Optimization of a Biomass Stove Insulated with Fiber Ceramic Blanket Using a Fan Control System Based on Arduino Nano

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ABSTRACT

The dependence of household energy consumption in Indonesia on fossil fuels, particularly LPG, drives the development of renewable energy-based technologies. One alternative solution is a biomass stove equipped with a fiber ceramic blanket insulator, capable of withstanding temperatures up to 1260°C and improving combustion thermal efficiency. A modification was carried out by integrating an Arduino Nano–based fan control system that regulates a 12V DC PWM fan with variable speeds (F1: 100%, F2: 80%, F3: 60%, F4: 40%, F5: 20%, and a no-fan condition).

Testing was conducted using the Water Boiling Test (WBT) method with coconut shell fuel, showing that the addition of fan control influences the temperature increase generated by the biomass stove. The exhaust temperature from the stove reached up to 900°C at F1, while the burner temperature peaked at 1023°C across all trials. The thermal efficiency values obtained were F1 (100% PWM): 13.20%, F2 (80% PWM): 15.80%, F3 (60% PWM): 17.55%, F4 (40% PWM): 19.01%, F5 (20% PWM): 22.18%, and No-fan: 22.14%. The highest efficiency with fan control was achieved at F5 (22.18%), compared to 22.14% without fan assistance. These results indicate that optimal combustion occurs at a moderate air supply rate. Excessive fan speed does not always correspond to higher thermal efficiency and may even increase fuel consumption due to an oversupply of air beyond the optimum point, leading to unstable combustion and losses of fuel or pyrolysis gas. The use of an air chimney proved effective in directing airflow and reducing the influence of external wind on flame stability.

This study demonstrates that microcontroller-based airspeed regulation provides a practical solution for developing environmentally friendly and energy-efficient biomass stoves, suitable for both urban and rural areas with limited access to electricity and LPG.

Keywords*: biomass stove, fan control, thermal efficiency*