Research article

Developing of Incinerator with Hydrogen Gas for Hospital Wastes Treatment

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Abstract In this experiment, we studied the construction of incinerators using Hydrogen gas as fuel in small hospitals. The Hydrogen Gas Incinerating System in this study consists of 3 major parts, the Water Separation System, Furnace and Combustion System, and the DC Power Control System. The authors used water mixed with Sodium Bicarbonate ($NaHCO_3$) solution to separate Hydrogen (H) from water by using 12 VDC and 15.50 A which resulted the 909.09 ml/min of gas flow rate to burn 100 grams of infected waste. The experiment showed that the waste was completely burnt into ash within 13.35 minutes and the average power consumption was 0.04 kW-hr. It was concluded that the gas flow rate should not be less than 800 ml/min because it can have a fire back phenomenon. The result also showed that the burning cost of waste incineration in this study equaled to 1.50 baht/kg which was much cheaper than the one of general infected waste in hospital which costs 5 baht/kg.

Keywords electrolysis, medical waste, incinerator

INTRODUCTION

Medical waste with strong infections, toxic and corrosive, emissions, lax management or improper handling characteristics can cause pollutions to water, atmosphere, and soil and it also makes direct harm to human body if people do not handle with care (Abah and Ohimain, 2011). In order to ensure that the medical waste is in efficient management, harmless to be disposed, and prevent the spread of disease, scientific research tries to design medical waste treatment machines, which use high temperature to disinfect and sterilize medical waste and biomass decomposition, and save the cost of transportation which can also create higher economic benefits (Wajs and Golabek, 2019). However, combustion is a rapid and exothermic reaction between a fuel and oxygen. In incineration application, the predominant waste is fuel and the oxygen source is air, and the sources of combustion can be in many forms of products, whether the materials burned are natural gas, coal, wood, gasoline, hazardous waste, or medical waste which can create pollutions (Allsopp et al., 2001).

Hydrogen fuel is regarded as clean energy. It creates zero-pollution emission when burned with oxygen. It can be used in electrochemical cells, or internal combustion engines to power vehicles or electric devices (Bicelli, 1986). Hydrogen energy is a significant alternative energy. It is as an emerging market for energy business because it creates complete combustion. It also makes high efficient combustion. The benefit of hydrogen fuel is that it provides more than 2.5 times of hydrocarbon energy. Due to, combustion with hydrogen fuels produces no greenhouse gases, smoke, dust, and it is regarded as a conventional energy application. Moreover, the production of hydrogen from water by a process called electrolysis has steadily been being developed (Kudo, 2003).

Therefore, the research team has developed a device called “Dry Cell” to produce hydrogen from water which has been applied with a small stove. This small stove can be used to burn garbage in small hospitals. The infected waste in many small hospitals at rural areas is removed unsuitably, or inconveniently to destroy because of long distance. The development of a hydrogen fuel combustion plant, or the Hydrogen Gas Incinerator Plant is an alternative device to decrease pollution, cost of transportation, and risks from removing waste. The researchers attempt to create a series of dry cells to produce hydrogen gas as a source of fuel for the medical waste incinerator trial version machine which there are many factors in the production of hydrogen gas is needed to control. The quantity of hydrogen gas is more or less depending on these variables such as, the distance between conductance, the electrical current, and the electrolysis method (Kuracina, Fiala and Soldan, 2014). The authors realize the importance of the effectiveness of the medical waste incinerator which has been desired as a water electrolysis machine, including a pipe line, series of hydrogen gas and water separating, and slurry filling box in order to get the best performance in the separation of hydrogen which is used as fuel in combustion infected waste.

OBJECTIVE

The objective is to study the construction of an incinerator using in small hospitals using hydrogen as fuel.

METHODOLOGY

The principle design of medical waste incinerator with hydrogen gas consists of three parts: I, the Water Separation System, using direct current electricity to separate hydrogen and oxygen gas by putting a pure and high quality aluminum electrode plate inside and place in layers. The electrons flow from the negative terminal of the DC power source to the positive terminal, where they are consumed by hydrogen ions to form hydrogen atoms. II, the Furnace and Combustion Systems, for burning the waste, and III, the DC Power Control System used for electrical work. The three parts are described as the followings:

Part I: Water Separation Systems, the general process of water electrolysis, hydrogen ions move toward the cathode, whereas hydroxide ions move toward the anode. A secondary electrochemical cell using aluminum plates as electrode which is drilled for water flowing between each layer. The insulator is made of rubber cutting edge in every sheet preventing water out of the box. Aluminum sheets and rubber sheets are arranged alternately as you can see in Fig. 1. It is pressed tightly with screws and nuts enclosed with acrylic plate to prevent water leakage. The tube is used to connect between the reserved water box and electrolysis box. Hydrogen gas from splitting water by electrolysis procedure then it flows into the reserved water box and flows to the air filtration set. The water inside the reserved water box will flow into the dry cell or electrolysis box. As a result, the water inside the box is full at all the time. Because this design does not have a gas separating type. The gas in electrolysis procedure is a mixture of hydrogen and oxygen which is used as a fuel. It will pass through a one-way pipe towards the following combustion systems.

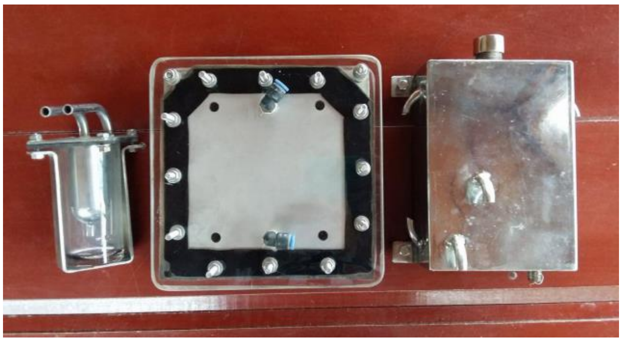

Fig. 1 Hydrogen gas production equipment

Part II: The Furnace and Combustion System consists of a furnace box frame inside which is lined with refractory brick and has steel mesh to allow the ash fall into the bottom. The furnace side is drilled to connect to the pipe with jet valve type to deliver hydrogen and oxygen. To prevent fire back phenomena, the check valve has been installed for controlling the direction of the gas flow. The jet valve is also connected to the spark plug for ignition to burn the garbage.

Part III: The Control System which is for electrical work consists of a 220 VAC switching to a 12 VDC 50 A for power supply. The electrical energy is shown by the voltmeter and the current meter equipment which is supplied to two devices. The first batch of electrical energy supplied to an electrolysis unit is controlled by electric control circuit. The second one is supplied to a set of the sparking that the circuit generates a high frequency and high power for transmission to automotive spark plugs. The pipeline design in all 3 parts can be simplified as illustrated in Fig. 2.

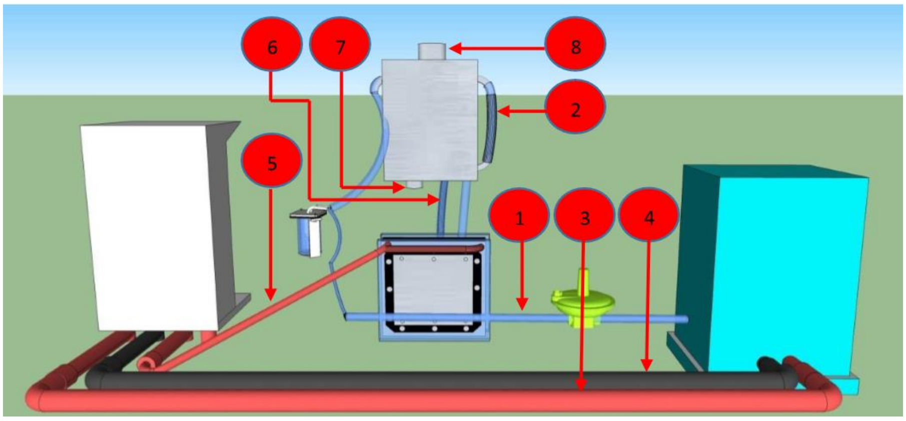

Fig. 2 The pipeline design of the incinerator

1. Hydrogen gas pipeline
2. Water level measuring tube box
3. Cable Anode wire
4. Cable Cathode wire
5. Power supply pipeline
6. Water supply pipeline
7. Drain tube
8. Water and slurry filling pipe

Fig. 3 The hydrogen gas incinerator plant with 3 sections

RESULTS AND DISCUSSION

In the electrolysis process, the separation efficiency of gas with electricity depends on different variables: the spacing of the electrode plate, size of the electrode plate, voltage and electrolyte solution. The quantity of hydrogen gas is proportional to the inverse of the distance between electrodes, while the size of the electrode plate voltage and the concentration of the electrolyte solution is proportional to the quantity of gas. The distance between the plates sheet was set as close as possible at the range of 0.1 mm. The size of the conduct sheet using 22x22 cm. The supply voltage is 12 VDC. Use sodium bicarbonate (Na_2CO_3) amount of 300 grams in 1 lite of water to prepare of electrolyte solution. The results showed that default value of electricity is quite low as about 10 A when the supply 12 VDC was applied. Initial temperature of water is equal to the temperature of water at room temperature. When the process of electrolysis occurs, water will be change into hydrogen and oxygen gas. This process is exothermic, the temperature of the water is increased, as a result, the electrical resistance is dropped. Consequently, the electric current increases, the rate of gas will also increase. It can be interpreted as the rate of gas that produced is proportional to the voltage and the temperature rise as shown in the Table 1.

Table 1 The flow rate of hydrogen and oxygen

Current (A.)	Temperature of water (°C)	Gas flow rate (mm^3/min)
11	33.0	432.90
12	35.0	492.61
13	40.0	699.30
14	44.0	769.23
15	45.6	909.09
16	47.0	942.40
17	48.0	956.70
18	48.5	977.50
19	48.7	982.30
20	48.7	990.40

Although the flow rate of gas is increased according to the value of electrical current, the rate is stable when it reaches the value of electrical current at 15A as shown in Fig. 4, where the flow rate of mixing gas value is close to 1,000 mm^3/min.

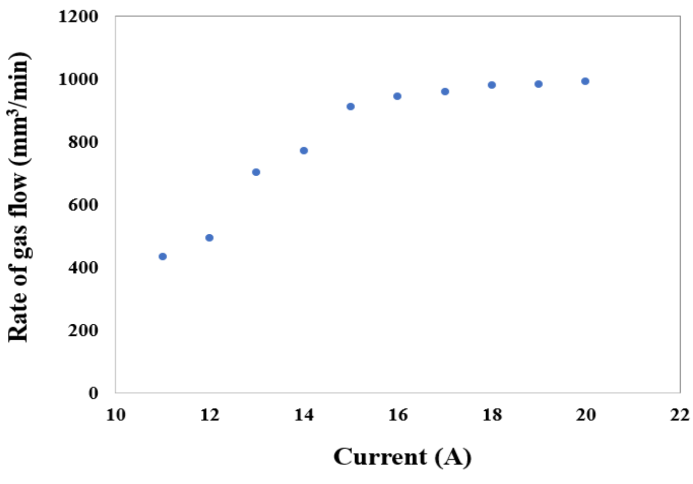

Fig. 4 The Plot between the Rate of gas flow and current

The infectious dry waste in quantity of 100 grams of cotton, gauze and bandage were selected in the experiment. A measurable 12 VDC voltage and an average current of 15.50 A were selected. It was found that the incinerator was able to burn 100 grams of dry waste within 13.35 minutes, and the average power consumption is 0.04 kW-hr.

Table 2 Results by burning dry infectious waste incinerators

No.	Current (A.)	Time (Minute)	Average Power (Watt)	Energy (kW-hr)
1	15.0	13.37	216.2	0.04
2	15.1	13.37	216.3	0.04
3	15.5	13.35	216.6	0.04
4	15.7	13.34	216.6	0.04
5	16.0	13.33	216.7	0.04

The infectious wet waste quantity of 100 grams of cotton, gauze and bandage with humidity at 85% were selected in the experiment. A measurable 12 VDC voltage and average current of 15.1 A were selected. It was found that the incinerator was able to burn 100 grams of wet waste within17.40 minutes, and the average power consumption is 0.07 kW-hr.

Table 3 Results by burning wet infectious waste incinerators

No.	Current (A.)	Time (Minute)	Average Power (Watt)	Energy (kW-hr)
1	15.0	17.36	223.2	0.07
2	15.1	17.36	223.1	0.07
3	15.0	17.41	223.1	0.07
4	15.1	17.40	223.2	0.07
5	14.5	17.44	223.4	0.07

CONCLUSION

From the production of medical waste incinerator using energy from hydrogen and oxygen from water separation process, it was found that the quantity of electricity flowing through the electrode sheet varies to the water temperature. The water resistance is inversely proportional to the temperature. The gas mixture of hydrogen and oxygen used to burn the garbage which shows the approximately minimum gas flow rate should be not less than 800 ml/min. If the flow rate is less than this value, it can have a fire back phenomenon. In addition, the results showed that dry waste consumed less double energy than wet waste as shown in Tables 2 and 3. When calculating the cost of electricity, it was found that the average power for burning dry waste is about 0.04 kW-hr, while burning the wet waste is 0.07 kW-hr respectively. The result also showed that the burning cost of infectious dry waste equaled 1.50 baht/kg, however the medical infectious incineration method in general hospital cost 5 baht / kg.

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