Application of Microcontroller for Controlling HHO Dry Cell in Small Trucks

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Abstract. *This paper proposes an application of microcontroller for controlling the HHO dry cell regarding to separate hydrogen gas from water. The proposed control system consists of a display control microcontroller, a PWM signal generation microcontroller, key switches, buck converter, a separator and sensors. The experimental results show that the proposed control system can regulate the output current of the HHO dry cell constantly; even under the significant variations of battery voltage or the change in dry cell internal resistance. Furthermore, the proposed system could also protect the system operation by limiting the minimum voltage for the battery and maximum output current and temperature of the HHO dry cell. The test of the prototype truck by running for 15,000 kilometers was found that the truck could save the fuel approximately by 10 % when applied the proposed control system as the co-fuel source. In addition, one liter of pure water could be used for the operating engine and could operate continuously up to 800 kilometers.*

Keywords:

Microcontroller, hydrogen, HHO dry cell

1. Introduction

The depletion of conventional fossil fuels (i.e. natural gas, coal and oil) and the increase of energy demands for supporting the higher number of world population and the growth of industries worldwide lead to the need of more energy to be shared from renewable resources. Extracting energy from the chemical reaction would be one of the most interesting renewable energy production techniques [1].

In fact, producing energy from the chemical reaction with hydrogen gas is currently the most focused technique due to the simple possible methods to generate the gas; where the gas can be easily produced in terms of hydrogen gas and oxygen gas (or hydroxy gas or HHO) from small electrolytic plates of stainless steel that dipping in the potassium hydroxide solvent [2]. Alternatively, the gas can be produced from the decomposition of water, which will give the hydrogen and oxygen from a molecule of water using electrolysis effect with a productive ratio of 2:1.

However, producing energy from hydrogen gas with the electrolysis effect would encounter some problems related to the risks of fire explosion due to overcurrent/voltage or temperature, as the hydrogen gas is a flammable material. In addition, the process of generating hydrogen gas can be very slow and thus would spend much time for giving significant amount of hydrogen and energy [1],[3].

To eliminate the aforementioned problems, this paper proposes the implementation of the control system using microcontrollers in order to increase the production rate of hydroxy gas from the HHO dry cell. The proposed control system also consists of the feedback control and safe operation monitoring unit. The simple PIC microcontroller was used for the experimental prototype.

The experimental results show that the proposed control system could regulate the generated electric current of the HHO dry cell even the resistance of the cell is varied due to the inhomogeneous of the salt-water mixing solvent; including also the case of variation of battery voltage. The additional monitoring system was also implemented in order to ensure safe operation of the system; where the system will cut off the HHO dry cell from the electric charger when battery voltage becomes lower or the temperature presents on the HHO dry cell becomes higher than the limiting values.

2. Hydrogen Electrolysis Process

Fig. 1 shows the block diagram of the hydrogen electrolysis system under this study. The system consists of a HHO dry cell, a separator, a filter and a dc power supply (or an electric charger system) [3]-[5]. From Fig. 1, when the dc power supply powers an electric current through the HHO dry cell, the electrolysis reaction will begin to operate. The process produces the gas bubbles containing some water, oxygen and hydrogen. These three products then will be separated by the separator using weight classification technique. After that, the pure oxygen (O_2) and hydrogen (H_2) are cleaned by the special filter. These gases are then injected into the ID pipe mixing with oil as the fuel energy for the further using; such as for electric cars or trucks.

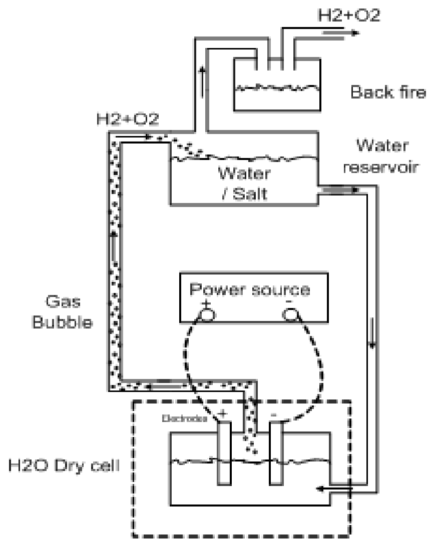


Fig. 1 Block diagram of hydrogen electrolysis

3. The Proposed Control System

Fig. 2 shows the block diagram of the proposed control system used to control the output current of the HHO dry cell. The proposed control system has two microcontrollers, key switches, a power inverter and sensors. The first microcontroller is used for controlling and processing the control parameters of the system, which can be switched for displaying by key switches. The key switches are used for selecting one of two operating Modes: Mode 1 and Mode 2. The Mode 1 is used for displaying the measured parameters of the system: the temperature, output current and battery voltage. The Mode 2 is used to control the parameters related to safe operation of the system: minimum battery voltage level, maximum output current and maximum allowable temperature. The second microcontroller is used as the PID controller for generating proper control signal in terms of pulse width modulation (PWM) signals. The control signals are used to control the operation of the switches and thus generate desired output current from the HHO dry cell.

In order to achieve the designed control targets, the output current from the HHO dry cell is measured on-line and is fed back to the PID microcontroller. The PID microcontroller then compares the measured value of current with the desired reference value. The current error then is used as an input signal for the PID controller that therefore gives the control signal for controlling the switch with proper gains of proportional, integral and derivative controller. The control signal used is in the form of PWM signal, which is a series of pulses with variable pulse width depending on the level of output HHO dry cell current. In this research, the PIC microcontrollers with build-in feature and with the Mikro C Pro programming base are used. This type of microcontroller is used for this research due to its simple programming functions, as well as, having low price. The generated PWM signal is then amplified in order to have sufficient voltage levels for driving the power MOS-FET as shown in Fig. 2.

The display microcontroller is also able to communicate and synthesize to the PID microcontroller via the RS-232 series port. The dc buck converter is used for the power conversion part of the control system; where its average output voltage can be determined by integrating the square wave pulse across the HHO dry cell. The average output voltage of the HHO dry cell must be varied in order to regulate the equivalent resistance seen across the HHO dry cell's terminals. This will give then the constant output current from the cell. Fig. 3 shows the prototype of the proposed control system, while Fig. 4 shows diagram and photograph of the test control system prototype.

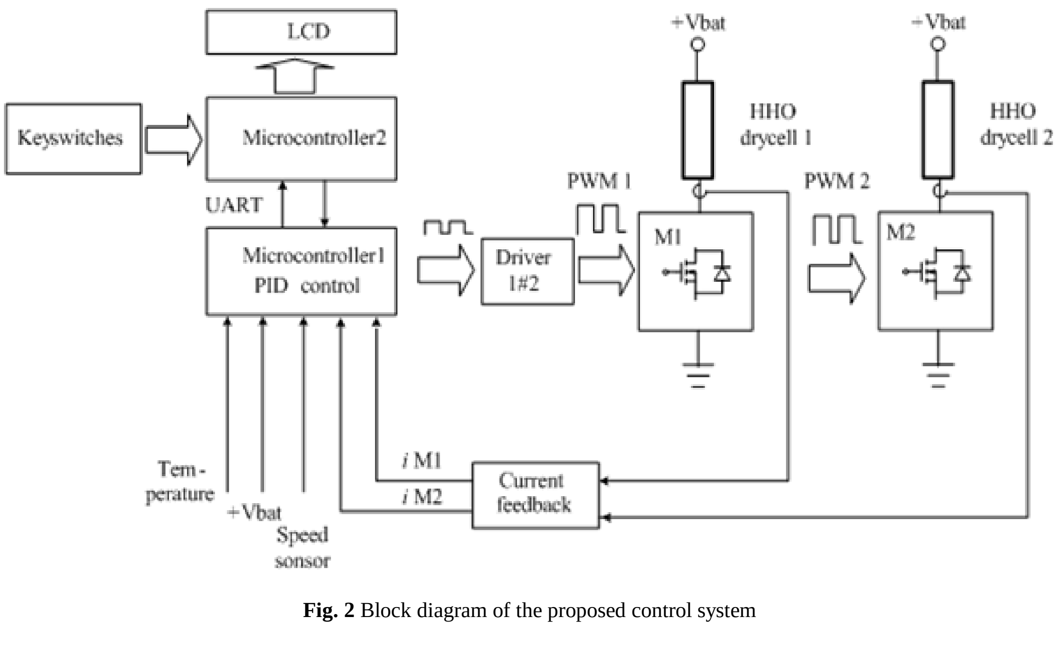


Fig. 2 Block diagram of the proposed control system

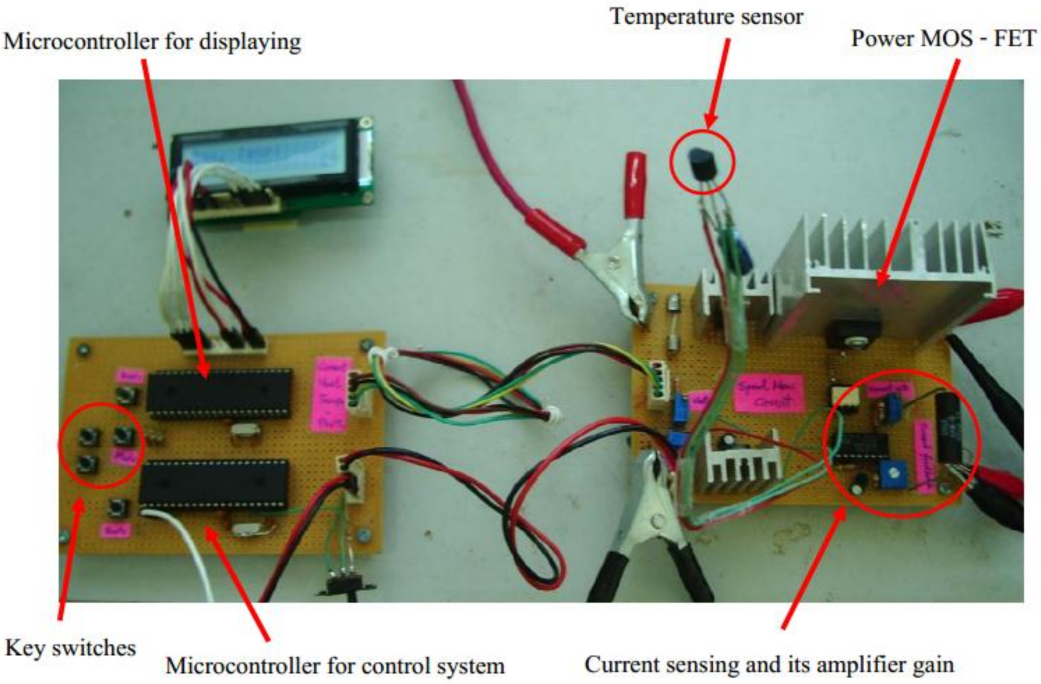
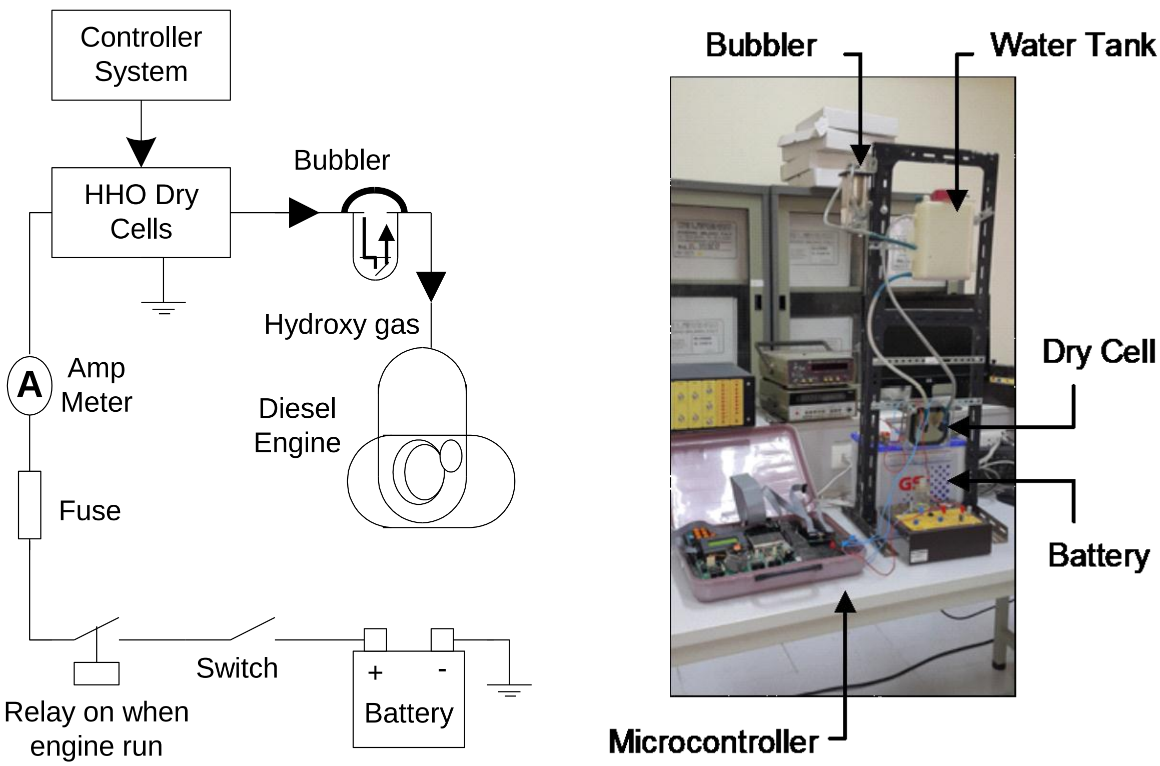


Fig. 3 Implemented circuit for the proposed HHO dry cell control system



(a) (b)

Fig. 4 (a) diagram and (b) photograph of the test rig of the proposed HHO dry cell control system

4. Experimental Results

From Fig. 4, the system prototype was implemented with a 2500 cc, turbo-intercooler, small-truck vehicle. The battery used for the small-truck vehicle was used as a power supply for the HHO dry cell generator as well as for all the control system equipment. The hydrogen gas was applied to a conventional diesel engine through the bubbler.

The experiment test-rig was able to produce the hydrogen gas and generated amount of electric current of 12-14 A, voltage of 12-13.5 V, surrounding temperature levels near a series of HHO dry cells in the range of 35-45 ^{o}C under the test of water circulating rate of 500 to 800 ml/min. continuously. The HHO dry cell limit control parameters were set by having the maximum output current of 10 A, minimum battery voltage of 10 V and maximum temperature of 40 ^{o}C.

As it is difficult to find the transfer function or the HHO dry cell, the optimal PID parameters of the control system can be found using Ziegler - Nichols tuning method. The method provides the control values for the PID controller of K_P= 96, K_I=48 and K_D=8; where the scaling factor is 8 and switching frequency 2 kHz. The measured parameters of the HHO dry cell and battery voltage in comparison to the control signal for the buck inverter are shown in Fig. 5 and Fig. 6, respectively.

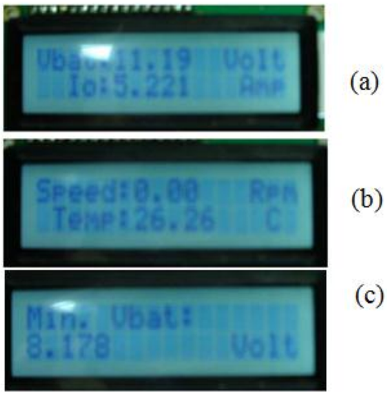


Fig. 5 LED display screen for (a) output current, (b) temperature and (c) battery voltage

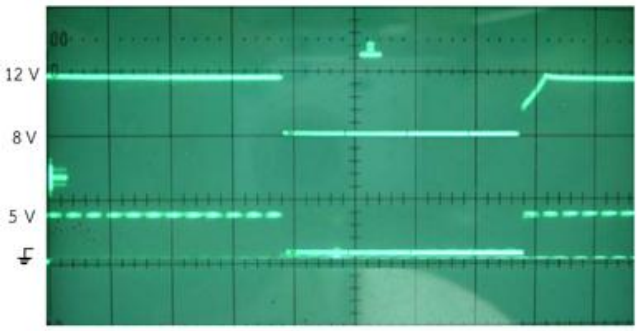


Fig. 6 Measured waveforms of (a) Battery voltage and (b) control signal

In addition, when the 2500 cc, turbo-intercooler, small-truck had installed with the HHO dry cell gas generator as with fully control by the microcontrollers. The test of running the vehicle by 15,000 kilometers test has proven that the proposed controller can save the fuel by approximately 10 % when applied the HHO dry cell in small trucks with the proposed control system as a co-fuel. One liter of pure water could be used for the operating engine and operate continuously with the test distance up to 800 kilometers for a trial operating truck.

5. Conclusions

This paper proposed the control system for hydrogen electrolysis. The proposed control system was implemented by the PIC microcontrollers. The experimental results show that the control system can maintain the HHO dry cell current constantly even under the significant variation of battery voltage and cell resistance. In addition, for safety issues, the proposed control system can limit the maximum reactor current and cut off the power circuit from the battery voltage when the battery voltage is lower than the set point value efficiently.

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