and mileage is about 75mile (120km).
(2) H_2 gas is charged speedily in the hydrogen storage material in about 15 minutes.
(3) Weight of the Pipe EV using a fuel cell is about 20kg less than the EV using batteries.

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