Design, construction and testing of a temperature control system for household biodigester using Arduino technology

Francis Makamure and Patrick Mukumba

Department of Physics, Faculty of Science and Agriculture, University of Fort Hare, Private Bag X1314, Alice, 5700, Eastern Cape, South Africa.

Email: makamfra@gmail.com/pmukumba@ufh.ac.za

Abstract

Biogas production under temperature-controlled environments has been at the center of research in recent years due to the process's dependence on temperature. The methanogenic bacteria responsible for converting biomass into biogas are very sensitive to temperature variability and thus operate efficiently in environments where temperatures are stable. The temperature in a digester is influenced greatly by environmental temperature and it is impossible to maintain a stable temperature in the digester without some form of control. The control mechanism should be able to supply the required heat when the digester temperature is falling and to stop the heat supply when the optimal temperature is achieved.

This research paper explores designing, construction and testing of a temperature-control system to maintain a stable favourable temperature in a household digester using Arduino technology. An Arduino mega 2560 board with a temperature-logging shield, fitted with a real-time clock was used to design the temperature control system. The Arduino board was programmed to control the opening and closing of an electrical ball valve to allow and stop hot water flow to the heat exchanger located in the digester. The normally closed electric ball valve would open to allow hot water flow when the average digester temperature was below 35ºC and close when the average digester temperature was above 35ºC. The water was heated by a solar geyser mounted at the site. The heat-depleted water, after passing through the heat exchanger, was pumped back to the geyser for reheating by a circulation pump. Digester temperature was measured at three different positions in the digester using waterproof DS18B20 temperature sensors. The program averages these temperatures and compares the value with the set temperature of 35ºC, then gives a command to open or close the electric ball valve depending on the result of the comparison.

The temperature control system was tested in a fixed dome digester for a 30-day retention period, and it was observed that the system maintained the digester temperature at 35±0.5 ºC for 82.76% of the retention time. An increase in biogas production rate of 42% as compared to the uncontrolled scenario was achieved. It was further observed that the cumulative biogas produced in the 30-day retention time was 26.77 m^3 for temperature-controlled and 18.05 m^3 for uncontrolled, an increase of 33%.

Keywords: Arduino, temperature control system, Fixed dome digester, retention time.