

A simple method for producing the smokeless eucalyptus charcoal

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ABSTRACT: At present, the redundant cultivation of eucalyptus wood for paper industry in Thailand causes a large amount of residue of eucalyptus wood. Beside, the business of fired food is booming. The production of smokeless charcoal is necessary done by reducing volatile content in charcoal until its content remained at least. The aim of this research was to construct the furnace and find the condition for producing smokeless eucalyptus charcoal. The furnace built from 200 litres oil tank. It consists of a burning chamber equipped with special thermal resistance cement in a thickness of 8 cm and an opening of 20x10 cm² at the bottom of furnace to get fire to eucalyptus wood. To prevent heat loss, furnace was insulated by rice husk mixed with sand. Thirty two kilograms of wood was placed into the furnace in two layers. The first layer placed fully in the vertical with furnace and the second layer locates in the horizontal direction. The procedure of controlling of furnace temperature in a range of 550 °C to 650 °C with a burning time of 100 min was undergone by on-off of fan and was then closed air inlet everywhere when burning finished. Undergoing with this method, it found that the mean values of temperature, true density, moisture content, volatile, fixed carbon, ash and heating value were 588 °C, 651 kg/ m³, 2.49% db, 3.82%, 88.96%, 5.04% and 31.12 MJ/kg, respectively. The remaining weight of charcoal after burning was 3.8 kg.

Keywords: Charcoal; Eucalyptus; Fixed Carbon; Volatile

1. INTRODUCTION

Charcoal is a kind of solid fuel, is used for domestic cooking, the water purification from heavy metals, and chemicals (carbon

black or activated carbon). To obtain the high yield biomass charcoal, recent improvements in the charcoal production technology have approached to equal the theoretical limit [1&2]. A heating rate of

10°C/min to a final temperature of 450°C with a 15 min hold at the peak temperature was employed. To prevent weight loss, the nitrogen gas was purged through the sample bed at different pressures of 0.1 and 1 Mpa with a purge gas flow of 0.25 L/min. Utilization of charcoal usually involves a devolatilization process. The physical and chemical properties during devolatilization are not well understood. Várhegyi and Szabó [3] studied the kinetics of biomass charcoal devolatilization. This process occurs from the formation and loss of gaseous species from parent charcoal. A given species may arise from physically or chemically different sites because biomass charcoals are inhomogeneous materials. The distribution activation energy mode (DAEM) is the suitable mathematical model for describing the physical and chemical biomass charcoal. In order to value added for charcoal, we tried to produce the low volatile content eucalyptus charcoal and its proximate analysis was also studied.

2. MATERIALS AND METHODS

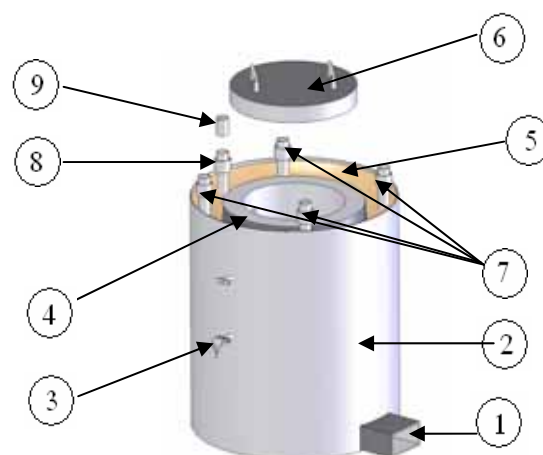
2.1 Apparatus and raw material

Figure 1 shows the simple furnace for burning eucalyptus wood to charcoal. A 200 liters oil tank was used for building the furnace. It consists of a burning chamber bound with special thermal resistance cement in a thickness of 8 cm from inner tank and an opening of 20x10 cm² at the bottom of furnace to get fire to eucalyptus wood. To protect heat loss of furnace, the outer tank was confined by sand and rice husk with a thickness of 15 cm. Main components of furnace are represented in Figure 1. Eucalyptus wood was collected from Mahasarakham province in North-East of Thailand. Figure 2 illustrates the arrangement of eucalyptus wood in burning chamber and the air flow direction. Thirty two kilograms of wood was placed into the furnace in two layers. The first layer place fully in the vertical with furnace and the

second layer locates in the horizontal direction.

2.2 Procedure for burning charcoal

First, dried rice straw, started combustion material, was located on the screen at the bottom of burning chamber and thirty two kilograms of eucalyptus wood was then placed into the chamber. Dried rice straw get fire to eucalyptus wood by flaming paper into the opening at the bottom of burner (opening number 1 in Figure 1). The air was supplied into the burning chamber through opening number 1 by a small centrifugal fan. After 15 minutes from the beginning, the top lid of furnace and inlet and outlet pipe (pipe number 7 in Figure 1) closed except the exhaust gas pipe (pipe number 8 in Figure 1) opened for forcing the exhaust gas to only one pipe exit. The smoke from furnace at exhaust gas pipe was continuously observed until it is rather clear. Consequently, all of parts of air supply closed in order to charcoal forming. The charcoal was left and cooled down in the furnace for one night.



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|------------------------------------|---------------------------------|-----------------------|
| 1. opening for flaming and blowing | 2. zinc wall | 3. thermocouple |
| 4. thermal resistance cement | 5. insulator (sand & rice husk) | |
| 6. top lid | 7. inlet and outlet air pipes | 8. exhausted gas pipe |
| 9. pipe lids | | |

Figure 1: Main components of smokeless eucalyptus charcoal burner

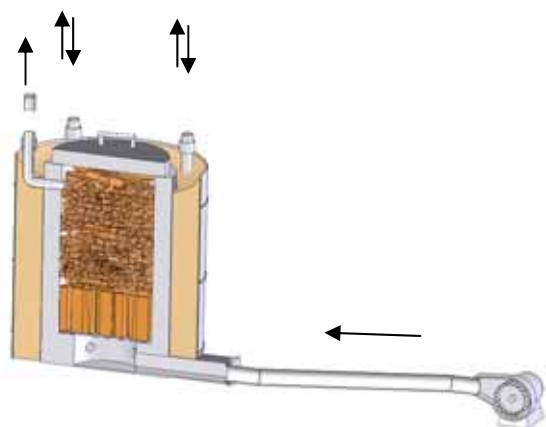


Figure 2: Arrangement of eucalyptus wood and air flow direction

2.3 Experimental conditions

Uncontrolled burning temperature

During making charcoal, throughout the burning was continuously blown by fan with a constant average air flow rate of 3.3 m³/h and the burning time was varied as follows: 60, 90, 100, 110 and 120 minutes.

Controlled burning temperature

As same as the uncontrolled burning temperature, the air supplied with a rate of 3.3 m³/h. However, the burning temperature was controlled by on/off the fan in three different ranges of 500-600°C, 500-650°C and 500-700°C.

2.4 Testing for charcoal properties

True density of charcoal was determined using the toluene displacement method. The volume of toluene displacement obtained from immersing a weighed quantity of charcoal in the toluene [4].

Determination of the moisture content in test samples was done according to ASTM D3173-87 method in Hightech electromagnetic inductive moisture meter. The fixed carbon, volatile matter and ash content were determined according to ASTM D3174-89 method in electric muffle furnace. The volatile matter was analyzed at 750°C but the fixed carbon and ash content was observed at 990°C. The volatile matter and fixed carbon was estimated by difference weight of sample before and after test.

3. RESULTS AND DISCUSSIONS

3.1 Uncontrolled temperature conditions

Generally, the pyrolysis temperature of wood and biomass charcoal was performed in wide range of 300-1000°C. Via this constructed furnace, the temperature in furnace could be developed up to 800°C. Thus, the experiments were ran to find out the burning time for obtaining high product yield and low volatile content prior to burning temperature control. From the proximate analysis and yield percent as depicted in Table I and II, it showed that the moisture and volatile matter were decreased with burning time while the fixed carbon was increased. The heating values of them were nearly in a range of 30.70-32.87 MJ/kg. For the true density of eucalyptus charcoal, it was varied in a range of 612.60-768.63 kg/m³ which depended on the quality of raw wood. To obtain the highest product yield (in case of overall eucalyptus wood in the chamber was completely burned as charcoal) and a medium volatile content from the five levels of burning time, the 100 minutes was recommended.

Table I: Proximate analysis of uncontrolled temperature at various burning times

Burning time (min.)	Proximate analysis			
	Moisture (%)	Volatile matter (%)	Fixed carbon (%)	Ash (%)
60	3.64	28.50	64.19	3.68
90	1.88	22.17	69.86	6.10
100	1.50	15.41	79.61	6.64
110	0.75	9.10	85.52	4.63
120	1.80	3.95	87.99	6.04

Table II: Yield percent, heating value, and true density for uncontrolled temperature condition

Burning time (min.)	Yield (%)	Heating value (MJ/kg)	True density (kg/m ³)
60	17.2	30.92	649.22
90	15.6	32.51	612.60
100	14.5	30.70	768.63

110	13.3	32.87	687.26
120	6.5	31.60	730.81

3.2 Controlled temperature conditions

After meet the burning time as mentioned above, the temperature in furnace was controlled by on-off air supplier in order to devolatilization in charcoal as expect. Three different ranges of simple temperature control were shown in Figure 3. As the results in Table III and IV, the proximate analysis and yield percent indicated clearly that the charcoal treated by temperature ranges of 550-600°C and 550-700°C provided higher yield percent, higher volatile matter and lower fixed carbon than that treated at 550-650°C. The results of heating value and true density were similar to the uncontrolled temperature condition. However, the burning at 550-650°C and 100 minutes was not the optimal condition for preparing the smokeless eucalyptus charcoal. The future work will try to carry out the optimal condition.

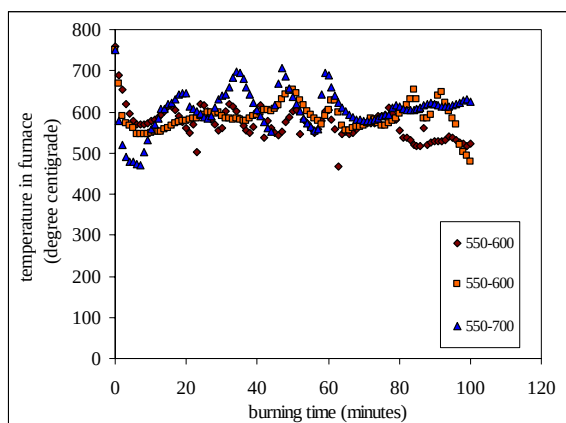


Figure 3: On-off air supplier to control temperature in various ranges for 100 minutes of burning time

Table III: Proximate analysis of controlled burning temperature in various ranges

Temp. ranges (°C)	Proximate analysis			
	Moisture (%)	Volatile matter (%)	Fixed carbon (%)	Ash (%)
550-600	2.94	19.02	73.8	4.45
550-650	2.50	3.82	88.96	5.04

550-700	2.79	10.21	81.48	5.58
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Table IV: Yield and incomplete charcoal percent for controlled temperature condition

Temp. ranges (°C)	Yield (%)	Heating value (MJ/kg)	True density (kg/m ³)
550-600	16.1	31.55	684.30
550-650	13.3	31.12	651.00

4. CONCLUSION

Low volatile content of eucalyptus charcoal could be prepared by controlling the temperature in a range of 550-650°C with a burning time of 100 min. Even yield charcoal was lower than that 550-600°C and 550-700°C but it had a very low volatile content. The obtained charcoals were low true density and high fixed carbon and heating value for 651 kg/m³, 88.96%, and 31.12 MJ/kg, respectively.

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