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Assessment of Carbonisation of Wood Chips Using a Multipurpose Top-Lit Updraft Reactor in Rural Areas

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Abstract

A multifunctional reactor for charring of biomass residues and simultaneous utilisation as stove implies great potential for its implication in developing countries. In this study, a top-lit up-draft (TLUD) reactor was re-engineered and evaluated for its performance in char production and heat provision from wood chips. Temperature sensors were installed inside the reaction chamber, chimney, and hot plate on the lid of the reactor. The air flow was measured at the primary air inlet duct, and adjusted by regulating the opening of an air flap (100, 80, and 50 %) at the bottom of the reactor. Average air mass flow rates at different openings were measured at 26, 45, and 58×10^{-3} kg s^{-1} respectively. The initial substrate load of 32 kg (80 % of barrel volume) was held constant for all runs. Transition times from biomass-conversion to char-conversion phase were decreasing with increasing air flow, namely after 144, 137, and 131 minutes. The temperature in the reaction chamber was interpolated and represented as a response surface. It was found, that heat generated in the ignition area was evenly distributed in the entire chamber after 100 minutes of operation. A similar pattern was detected for all different openings of the air flap. The mass conversion rates were fitted into exponential models, and the char yields after the biomass-conversion phase were 19.6, 23.0, and 25.8 % of the initial weight respectively. After a maximum of 15 minutes, the heat provided on the hot plate exceeded 100°C and remained above this threshold until the end of the process, indicating adequacy for cooking purposes. Smaller air openings lead to higher average temperatures of the plate, namely 210.4, 238.4, and 252.3°C. The highest temperature of exhaust gas after the secondary air inlet was recorded at 490.1, 497.7, and 494.5°C respectively. The energy could be further used for other function such as in a stirling engine. For further improvement, the reactor should be utilised with other biomass such as shells of *Jatropha curcas* L., maize cobs, and stalks.

Keywords: Biochar, bioenergy, biofuel, gasification, pyrolysis

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