Commissioning of an Open Source Twin Trough Pyrolyser

Professor GX Pan, Dr Q Ding, Professor S Joseph, Professor LQ Li and Professor F C Christo*

Nanjing Agricultural University Biochar and Green Agriculture

* Barbara Hardy Institute - University of South Australia

Background

Professor Genxing Pan and Dr Qishuo Ding of Nanjing Agricultural University Biochar and Green Agriculture established a collaboration to develop and test an open source pyrolysis system for use in small rural enterprises. The unit was designed to take a range of feedstocks, over a range of temperatures and be flexible enough to produce enhanced biochars and biochar NPK fertilizer. The unit is designed to be transportable. It has a standalone generator and its own water supply.

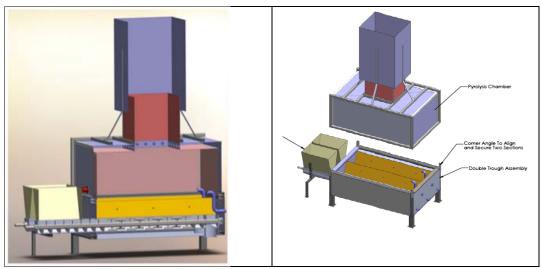


Figure 1: Schematic of Twin Trough Pyrolyser.

A set of concept drawings (figure 1) was provided by Prof Stephen Joseph who has a three year appointment as a visiting professor at Nanjing Agricultural University. A process and instrumentation diagram was prepared and an initial hazard and operability study carried out as per the guidelines developed by IBI for the Design and Testing of Biochar Kilns (Lynch and Joseph 2010). Staff and students took the concept drawings and fabricated the unit over a period of 5 months.

The unit has an LPG burner that is used to preheat the chamber. Fuel is fed from two external hoppers. Exhaust gas from the generator is ducted into the feed hopper to minimise the tramp air that comes in with the fuel. The flame from the LPG burner starts the pyrolysis process. Primary air, supplied by a centrifugal fan, is ducted under the troughs in three pipes. Air from these pipes then flows through holes in an apron above the pyrolysing biomass. Air is also introduced above the pyrolysing biomass through 2 jets on the end wall. There are dampers placed in all of the air pipes to control the amount of air. Water spray jets are

placed at the end of the trough to act as a safety device if the pyrolyser is shut down in an emergency.

The paddles stir the pyrolysing biomass and sweep it to the bottom of the trough where it mixes with the cooler biomass and/or biochar. At the end of the trough the biochar drops over a weir.

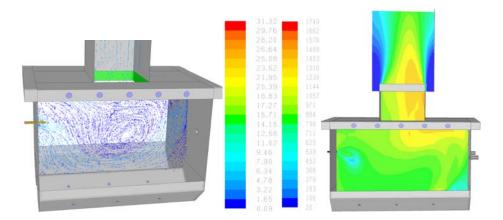


Figure 2; Velocity profile with scale in ms/sec on left and temeprature profile with scale in $^{\circ}\text{C}$



Figure 3; a) Professor Li next to the finished unit. b) Assembling the unit for commissioning c) Dr Ding visually checking the flow characteristics of the straw d) Students discussing control strategy with Professor Joseph.

Temperature of the biochar can be controlled by changing the feed rate by adjusting the speed of the motor driving the shaft, the flow rate of fine water droplets onto the charring bed and the amount of primary air entering the chamber. The temperature of the burning gas is maintained above 700°C to ensure complete combustion. Figure 2 illustrates approximate flow patterns and the temperature profile as modelled by Professor Farid Christo of the University of South Australia when wood chips are used as the fuel.

The prototype unit was assembled outside of one of the equipment sheds at Agricultural Engineering campus (Fig.3). Wheat straw that have been chopped into 15-20mm long pieces was manually placed in the feed bin and moved into the main body of the pyrolyser. Problems were encountered with the burner so the straw in the pyrolyser was ignited manually and then the air was turned on (Figure 4).



Figure 4. a) Running the unit with very low emissions. b) Flaming pyrolysis c) Biochar d) Examining the unit after running.

When the temperature in the reactor had reached approximately 400° C the feed screws were turned on and the unit was run for approximately 1 hour until steady state temperatures were achieved. At this stage biochar was being drawn from the unit. Gas analysis was carried out using a Bacharach portable analyser. Small amounts of water were sprayed onto the biochar at the weir to maintain the temperature at around 450° C.

CO fluctuated between 200ppm and 500ppm and NOx was less than 20ppm.

The unit was run for approximately 3 hours and then switched off. The top was taken off the unit and the inside was inspected. It was apparent that modifications were needed to get more optimal production of biochar and to lower the CO to the desired 100ppm. Redesign and modification will be carried out over the next month. Students will work on a control system and the burner system will also be changed. Also, a detailed CFD model is currently being developed, (an extension of the earlier simplified model), which will assist in the design optimisation process.

Once the commissioning is completed the unit will be used to make biochars and biochar fertilisers for field experiments to be carried out next year. Detailed measurements will be taken and used to refine the CFD model. The unit will also be used to train engineers and scientists in the use of biochar.

Lynch J and Joseph S 2010 Guidelines for the Development and Testing of Pyrolysis Plants to Produce Biochar http://www.biochar-2010 international.org/sites/default/files/IBI_Pyrolysis_Plant_Guidelines.pdf