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Automation of 10 KW Biomass Gasifier and its effectiveness on saw dust briquettes with binder cow dung.

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Abstract*— *India is very rich in biomass. It has a potential of 19,500 MW (3,500 MW from bagasse based cogeneration and 16,000 MW from surplus biomass). Currently, India has 537 MW commissioned and 536 MW under construction.(GENI). On the other hand rural biomass gasification projects for power generation are facing lot of practical difficulties on operational effectiveness of gasification due to shortage of man power and knowledge worker for the operation of gasifier. Preparation of briquettes and starting and stopping of gasifier is a difficult task in many rural areas. So many rural power projects are failed to take momentum on implementation. This paper is focus on experimental investigation on effectiveness of automation of rural 10 KW biomass gasifier and its effectiveness. PLC based SCADA system was introduced in the programme controlled gasification of bio mass gasifier was experimentally tested. The results reveal that it improved gasification efficiency and less dependent of human man power. This experiment was tested with saw dust briquette with cow dung as binder having 75:25 ratio at 800* C. This ratio is selected because of higher gas composition than any other ratio's. it is investigated in manual mode operation and Automation mode operation for its effectiveness in a 10 KW down draft gasifier The experimental result reveals that, the gasification effectiveness is high due to complete combustion and its efficiency is improved around 10%. Automation leads to complete combustion and it helps to improve the reduction process of gasification. it increases in the production of Methane and CH4 in producer gas.. Quality of product gas produced is comparatively better in automation of gasifier.

Key Word:
Programmable Logic Controller, Combustion. , Manual mode, Auto mode, gasifier efficiency, gas composition, Product gas

I. INTRODUCTION

Rural biomass gasifier plays a vital role on decentralized power generation for rural electrification. Different agro based bio mass fuels are available in rural areas where in the moisture content and ash content are a problem for gasification. Briquetting of rural biomass will address the practical problems of moisture content transportation, and handling of biomass for rural gasifier

There are different briquettes available; where in agro based briquettes for rural electrification application faces the problem of reliable binder and briquetting technology. There is a finding that, the bio mass cow dung can be used as binder cum biomass for briquette preparation. It has been formed also identified that, easy to prepare the saw dust with cow dung as binder for manual operated piston press technology for rural biomass briquettes production. It is easy to prepare saw dust with cow dung binder briquette by the rural people [2][3]. There are different experiments were carried out using cow dung binder with different rural agro biomass where in 75 :25 ratio of saw dust with cow dung is yielding better performance . Another problem faced by the rural electrification projects are man power for operation of gasifier[4][5]. Automation of rural biomass gasifier will address this problem Automation of Biomass gasifier consists of PLC and SCADA system. The program, which defines the operation of the controller, determines in what sequences sensor contacts are scanned, according to which logic functions (AND, OR) are gate and how the results are assigned to the outputs, i.e. whether the actuator coils are switched ON or OFF. **T**he programming device, or terminal, is used to enter the desired program into the memory of the PLC. This program is entered using relay ladder logic. The logic program determines the sequences of operation and ultimate control of the process equipment. The programming device must be connected to controller only when entering or monitoring the program.

II. PLC AND SCADA OPERATON

All PLC's have four basic stage of operations that are repeated many times per second. Initially when turned on the first time it will check its own hardware and software for faults. If there are no problems it will copy all the input and copy their values into memory, this is called the input scan. Using only the memory copy of the inputs the ladder logic program will be solved once, this is called the logic scan. While solving the ladder logic the output values are only changed in temporary memory. When the ladder logic is done the outputs will be updated using the temporary values in memory, this is called the output scan. The PLC now restarts the process 10 to 100 times per second for its functioning.. SCADA is the Supervisory Control and Data Acquisition.

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The term refers to a large-scale, distributed measurement (and control) system. SCADA systems are used to monitor or to control chemical, physical or transport processes, in gasifier systems, to control briquette level, reaction process, gas generation and its flow, filtering and cleaning of product gas and supply to engine and its processes.

III. Systems Concepts

A SCADA system includes input/output signal hardware, controllers, HMI, networks, communication, and software. The term SCADA usually refers to a central system that monitors and controls a complete gasifier system. The three components of a SCADA system are:

1. Multiple Remote Terminal Units (also known as RTUs or Outstations).
2. Master Station and HMI Computer(s).
3. Communication infrastructure

IV. Experimental set up

A commercial small scale 10 kW downdraft gasifier for rural power generation is used for the experiment and investigation [1]. The engine and generator set is commercially available and designed to operate using methane or producer gas. This air fed gasifier is capable of producing product gas at a rate of up to 20 $Nm^{3/}$hr. It was designed primarily for woody biomass, but can handle many different briquettes and feedstocks if they are pelletized and have wet basis moisture content below 25%. A detailed cross section view of the gasifier is shown in figure.1.

Fig. 1. Section schematic of gasifier and product cleaning system

The reference numbers in the following description refer to the locations in figure 1. Biomass briquettes are fed into the gasifier as needed through the biomass feeder [1].. The feed door (2) allows briquettes to enter into the hopper [3]. The stratification of the reactions that occur inside the hopper and reactor develop as follows; moist biomass sits on top of the bed [4]. drying/pyrolysis [5]. occur towards the bottom of the hopper, and pyrolysis/gasification [6]. occur from the bottom of the hopper to the constricted hearth. The gasifier has a 114.3 mm (4.5-inch) restricted hearth, that creates the high temperature reaction zone. The hearth constriction sits directly above an inert charcoal bed [8]. An induced pressure drop is used to draw in air just above the hearth through two 19 mm (0.75-inch) air intakes [7]. The oxygen in the incoming air combusts with some of the biomass in order to generate the heat that is then used by the pyrolysis and gasification reactions [6]. The resulting producer gas exits through the bottom of the bed along with small particles of ash into an outer chamber that surrounds the charcoal bed. The ash is pushed out of the charcoal bed by the bed ash rotor [9]. and falls down into an ash removal box [10]. The producer gas is drawn out of the gasifier through the use of a venturi water scrubber that sprays into the cyclone separator [11]. The venturi induces the pressure drop that draws the air into the gasifier while the engine is not running. After the gas is drawn out of the reactor it enters a series of apparatus meant to clean the gas. In the schematic shown in figure 1, the venturi scrubber utilizes a pressurized water spray to cool and drive the producer gas and water mixture into the cyclone separator (11). The cyclone separator causes some of the tars to fall into the waste water box [12]., which drains into an effluent container. The scrubbed gas flows into passive sawdust filter [13]. where it is dried and further cleaned before owing into a final fiber filter [14]. The producer gas that exits the fiber filter is now relatively clean and can then be burned off or run into a modified natural gas engine. The engine creates an additional pressure draw that increases the air flow into the gasifier, which increases the production and flow of producer gas.

V. Measurement Devices

The experiment for this system set up required quite a few intricate measurement instruments. One of the most important tools for all of these experiments is a gas chromatograph (GC) used for producer gas composition analysis. The GC used was the Agilent MicroGC300, which is on-line, and can sample once every 2-3 minutes. It samples small amounts of the producer gas from the flow line after the fiber filter. The GC is connected to a computer and measured the retention times of the component gases in two different columns. A screen shot was taken of a typical analysis. The peak values of column are calibrated with a known gas to calculate the experimental values.

The remaining measurement tools are electronic sensors connected to a data acquisition (DAQ) system monitored by Lab view to record data continuously. An Omega PX409 vacuum pressure transducer was connected to the hopper to monitor the vacuum pressure in the reactor. It is also monitored the air intake of the gasifier. A venturi type flow meter, located before the GC on the clean producer gas line, was used to monitor producer gas flow rate. The venturi flow meter is a simple device that has a static pressure tap before it constricts the flow to a smaller area containing another static pressure tap, and finally re-expands the flow. An Omega PX653 differential pressure sensor was connected to these pressure taps. Using the pressure differential, cross sectional area ratio between the tap locations, and the density of the gas, the flow rate of the producer gas was computed. These two pressure sensors were calibrated to a manometer to compute the continuous pressure from the voltage data collected in Lab view.

VI. GASIFIER START UP LOGIC

Manual Mode:

❖ In manual mode, all electrically operated devices can be switched "ON/OFF" with the help of start/ stop push button switches provided individually.

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Auto Mode:

- Put Auto / Manual selector switch in Auto.
- Press "Auto Start" Push button.
- Air nozzle will open. After set delay time Promiser pump will start and after set delay time Promiser cooling water pump will start.
- After set time Wet Blower will start after change over to delta Vibrator motor, Gasifier Cooling Pump & Fan, Screw Conveyor Motor, Fine Filter Motor, Vibratory Sieve motor, Dry Blower and one of the last selected lines is also opened simultaneously and vent flare will close.
- Comb Rotor will start by three position selector switch.

Position 1: Signal from pressure transducer (Delta PG) to PLC will rotate the Comb Rotor Motor ON/OFF for specified time periods as required based on the PG values.

Position 0: (Manual mode) by pressing start push button. Position 2: Timer mode

VII. RESULT ANALYSIS & DISCUSSION

Using the experimental set up, gasification process was carried out on the gasifier using saw dust briquette with cow dung as binder by 75: 25 ratio. The experiment was carried out in manual mode and auto mode. The volumetric flow rate of wet product gas was measured with a gas flow meter. Using gas chromatograph (GC) the gas composition of product gas produced are investigated. Drying, pyrolysis oxidation and reduction zone temperature of the gasifier and the water scrubber and box filter outlet temperature were also monitored with the aid of thermocouples.

VIII. GAS COMPOSION

Using gas chromatograph, the gas composition of manual mode experiment data and auto mode data's are tabulated. In manual mode operation, gas components and gas 75:25 composition of Briquetting saw dust and cow dung at 75:25 ratio at 800^0C measured.

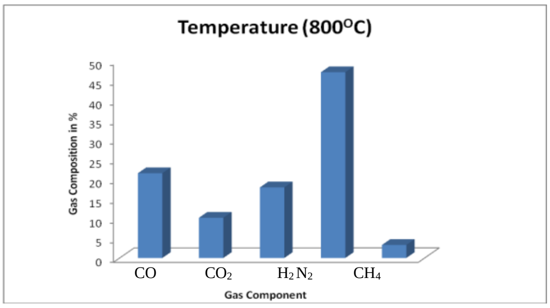

Figure.2: Gas components and gas composition in 75:25 Briquettes of sawdust and cow dung in manual mode

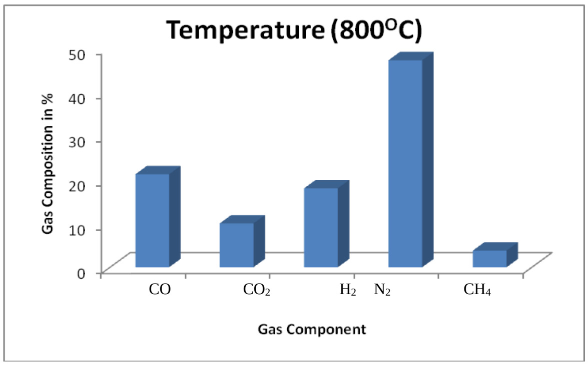

Figure. 3: Gas components and gas composition in 75:25 Briquettes of sawdust and cow dung in Auto Mode

The experimental results are shown in the Fig.2 and 3 for manual and auto mode operation. The experimental data reveals that, CH4 in product gas produced in the manual mode operation is 3.1% of total gas generation. Where as it is 3.6% in auto mode. The CO in product gas produced in manual mode is 23.2% where in auto mode is 21.2%. The experiment reveals that, the methane generation is comparatively high in auto mode due to effective reduction in reactor and complete combustion of briquettes reduces the CO generation. It is also identified that N2, CO2 and H2 gas components in product gas is slightly increased in auto mode operation.

IX. GASIFICATION EFFICIENCY

Gasification efficiency is the ratio of thermal power of the product gas produced to the thermal power of the input briquette bio mass material supplied. It gives general idea about the how much energy from briquetting bio mass material is effectively utilized. Generally Gasification efficiency of briquetting bio mass depends up on the moisture content of briquettes. Gasification efficiency of briquetting saw dust and cow dung at 75:25 ratios were calculated with different air flow rate in auto mode and manual mode operation. It is found that, briquetting bio mass material of 75% saw dust and 25 % cow dung in auto mode operation has higher gasification efficiency than manual mode operation and it increases with increase in air flow rate as shown in Figure. 4.

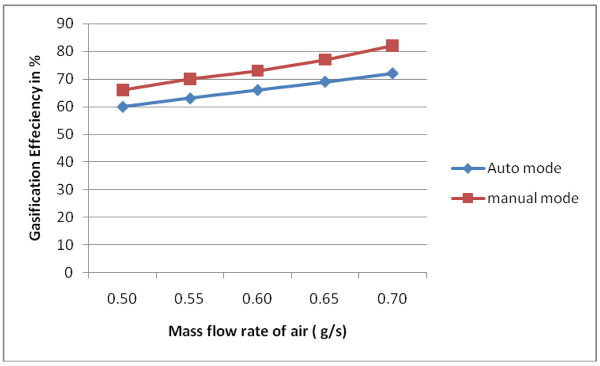

Fig. 4: comparison of gasification efficiency in auto and manual mode operation with different air flow rate

X. CONCLUSION

The following conclusions are drawn from the experimental analysis carried out on 10kW down draft gasifier by using briquetting of saw dust and cow dung as binder bio mass material. The results are investigated to find the effectiveness of auto mode operation than the manual mode gasification unit. The carbon monoxide, nitrogen and methane content of the 75:25 ratio of briquetting bio mass saw dust and cow dung in auto mode is comparably more than the manual mode operation. Gasification efficiency of Briquetting of 75% saw dust with 25% cow dung used as binder in down draft gasifier by auto mode operation10 -12% is higher than the manual mode operation as well as the efficiency increases with increase in air flow rate. It is found that gasification efficiency in auto mode operation is 81 % but it is 73% in manual mode operation for mass flow rate of air at 0.7 g/s. The man power requirement for preparation of briquettes and operation of rural biomass gasifier is comparatively less in auto mode than Manual mode operation.

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