ABSTRACT

All developing countries are targeting maximum efficiency in harvesting energy and they are targeting 25% of primary energy demand by 2020 with renewable energy sources. The relevance of a biomass gasifier is immense today, with the deteriorating of the non-renewable resources. Biomass is a biological material from living organisms. As an energy source, biomass can either be used directly, or converted into other energy products such as biofuel. Biomass is composed of carbon, hydrogen and oxygen. It is used as a source of power generation and thermal applications. Power generation from biomass has become a complement to conventional sources of energy due to its contribution to the reduction of the greenhouse effect.

Biomass gasification technology is used to convert biomass into gas. The greatest challenge to researchers is automation and control of downdraft biomass gasifier system. The present study focuses on certain investigation on woody biomass gasification. Two different downdraft biomass gasifier systems with capacities (135Kg/hr) and (6Kg/hr) have been considered and operated under stable conditions using wood as fuel and air as gasification agent. Preliminary experiments were carried out in both the systems and it was observed that the efficiency of the system was mainly dependent on moisture content of the wood, size of the wood and temperature of the process. Based on these experimental studies it is decided that the
stable operation of gasifier needs a suitable controller. In this study, the fuzzy
based intelligent control technique has been proposed to control the
temperature and gas composition.

Downdraft biomass gasifier system with capacity (135kg/hr) has
been considered to develop a static model and controller. The experimental
data observed from this gasifier characterizes this process as a non-linear and
slow process, and hence the development of a model has become a challenge.
The proposed model must be represent the non-linear characteristics of the
process. Certain simple mathematical equations have been developed for the
static model of the gasifier operations by adjusting the mathematical relations
between the variables with reference to the recorded data in order to equate
the original plant data.

The fuzzy controller has been developed for the modeled
downdraft biomass gasifier system. The controller inputs were the
temperature and the ratio of carbon monoxide to carbon dioxide (CO/CO₂)
and the outputs were airflow rate and frequency of rotation of grate. Fuzzy
rules were implemented in a microcontroller (prototype) and the controller
outputs were fed to gasifier model simulated in LabVIEW. The developed
fuzzy controller for this non linear process offers better performance in terms
of low settling time and minimum oscillations.

The small scale downdraft biomass gasifier system with capacity
(6kg/hr) was also considered to develop a dynamic model and controller. The
development of the dynamic model for this gasification plant has been done using the process reaction curve method. The developed dynamic model was first order system with dead time. Based on the experimental result the gasification temperature has the highest influence on the efficiency and hence temperature has been considered as a controlled variable with air flow rate as a manipulated variable.

In this proposed work, a single-input-single-output (SISO) process control loop has been recommended with an intelligent fuzzy logic controller for the optimization of the process temperature. The conventional industrial controllers such as Proportional Integral (PI), Proportional Integral Derivative (PID) controller have been designed for this process and their performance was considered with fuzzy controller and self tuning fuzzy controller. The self tuning fuzzy controller automatically tunes its parameters to obtain the desired properties of a closed loop stable system. The simulation was carried out in LabVIEW and MATLAB. From the results, it was observed that self tuning controller is better than conventional controllers like PI and PID controllers, with respect to overshoot, undershoot, and settling time.

As a part of the research work the automatic ash removal process of downdraft biomass gasifier system also has been proposed. In wood gasification plant the ash removal process is a major challenge because the
accumulated ash affects the efficiency. In existing biomass gasifiers, the removal of ash is done manually. The amount of ash collected in the ash chamber varies in proportion to the size and moisture content of the wood and hence automating this process is difficult. The pressure was considered as the control variable because the pressure in the chamber was directly dependent on the weight of ash accumulated. Fuzzy controller was developed to regulate the pressure which offers better settling time and without over shoot.