CONTINUOUS CARBONISATION SYSTEM FOR THE PRODUCTION OF CHARCOAL FROM OIL PALM BIOMASS

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Activated carbon (AC) is widely used as an adsorbent in the treatment of liquids and gases. Many industries such as pharmaceutical, mining, petroleum, nuclear, water treatment, food and beverages are using activated carbon in their processing units. The important parts of the production process of activated carbon are the carbonisation (production of charcoal) and activation (production of activated carbon). Most of the AC industry in Malaysia use charcoal made from coconut shell, and the charcoal is obtained from local suppliers or imported from Philippines and Indonesia. It is only a handful which are involved in the production of AC from oil palm biomass [specifically palm kernel shells (PKS)], due to shortage of charcoal supply and the low quality. To achieve sustainable production of charcoal, an environmental-friendly and a continuous process is crucial. In the earlier years, two batch systems of carbonisation systems were introduced; namely the Hollow Plinth Carbonisation system (Astimar and Ropandi, 2011) and Taki Carbonisation system (Astimar *et al*., 2012, Rugayah *et al*., 2014). Both systems are considered environmental-friendly (having the smoke emitted being scrubbed and treated). With the increasing demand of charcoal, especially in the bio-energy and waste water sectors, opting for a sustainable and continuous carbonisation system is very important. The shortage of labour for working in the batch systems is also one of the issues that hinder the commercialisation of charcoal.

THE TECHNOLOGY

This continuous carbonisation system was developed together with Hakita Engineering Sdn Bhd. The pilot plant was fabricated and installed at MPOB/UKM Research Station, Jalan Sekolah, Pekan Bangi Lama, Selangor (*Figure 1*). In this process, the biomass is passed through a horizontal rotary kiln heated to a final temperature of about 600°C -700°C. The system uses an external heating system, using diesel as fuel which is adaptable to using natural gas or biogas. Thus, this system can be installed in the mill and utilise the biogas from palm oil mill effluent (POME) as fuel for the carbonisation process. If production of AC is also intended, the excess steam from the boiler can be used as the activation agent. Studies carried out on PKS charcoal treated with steam have produced AC which comply with the commercial specifications (Rugayah *et al*., 2014).

The heating temperature is controlled at three points of the rotary kiln. The rotating motion of the kiln moves the carbonising materials along the kiln and the speed is controlled based on the period of the heating required. Gases, light oil, tar and acidic liquor are the volatile carbonisation products which are removed from the kiln by suction.

The system is capable of carbonising up to 2 t PKS per day. Since this is a continuous system, once the carbonisation has started, it will run for 24 hr and the system would only stop occasionally (depending on situation). For setting of the temperature, the burner will ignite and heat for 2 hr until it reaches about 500°C and the heater will stop, and the PKS will start self-burning (exothermic process) throughout the process.

From the tests that we were carried out using the system, it was found that the charcoal from PKS produced at 500°C gave better qualities, and the input rate of raw

Reference Specifications

Type of kiln - Continuous type

System of kiln - External heating system

Type of burner - Air forced system

Firing temperature - 600°C -700°C

Fuel - Diesel (adaptable for LPG and biogas)

Figure 1. The prototype of the rotary kiln system for continuous carbonisation and the commercial specifications.

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material also plays the role in ensuring the carbonisation efficiency. The input rate of PKS at 25 t hr^{-1} produced charcoal with the highest fixed carbon content and the highest BET surface area (*Table 1*).

THE ECONOMICS

The basic calculation on the economics of the prototype system is shown in *Table 2*.

TABLE 1. THE CHARACTERISTICS OF CHARCOAL PRODUCED FROM PALM KERNEL SHELL (PKS) CARBONISED AT 500°C AT DIFFERENT INPUT PER HOUR, USING THE CONTINUOUS CARBONISATION SYSTEM

T (°C)	Input of PKS (t hr^{-1})	Moisture content (%)	Volatile content (%)	Fixed carbon (%)	Ash content (%)	BET surface area (m^2 g^{-1})	pH
500	20	6.87	9.57	62.1	19.19	97.039	9.56
500	25	5.19	6.66	78.14	8.16	244.505	9.42
500	30	5.3	15.91	72.28	5.74	1.155	8.06

TABLE 2.

No.	Items	Cost (RM)
1.	Capital Cost (building and rotary kiln system)	500 000
2.	Operating Cost (per month)(A) Labour (RM 3600) Diesel (RM11 027) Electricity (RM 2550) Water (RM 20) Transportation (RM 4800) Raw material, PKS (RM 10 656)	32 653
3.	Average Sale of Charcoal and Vinegar (per month) (B) Price of charcoal (RM 3000 t^{-1}) Plant capacity is 17.28 t per month = RM 3000 x 17.28 t	51 840
4.	Net profit per month= (A) – (B)	19 187
	Payback period: = Capital investment/net profit per year	2.2 years

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