Biomass Gasifier: A Relative approach with FLC

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Abstract— Biogas technology is a particularly useful system in the Indian rural economy and can fulfill several end uses. Gas is use as a fuel substitute for firewood, dung, agricultural residues, petrol, diesel, and electricity, depending up on task, and local supply conditions and constraints, thus biogas energy is used for cooking and lighting. Biogas systems also used as a residue organic waste after anaerobic digestion that has superior nutrient qualities over the usual organic fertilizer, cattle dung, as it is in the form of ammonia. Anaerobic digesters are function as a waste disposal system, particularly for human waste and prevent potential sources of environmental contamination and the spread of pathogens. Small-scale industries are also alternate from the sale of surplus gas to the provision of power for rural industries. Therefore, biogas also offers the user with additional income generating opportunities. This gas can also use for power engines, in a dual fuel mix with petrol or diesel and may use in pumped irrigation systems or other domestic purpose.

Key words: Biogas, Gasifier, MATLAB, Simulation, Fuzzy Logic Controller (FLC)

I. INTRODUCTION

India's overall energy production is considerably less than its overall energy consumption. India's energy demand increases day by day, and unable to step up production to meet demand [5]. The gap between consumption and production may also increase into the next century, as demand for energy is projected to grow at an annual rate of around 5% - which is highest in the world. Energy for industries, transport system, and a drive towards the electrification of India over the last two-three decades have contributed to the energy production deficit [6,8]. Mainly, deficit between production and consumption, particularly for the expanding rural sector, the government is pursuing alternative measures of energy planning. Renewable energy potential is high on the subcontinent. Energy from solar, wind, hydro and ocean all have a significant future potential to play in hybrid energy production scenario. However, of particular interest here, in the context of providing a devolved, sustainable energy supply for the burgeoning rural sector in India, is the potential of biogas; the gas created as a product of anaerobic digestion of organic materials [10]. The biomass gasification is incomplete combustion of biomass results production of CH_4, CO, H_2 called producer gas. This gas can be directly used as engine fuel or used as burning fuel for heating purpose.

II. SYSTEM DESCRIPTION

A. Static Model of Gasifier

Gasification process in biomass gasifier is highly non-linear and very slow process. Therefore, development of precise model of biomass gasifier is very difficult. A gasifier model must represent its non-linear dynamic characteristics. Based on availability of data of biomass gasifier process, a steady state model is proposed [4]. Four sub-systems are developed in MATLAB software which is shown in fig.1 and plant data is shown in table 1.

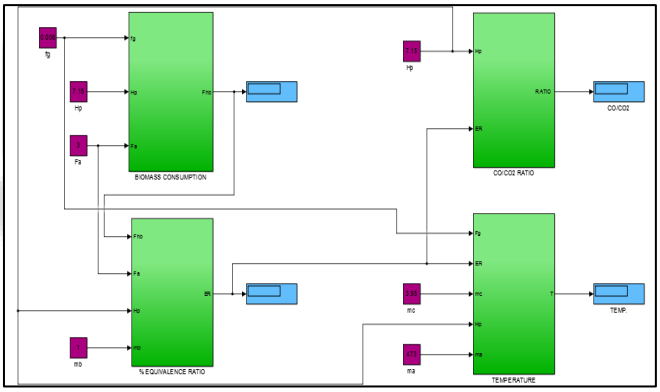

Fig. 1: Simulink model for static gasifier

S. no.	Fa (air flow)	Fg (freq. of grate)	Hp (Moisture Content)	Fhp(biomass consumption)	ER (Eq. ratio %)	T ^{0}C (Temperature)	CO/ CO_2 Ratio
1.	5.7	.006	7.15	1.73	22.2	716	.309
2.	6.9	.050	7.15	1.77	25.25	719	.392
3.	12	.050	7.15	1.96	39.05	733	.757
4.	18	.080	7.15	2.19	52.4	748	1.11
5.	22	.085	7.15	2.35	59.84	755	1.31

Table 1: Biomass plant data calculation from gasifier equations [4]

B. Fuzzy Logic Controller model of gasifier

Fuzzy logic is much closer to human thinking and language than any other traditional logic system. Fuzzy Logic Controller (FLC) gives the linguistic control conversion from knowledge in automatic control system. Here, a fuzzy system model having three inputs and two output based on the experimental data reported in table 1. The three input variables are Hp (moisture content), air flow and frequency of motion and the output variables are CO/CO2 ratio and temperature. Inputs are given to the fuzzy model in the operating region of the gasifier, it gives the outputs, based on the membership functions and the rules written. Fuzzy logic uses the whole interval between 'True' and 'False' to describe human reasoning. The basic configuration of FLC represents in steps.

1) Fuzzification

Converts the inputs in information and conditions that the interface mechanism can easily use and apply rule base.

2) Knowledge Base

It contains two parts 'data base' and 'rule base'. In data base, all membership functions define the control variable procedure. And in rule base contains fuzzy logic quantification of expert's description form of set of rule of how to achieve good control.

3) Interface Mechanism

It emulates the expert's decision making in interpreting and applying knowledge about how a plant to be control efficiently. Control rules are relevant at current time and decide what to input to the plant should be.

4) Defuzzification

Conversion of conclusions into actual inputs takes place. This process converts decisions into action.

III. SIMULATION AND RESULT

A. Simulink model of gasifier system without fuzzy controller

Biomass gasification is highly non-linear and very slow process. Therefore, development of precise model of biomass gasifier is very difficult. A gasifier model must represent its non-linear dynamic characteristics. Based on availability of data of biomass gasifier process (shown in table 1), a steady state model is proposed. Here, with the help of four subsystems, the static model of biomass gasifier is shown in Fig.2.

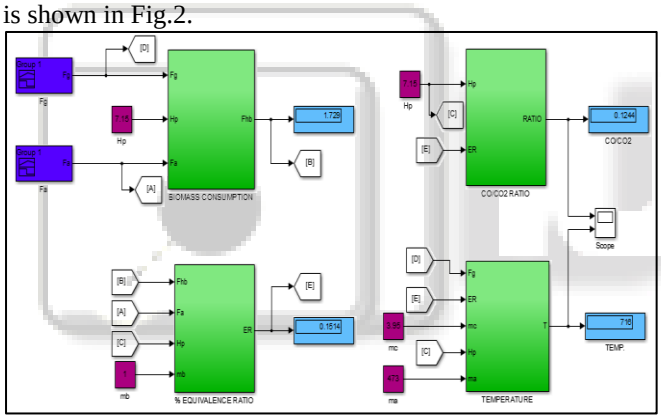

Fig. 2: Simulink model of Downdraft Biomass Gasifier

The output response of CO/CO_2 ratio and temperature in static model of downdraft biomass gasifier is shown in fig. 3.

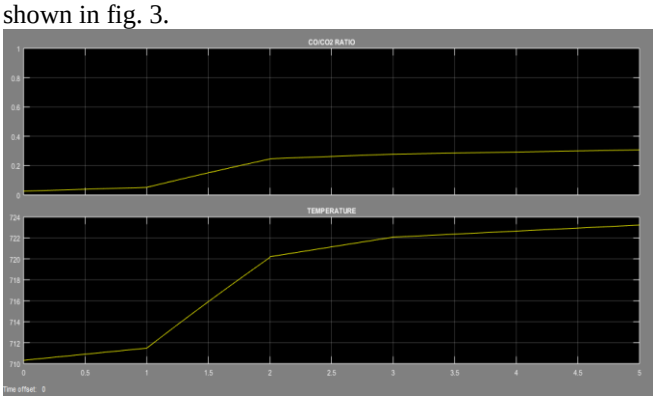

Fig. 3: Output Waveform of Static model of Downdraft Biomass Gasifier

B. Fuzzy Logic Controller model of Gasifier

A static model for the gasifier system has already been developed. But, the accuracy of this model was less with certain input conditions. It was less efficient and does not resemble the plant very closely for some input conditions. This is the reason to choose the fuzzy modelling approach. Here, a fuzzy system is modelled with three inputs and two output based on the experimental data. The three input variables are Hp (moisture content), Fa (air flow rate) and Fg (frequency of motion of grate) and the output variables are CO/CO_2 ratio and temperature [3]. Inputs are given to the fuzzy model in the operating region of the gasifier, it gives the corresponding outputs, based on the membership functions and the rules written. Fuzzy logic uses the whole interval between 'True' and 'False' to describe human reasoning. A logic based on the two truth values 'True' and 'False' is sometimes inadequate when describing human reasoning.

S. No.	Error Hp	Error T	Error CO/CO_2
1.	1	-134	0.442
2.	1.1	-143.4	0.401
3.	1.1	-48	0.302
4.	1.1	-4	0.662
5.	1.02	25	0.454

Table 2: Error values for controller input

This process is highly non-linear and very slow process and difficult to formulate modelling for it. Here, fuzzy system is modelled with three inputs (Error Hp, Error T and Error CO/CO_2 and two outputs (airflow and frequency of grate). Rule formulation are based on error T, error Hp and error CO/CO_2 which are converted into non-fuzzy values by defuzzificaton process and these values are fed to control system for controlling action [4]. Error values for controller input is shown in table 2. And fuzzy logic controller model of biomass gasifier is shown in fig.4.

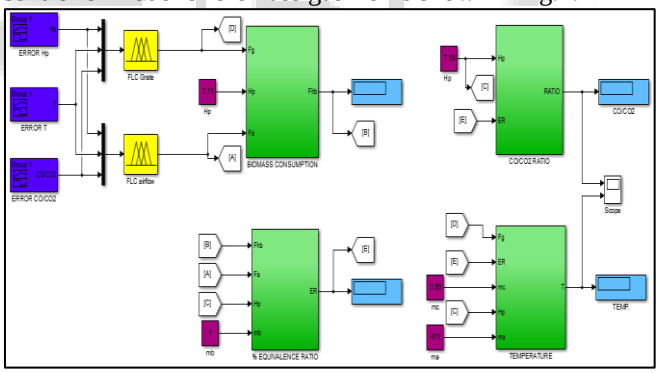

Fig. 4: Fuzzy Logic Controller model of Downdraft Biomass Gasifier

The output response of CO/CO_2 ratio and temperature of controlled fuzzy logic controller of biomass gasifier is shown in fig.5.

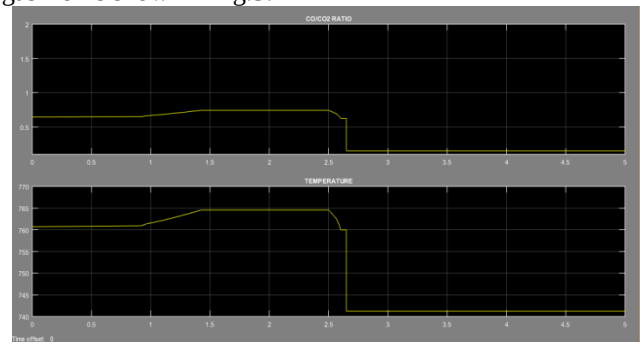

Fig. 5: Waveform of FLC model for Downdraft Biomass Gasifier

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