World Academy of Science, Engineering and Technology
International Journal of Electrical and Information Engineering
Vol:14, No:04, 2020

Development of a Feedback Control System for a Lab-Scale Biomass Combustion System Using Programmable Logic Controller

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Abstract : The application of combustion technologies for thermal conversion of biomass and solid wastes to energy has been a major solution to the effective handling of wastes over a long period of time. Lab-scale biomass combustion systems have been observed to be economically viable and socially acceptable, but major concerns are the environmental impacts of the process and deviation of temperature distribution within the combustion chamber. Both high and low combustion chamber temperature may affect the overall combustion efficiency and gaseous emissions. Therefore, there is an urgent need to develop a control system which measures the deviations of chamber temperature from set target values, sends these deviations (which generates disturbances in the system) in the form of feedback signal (as input), and control operating conditions for correcting the errors. In this research study, major components of the feedback control system were determined, assembled, and tested. In addition, control algorithms were developed to actuate operating conditions (e.g., air velocity, fuel feeding rate) using ladder logic functions embedded in the Programmable Logic Controller (PLC). The developed control algorithm having chamber temperature as a feedback signal is integrated into the lab-scale swirling fluidized bed combustor (SFBC) to investigate the temperature distribution at different heights of the combustion chamber based on various operating conditions. The air blower rates and the fuel feeding rates obtained from automatic control operations were correlated with manual inputs. There was no observable difference in the correlated results, thus indicating that the written PLC program functions were adequate in designing the experimental study of the lab-scale SFBC. The experimental results were analyzed to study the effect of air velocity operating at 222-273 ft/min and fuel feeding rate of 60-90 rpm on the chamber temperature. The developed temperature-based feedback control system was shown to be adequate in controlling the airflow and the fuel feeding rate for the overall biomass combustion process as it helps to minimize the steady-state error.

Keywords : air flow, biomass combustion, feedback control signal, fuel feeding, ladder logic, programmable logic controller, temperature

Conference Title : ICCEMAI 2020 : International Conference on Control Engineering, Mechanical Automation and Instrumentation

Conference Location : Boston, United States

Conference Dates : April 23-24, 2020