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Development of Carbonator^{TM} to Pyrolyze 20 ton/day Palm Oil Empty Fruit Bunch into Biochar

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Introduction

Biochar can be produced by thermal processing of biomass mainly pyrolysis and gasification. The type of thermal process used to produce the biochar determine the biochar output. Slow pyrolysis produces higher amount of biochar than fast pyrolysis and gasification for the same biomass input. Most research and development works have been focusing on fast pyrolysis and gasification to maximize the oil and syngas output for energy. Slow pyrolysis is limited to production of low grade activated carbon and pretreatment before gasification.

However among the three processes, the slow pyrolysis process is probably the easiest to scale up due to its low temperature and the output is largely biochar. Recent finding of the potential of biochar for environmental management will increase demand for it. Therefore, it is important for us to develop a pyrolysis unit capable of producing large amount of biochar using green technologies. Furthermore, the country has a vast amount of biomass waste which can contribute to green house gas emission if left to decay.

In Malaysia we produce more than 180 million tons of Palm Oil Empty Fruit Bunch (EFB) every year. EFB comes from the biomass bunch that hold together the fruitlets. When the fruitlets are removed for oil extraction, the empty bunch becomes a waste. In this work, we tried to convert 20 ton/day EFB into biochar at 400^{o}C. Since the process was energy intensive, we planned the energy recovery and recycle to keep the processing cost low. The schematic of the pilot plant is shown in Figure 1. The plant comprises of three pairs of oven and rotating drum. For the startup the oven was heated using hot air generated from a diesel burner. When fully operational, the heat was supplied by hot gas generated by recycle gas burner where gas produced by the pyrolysis process was combusted. The completed plant is shown in Figure 2.

The Palm Oil Fruit Bunch and EFB is shown in Figure 3. The EFB was fed to each of the three drums without shredding at different time. The process took about 4 hours to complete including drying and pyrolysis. The second drum operated after drying in the first drum completed and the third drum start when the drying in the second drum completed. In this mode of operation, the energy generated from the drum under pyrolysis by syngas combustion was used in the other drums. Excess energy was purged through the chimney.

Results and Discussions

The Plant construction was completed in 6 months. Early test where each drum was operated separately showed the EFB was fully transformed and biochar produced was in the form of carbon powder with average diameter of 2 mm. About 20 weight percent of the EFB was converted into biochar. 70 percent of the EFB was evaporated as water and the rest was as gas. The amount of oil was very small. Each drum took in 1.4 ton of EFB. This show the output was well within lab analysis of EFB [1]. The gas from the process was immediately combusted and there was no visible smoke observed at the chimney outlet.

The second stage of the development was to operate the plant for 24 hours with heat recycles where the heat produced by syngas combustion generated from one of the drums was sent to other drums. The maximum temperature recorded at the syngas burner was 1100^{o}C. This was above the temperature required therefore the gas was diluted with atmospheric air before recycled into the ovens and also purged through the chimney. The biochar powder was analysed.. The field study of the biochar as soil amendment is currently ongoing in the Universiti Putra Malaysia Soil

Science Department. Previously the researchers have used biochar from rice husk in a plot trial [2].

The analysis of the biochar is shown in Table 1. The carbon content was a lot higher than rice husk which has only 10% carbon [2]. The CEC value was also higher than rice husk. The normal soil in Malaysia has CEC value of about 15 Cmol$^{(+)}$/kg. Potassium content was significant although nitrogen was low due to the thermal treatment. The carbon content indicates that the biochar from EFB is good for carbon sequestration. Although plot trial is still ongoing, the potassium content suggests that the EFB biochar will have positive effect to plants.

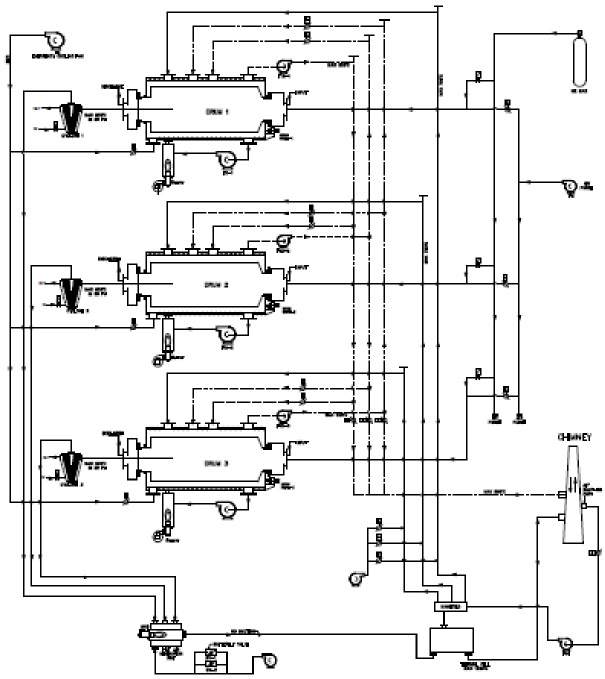

Figure 1. Schematic of the EFB biochar plant show the three rotating drums, syngas burner and heat cycles.

Figure 2. The EFB biochar plant

(a) (b) (c)

Figure 3. a) Palm Oil fruit bunch b) Empty fruit bunch (EFB) (c) EFB biochar

Table 1. Analysis of the biochar

C	45	%
N	0.32	%
P	626	µg/g
K	14200	µg/g
Ca	379	µg/g
Mg	290	µg/g
Mn	442	µg/g
BET Surface Area	12.7	m^2/g
CEC	42.85	Cmol$^{(+)}$/kg
pH	9.66	

Conclusions

We have successfully developed, build and operate a carbonator plant capable of processing 20 ton/day oil palm empty fruit bunch into biochar. The plant has run for twenty four hours without failure. The gas generated from the pyrolysis was successfully combusted and recycled to supply heat to the carbonator. The emission was negligible in the sense that no visible smoke was released. The biochar from the process has high carbon content, potassium and CEC value most likely to be suitable for carbon sequestration via soil amendment.

Acknowledgements

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