The development of spray tower equipment for the treatment of carbon dioxide and smog produced by agricultural waste combustion: a case study of coconut shells

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ABSTRACT: The objectives of this research were to develop spray tower equipment for the treatment of carbon dioxide and smog caused by the combustion of agricultural waste, using a case study of coconut shells and to study the breakeven point of spray tower equipment. The samples of this study consisted of an experimental group carrying out coconut shell combustion using spray tower equipment and a control group conducting coconut shell combustion by the regular method. The theories applied to spray tower equipment included: gravity law, inert force – both impact and reverse types, impact by inert force, diffusion and interception. The theories for the spray tower equipment comprised five main elements: electrical control system, water control system, coconut shell combustion control system, air flow control system, and spray tower system and water pit. The amount of coconut shell combustion could be 106 kilograms and the amount of carbon dioxide and smog caught at the end of the chimney before being released into the air from the spray tower equipment could be 602.5 millilitres, while the amount of carbon dioxide and smog from a regular combustion method was 438.5 millilitres. The breakeven point of the spray tower equipment would be ranged within two years.

INTRODUCTION

Nowadays, Thailand has engaged a local campaign to conserve energy and the environment by developing energy sources from agricultural waste, such as coconut shells, palm seeds and corncobs, which, when flattened into lumps, can provide heat during combustion. For example, palm seeds can give heat at 18.46 Mj/Kg, corncobs at 18.04 Mj/Kg and coconut shells at 17.94 Mj/Kg. Thus, the combustion of any agricultural waste, when flattened into lumps, can give heat from 5,000-7,500 Kcal/Kg [1]. Moreover, it was found that combustion from agricultural waste, like coconut shells, provides more stable heat than other materials for about 150 minutes [2].

Considering the types of agricultural waste that provide effective combustion and heat, it was found that coconut shells offer the highest amounts, especially in the southern part of Thailand and in factories where coconut pulp was divided and refined for oil. Therefore, there was a large amount of cheap coconut shells available. Coconut shells are also the raw materials qualified for study as raw materials for charcoal burning, and it was easy to be transported from place to place. Hence, many people have developed coconut shell kilns for charcoal burning [3].

However, it was found that, in order to eliminate agricultural waste, combustion was carried out in open fields or without complete combustion. This has led to smog pollution from chimneys, including carbon dioxide (CO_2), carbon monoxide (CO), oxygen (O_2), nitrogen (N), sulfur dioxide (SO_2), water (H_2O) and tar, as well as odour and smog that affects the environment of surrounding villages and/or is harmful the burner's health leading to suffocation. It also contributes to the greenhouse effect [4].

The optimum condition for the combustion of agricultural waste so that it is of good quality and has a high amount of charcoal is to combust it in an are with limited air space and vapour condensation and/or suitable exhaust air treatment before distributing it to ambient air. A well-known device for smog treatment at present is the spray tower, which can be used together with a circulatory air spray gun to satisfactorily achieve smog treatment [5].

According to the significance of agricultural waste, especially coconut shells, and the treatment of smog and odour from combustion, the researchers propose the present study in order to find alternative energy resources or energy conservation, as well as to solve the problems of smog and odour that arise during combustion, thus resulting in a cleaner environment for nearby villages [6].

OBJECTIVES

- To develop spray towers for the treatment of carbon dioxide and smog caused by coconut shell combustion;
- To compare the treatments of carbon dioxide and smog caused by coconut shell combustion using spray tower equipment and the regular method;
- To compare breakeven points of the treatment of carbon dioxide and smog treatment caused by coconut shell combustion from using spray tower equipment and the regular method.

HYPOTHESES

The hypotheses for the study are as follows:

- H_0 = The treatments of carbon dioxide and smog caused by coconut shell combustion by the spray tower equipment and regular method do not differ;
- H_1 = The amounts of carbon dioxide and smog caused by coconut shell combustion by the spray tower equipment and the regular method differ;

- H_2 = The breakeven points of coconut shell combustion of the spray tower equipment and the regular method differ.

EXPECTED STUDY OUTCOMES

The expected outcomes of this study are as follows:

- Factories that produce charcoal lumps from other agricultural waste, such as tapioca, corncobs and palm shells, can use spray tower equipment to effectively treat carbon dioxide and smog;
- Entrepreneurs can produce charcoal lumps without carbon dioxide and smog due to the fact that a spray tower alters smog and odour to clean gas, complying with the ISO standards, so that the gas is not harmful to the surrounding environment. Therefore, the community should not be opposed to such entrepreneurs;
- Entrepreneurs can reduce the cost of transportation to customers and/or moving from their original location, which, in the long-term, may cost significantly more than constructing a spray tower.

RESEARCH METHODOLOGY

Samples

The samples used in this study were composed of the following:

- Experimental group focusing on the combustion of coconut shells using a spray tower;
- Control group focusing on the combustion of coconut shells using the regular method.

Variables

The variables of this study comprised the following:

- The independent variables were the coconut shells, experimental group and control group;
- The manipulative variables were the spray tower, or the cyclone scrubber with an air pipe, equipped with spray heads, at the centre-bottom of the equipment. Dirty gas flows, like that found in a regular cyclone, then flows into a spray pipe to clean out smog and odour, which are dirty gases. Particles or frost and mist that cling with these water drops are separated to the wall inside the equipment by way of the eccentric force of the gas flow;
- The dependent variables were the amount of carbon dioxide and smog, as well as the breakeven point of the coconut shell combustion.

THE DEVELOPMENT OF EQUIPMENT FOR THE TREATMENT OF THE CARBON DIOXIDE AND SMOG CAUSED BY COCONUT SHELL COMBUSTION

The process for developing the equipment for the treatment of carbon dioxide and smog was composed of five steps, as shown in Figure 1.

RESULTS OF THE STUDY

The study of the amount of carbon dioxide and smog caused by the combustion of coconut shells is divided into two parts, as follows:

- The combustion of coconut shells using the regular method;
- The combustion of coconut shells using the spray tower equipment.

Measuring the Carbon Dioxide and Smog Caused by the Combustion of Coconut Shells

As shown in Figure 2, the locations to measure the carbon dioxide and smog caused by the combustion of coconut shells were as follows:

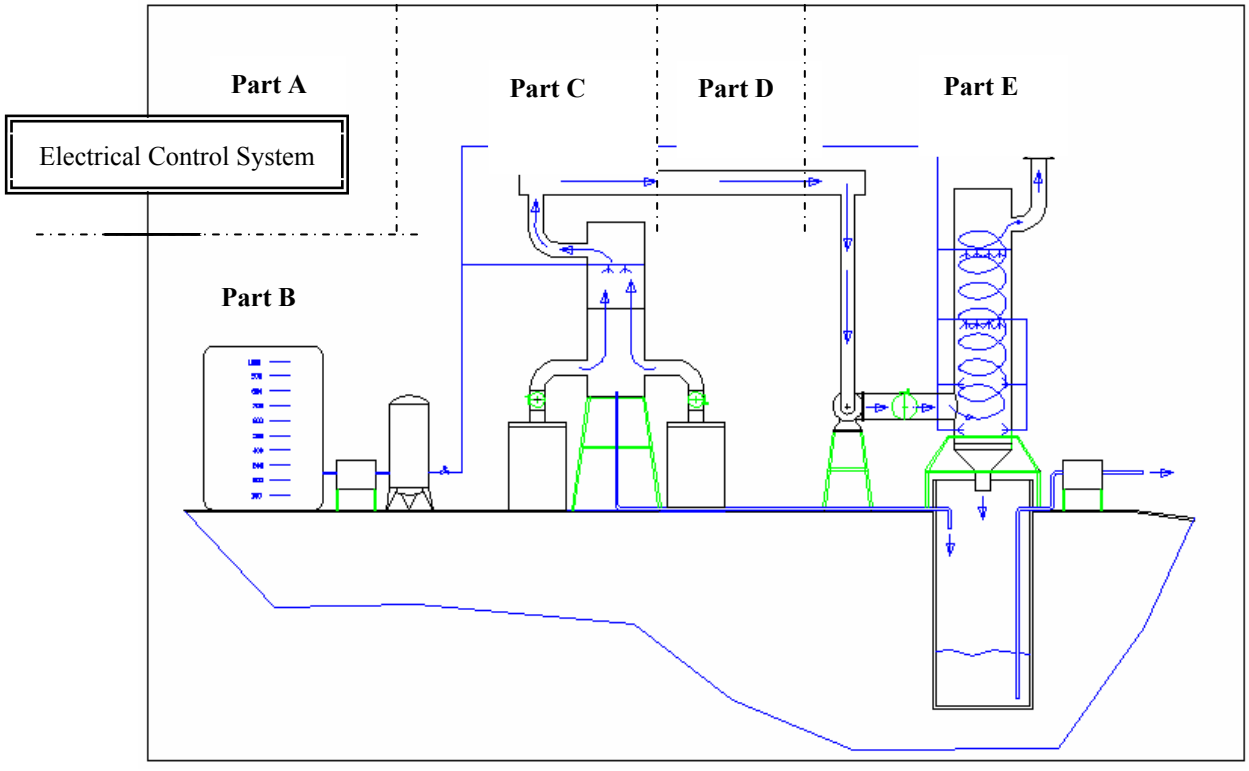

Figure 1: Equipment for the treatment of the carbon dioxide and smog caused by coconut shell combustion.

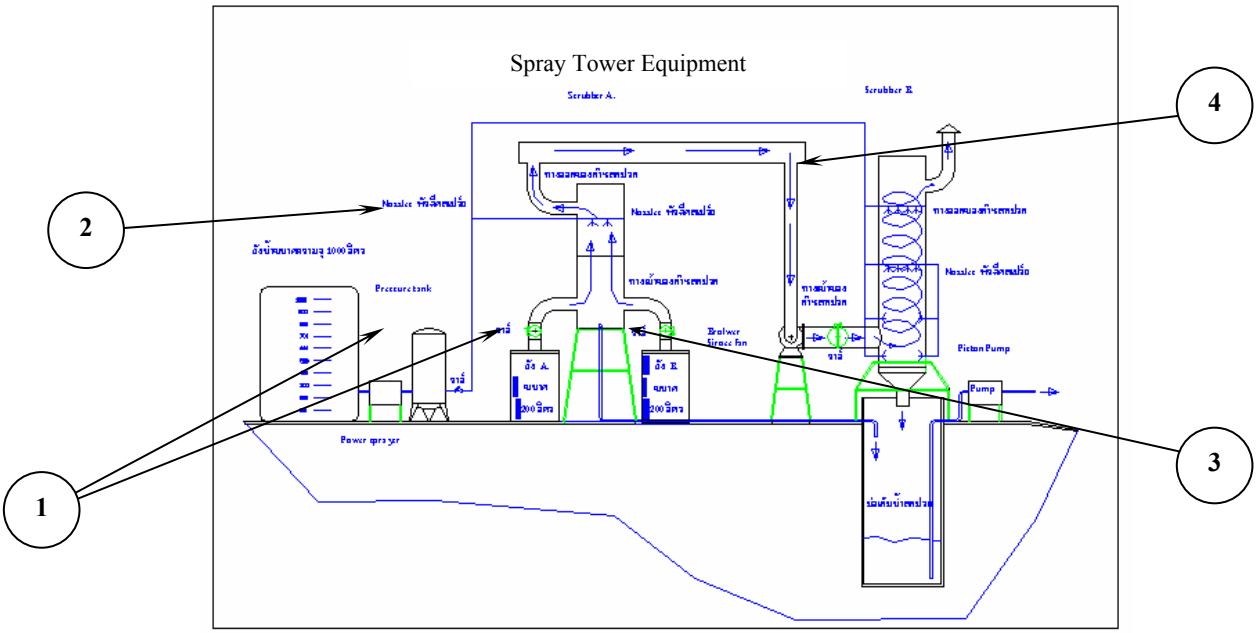

Figure 2: Locations for measuring the carbon dioxide and smog caused by the combustion of coconut shells.

1. To measure carbon dioxide and smog at the exhaust pipes of two spray towers;
2. To measure carbon dioxide and smog at the exhaust pipes of the first spray tower;
3. To measure carbon dioxide and smog at the point where the pipe is connected to air ventilation;
4. To measure carbon dioxide and smog at the exhaust pipe where the air ventilates to the outside.

The combustion of coconut shells using the regular method is the same as the typical one, but the amount of charcoal produced is increased by 25%. Moreover, it lasts only eight hours for each combustion. However, the combustion of coconut shells using spray tower equipment was found to be the same as the combustion of coconut shells by the regular method, but it uses electrical and water control systems to reduce carbon dioxide and smog emissions.

Studying the Breakeven Point of the Spray Tower Equipment Compared to the Regular Method

In studying the breakeven point of coconut shell combustion by the regular method, it was found that the cost of the regular method consisted of the investment in coconut shell burning kilns (around 30,000 Baht). But there was a maintenance cost as well (around 3,000 Baht per year), which was low, so it reached a breakeven point in a short period of time. However, it damaged the surrounding environment due to carbon dioxide and smog spreading to nearby villages. Entrepreneurs would have to move to another region, thus increasing costs.

To identify the breakeven point of coconut shell combustion by spray tower equipment, it was found that investing in spray tower equipment would yield a profit of around 100,000 Baht (this analysis was conducted during this study; changes may have since occurred due to economic status), as follows:

- NPV = analysis of breakeven point (current value of income per annum – current value of investment);
- N = amount of product at any point;
- P = profit;
- V = variable capital;
- Thus, NPV = 40,000 – 300,000 = 100,000 Baht.

The amount of electrical power consumption measured during the experimentation period for coconut shell combustion was from 12:00 to 19:00 (seven hours) and utilised 11 units of electrical power.

The amount of water used in the treatment of the carbon dioxide and smog caused by coconut shell combustion was from 12:00 to 19:00 (seven hours), using 3.5 units of water.

The maintenance cost for the spray tower equipment was determined as being 1,000 Baht per month.

DISCUSSION AND CONCLUSION

In developing the spray tower equipment for carbon dioxide and smog treatment, a problem was encountered regarding leakage at rubber shield joints because the heat from coconut shell combustion tended to melt the rubber shielding. The solution to this problem was to use metal shields.

In order to develop the spray tower equipment with pipes with spray heads for the two towers, 18 spray heads were arranged, layer by layer, each consisting of three spray heads, for combustion around eight hours a day. However, this wasted water; yet if the spray heads were reduced, the results would get worse. The solution was to use an impinger for the treatment, which operated like the spray tower equipment, except for the position of the spray tower. This method used only five spray heads and less water.

In order to measure the amount of carbon dioxide and smog, two methods were adopted, specifically:

- Direct measurement by using air pollution detectors was found to be not accurate enough because the regular method required new coconut shells every 15 minutes and the amount of carbon dioxide and smog was not accurate;
- Indirect measurement by measuring temperature changes at fixed positions or condensation. Using the equipment to measure the carbon dioxide and smog levels at closed joints at the end of the pipe showed that dirty water came out after coconut shell combustion.

The amount of carbon dioxide and smog after coconut shell combustion when using spray towers was found to be higher than that of the regular method because in the spray tower case, the carbon dioxide and smog would melt with the water to fall into a treatment tank, whereas the regular method had no treatment, so there was a lesser amount of carbon dioxide and smog detected.

The breakeven point for the spray tower equipment was just an approximation. In fact, there was no exact way to measure it, but it was more worthwhile than moving a factory to remote areas. In addition, there was no air pollution to surrounding areas.

The study of the amount of carbon dioxide and smog revealed that the best way to measure the level of carbon dioxide and smog was to measure using a condenser. This was because carbon dioxide and smog, in the form of water, could be measured by millilitre, which was more obvious than other methods.

SUGGESTIONS

From the results of this study, the following suggestions can be made:

- Measuring the amount of carbon dioxide and smog could not be carried out directly because of various limitations, for example, the regular method required new coconut shells every 15 minutes and measurement was not continuous. So indirect measurement, the measurement of temperature and waste water, was used instead;
- In order to analyse the breakeven point, the results could not be presented by way of exact numerical data. Indirect measurement then had to be used. Indirect measurement concerned environmental and air pollution so that it could not be calculated to an exact value;
- The price of the spray tower equipment that the researchers developed may differ from current prices due to the price of materials used in the development and economic changes;
- The price of the spray tower equipment did not include the cost for copyright. If this model was industrially developed, the cost for copyright must be incorporated as well;
- In order to develop the spray tower equipment in the future, an impinger for carbon dioxide and smog treatment should be used in order to compare its performance with the spray tower equipment. An impinger operates like spray tower but with different locations of the spray tower. Spray heads are placed and joined to the wall of the tower, with only five spray heads used. This would serve reduce the water used and the number of spray heads.

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