BIO-COAL PRODUCTION FROM OIL PALM BIOMASS USING A SELF-SUSTAINED CARBONISATION SYSTEM

NAHRUL HAYAWIN ZAINAL; JUFERI IDRIS*; SURAINI ABD-AZIZ*; MOHD ALI HASSAN*; ASTIMAR ABDUL AZIZ and ROPANDI MAMAT

726

MPOB INFORMATION SERIES • ISSN 1511-7871 • JUNE 2016

MPOB TT No. 597

The palm oil industry generates biomass in the form of oil palm empty fruit bunches (EFB), oil palm trunk (OPT), oil palm frond (OPF), mesocarp fibre and palm kernel shell (PKS). It was reported that a total of 439 mills were in operation with a total of 95.38 million tonnes of fresh fruit bunches (FFB) processed in 2014 (MPOB, 2014). The PKS is about 5.5% of the FFB, hence, it can be estimated about 5.25 million tonnes (dry weight) of PKS were available in that year. In the normal practice, some quantities of PKS and mesocarp fibres are used as boiler fuel for power generation (heat and electricity), and the excess is either exported or sold to other industries. It is an added advantage to the oil palm industry if this excess biomass can be turned into useful and valuable products such as charcoal (bio-coal) or activated carbon. Bio-coal is a product from a low temperature carbonisation or torrefaction process of biomass materials, producing charcoal having optimum or high calorific value.

Carbonisation is a process conducted in the absence or inadequate presence of oxygen to produce a high calorific value fuel and it is one of the promising technologies in the utilisation of biomass (Adam, 2009). There are many carbonisation technologies available, ranging from traditional methods to the high technology processes; but many of the technologies often come with environmental issues and high production costs. The self-sustained carbonisation process involves the combustion of biomass in inadequate oxygen using minimal external energy. This method is easy to be operated and requires low energy. This technology introduces a pilot scale self-sustained carbonisation system for the production of considerable high heating value (HHV) bio-coal from PKS.

THE SYSTEM

This technology was tested using a prototype built in MPOB/UKM Research Station. The reactor shown in *Figure 1*, is built with double walls of clay bricks (1000 mm x 1000 mm external dimension, 220 mm thick) to provide a natural insulation for the reactor. Approximately 40 kg of oil palm shell (OPS) can be carbonised per batch of operation. After the OPS sample is fed into the reactor, the fire has to be initiated manually at the top of the reactor using a portable propane gas burner for approximately 3-5 min. The cover of the reactor should be closed completely, and the carbonisation temperature will be maintained in a self-sustained manner from the exothermic reaction of the PKS. All parts of the reactor, especially the stainless steel cover, have to be closed tightly to prevent entry of oxygen. The temperatures were automatically recorded every 60 s using a data logger. Once the process has been completed and the temperature reaches below 50ºC, the furnace can be opened to recover the finished product.

THE PROCESS

Figure 2 shows the temperature profiles measured during the self-sustained carbonisation process. The carbonisation temperatures recorded were between 300ºC to 500ºC, which is an appropriate condition to produce charcoal. According to Spokas *et al.* (2012), temperatures ranging from 300ºC to 700ºC and long residence time, are suitable for the production of good quality bio-coal. For this technology, the residence time ranged from 120 to 1500 min. However, longer carbonisation retention times will not give good yield and quality of charcoal.

A proximate analysis of the PKS bio-coal is presented in *Table 1*. The average contents of carbon, volatile, ash and moisture are 74.09%, 8.67%, 8.67% and 5.86% respectively. This can be considered as good quality charcoal. The HHV of the charcoal are in the range from 22.74 to 31.10 MJ kg^{-1}. The highest charcoal HHV obtained was 31.10 MJ kg^{-1} and this charcoal can be used as a fuel for power generation.

*Department of Bioprocess Technology, Faculty of Biotechnology and Biomolecular Sciences, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.

ISSN 1511-7871

9 771511 787001

Malaysian Palm Oil Board, Ministry of Plantation Industries and Commodities, Malaysia
6, Persiaran Institusi, Bandar Baru Bangi, 43000 Kajang, Selangor, Malaysia. *Tel*: 03-8769 4400 *Fax*: 03-8925 9446 *Website*: www.mpob.gov.my

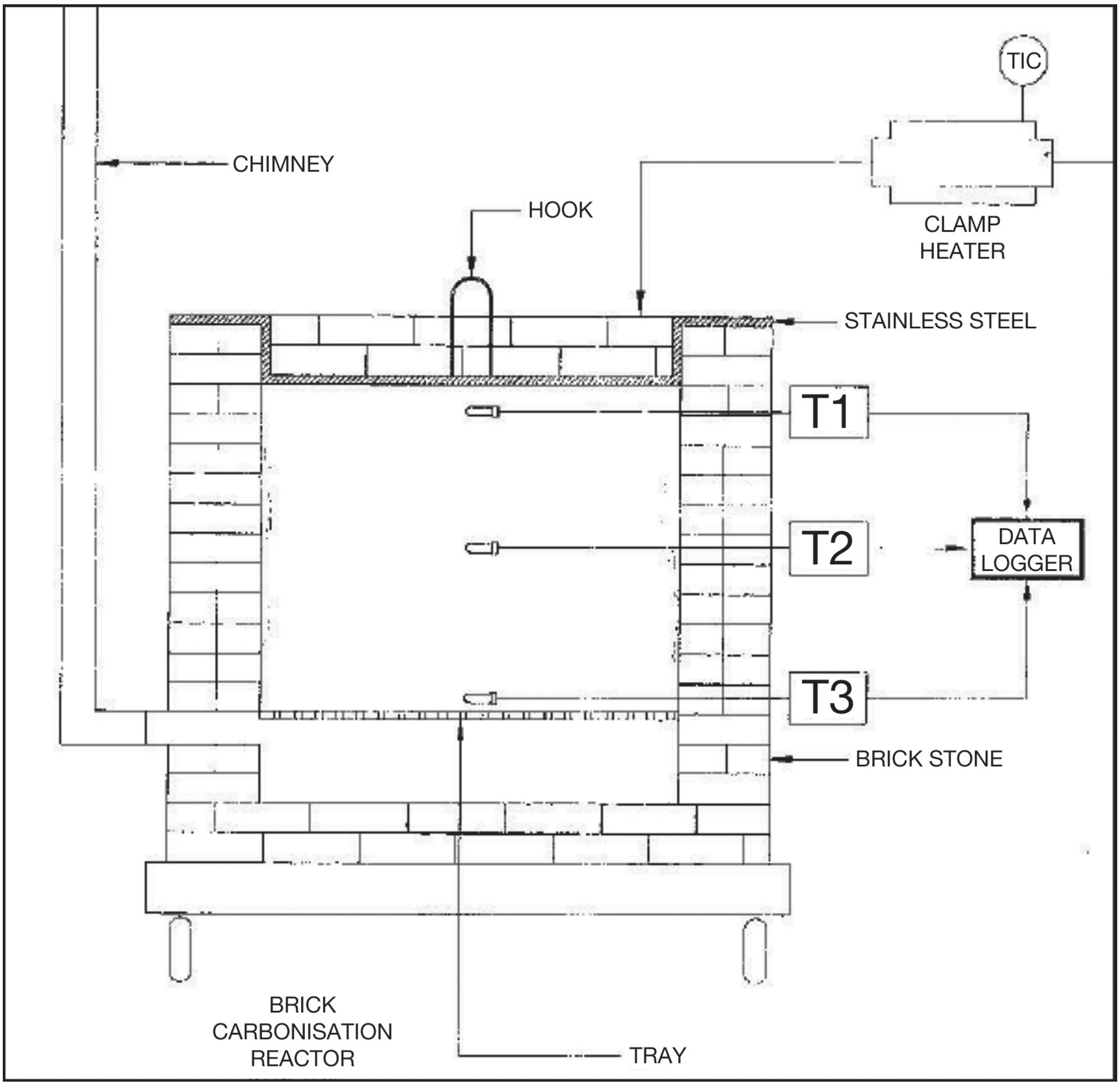

Figure 1. Schematic diagram of the self-sustained carbonisation reactor.

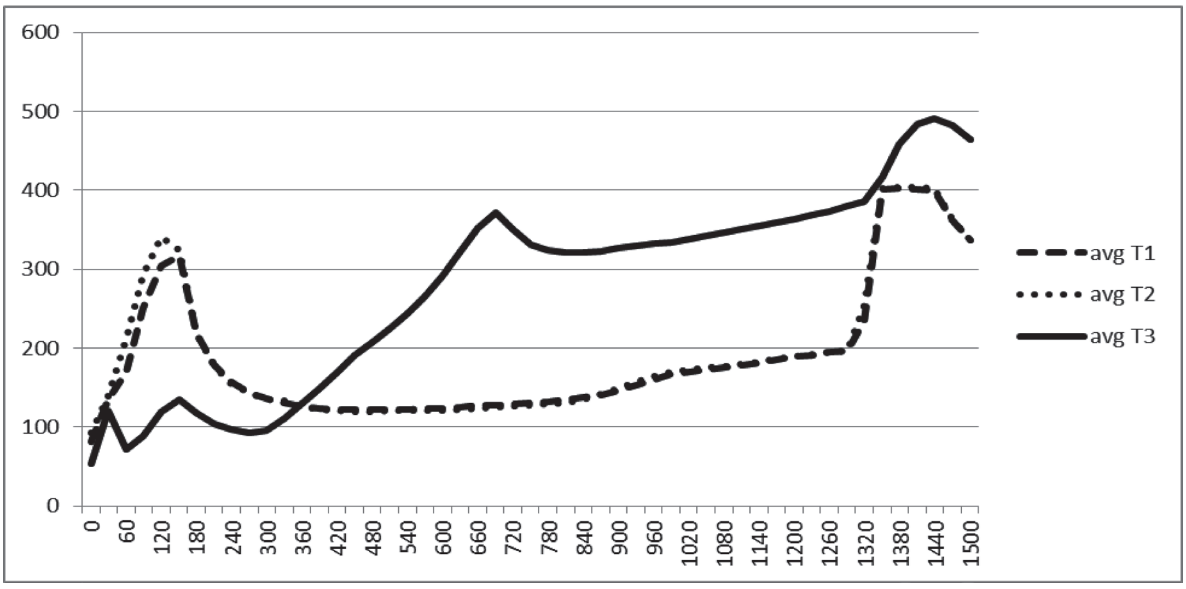

Figure 2. Temperature profile with time for the carbonisation of OPS in the self-sustained system.

TABLE 1. CHARACTERISTICS OF OPS CHARCOAL PRODUCED FROM SELF-SUSTAINED CARBONISATION SYSTEM

Samples	Carbon (%)	Volatile (%)	Ash (%)	Moisture (%)	HHV (MJ kg^{-1})
S1	78.741	8.497	6.596	4.787	22.746
S2	67.624	10.190	11.055	8.395	30.895
S3	74.913	8.054	9.285	5.958	25.787
S4	80.569	8.540	4.243	5.689	31.108
S5	72.181	8.042	12.150	4.476	23.857
Avg	74.085	8.665	8.666	5.861	26.824

ECONOMIC FEASIBILITY

The estimated fixed cost for the production charcoal from PKS is RM 1.7 million. The payback period is three years with an internal rate of return (IRR) of 34%. The net present value (NPV) at 10% discount rate is RM 1.3 million, with a benefit:cost ratio (B:C) of 1.43. Since the B:C is > 1, NPV is positive and IRR is greater than the opportunity cost of capital, the investment is expected to be financially feasible.

REFERENCES

ADAM, J C (2009). Improved and more environmentally friendly charcoal production system 220 using a low-cost retort–kiln (eco-charcoal). *Renew Energy, 34*: 1923 -1925.

MPOB (2014). *Malaysian Oil Palm Statistics*. MPOB, Bangi. http://www.commserv.mpob.gov.my

SPOKAS, K A; CANTRELL, K B; NOVAK, J M; ARCHER, D W; IPPOLITO, J A; COLLINS, H P; BOATENG, A A; LIMA, I M; LAMB, M C; MCALOON, A J; LENTZ, R D and NICHOLS, K A (2012). Biochar: a synthesis of its agronomic impact beyond carbon sequestration. *J. Environ Qual, 41*: 973 - 989.

For more information, kindly contact:

Director-General
MPOB
6, Persiaran Institusi,
Bandar Baru Bangi,
43000 Kajang, Selangor,
Malaysia
Tel: 03-8769 4400
Fax: 03-8925 9446
www.mpob.gov.my