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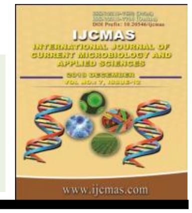

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Development of Open Core Bi-Reactor Gasifier with Effective Cooling and Cleaning Devices

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Bi-reactor open core gasifier was built with the capacity to process approximately 15 kg of briquettes per hour. The reactor was made up of double walled cylindrical body with 300 mm of outer cylinder diameter and 244 mm of inner cylinder diameters excluding the thickness of sheet 6 mm. Both the cylinders were made up of 3 mm M.S. sheet 18 SWG. Another reactor was fabricated with same specifications and both outlets were interconnected. Gate valves were fixed to regulate the air flow rate and control the producer gas. The generated producer gas cleaned by passing through primary cyclone separator and secondary cyclone separator before it was being put into gas burner. After passing through the primary cyclone, the gas still contained dust particles and tar, hence it was further cooled and cleaned by passing through secondary cyclone separator, where in medium sized and fines are removed

Introduction

The current availability of biomass in the year 2016 in India was estimated at about 500 million metric tonne per year. Ministry of New and Renewable Energy has estimated surplus biomass availability at about 120 to 150 million metric tonne per annum covering agricultural and forestry residues corresponding to a potential of about 18,000 MW. Biomass power generated of 17,538 MW (1.46 per cent), 5000 MW (0.42 per cent) from bagasse based cogeneration in sugar mills, 2556 MW (0.21 per cent) from waste to renewable energy in the India during 2016.

Biomass gasification means incomplete combustion of biomass resulting in production of combustible gases consisting of Carbon monoxide (CO), Hydrogen (H_2) and traces of Methane (CH_4). This mixture is called producer gas. During gasification, the biomass is heated to a high temperature with limited supply of air, which results in the production of volatile compounds (gases) and solid residues (char). Throat less open core downdraft gasifier features are co-current flow of gases and solids through descending packed bed. This gasifier was mainly considered to overcome the problem of bridging and channeling

Materials and Methods

Open core gasifier consists of a cylindrical vessel with a hearth at the bottom. During operation the air and biomass move downwards through the four zones in the reactor. The open top ensures uniform access of air and permits fuel feeding easily and uniformly, which keeps the local temperatures in control. The hot producer gas generated was drawn below the grate and up through the annulus of the reactor, where part of the heat of the gas was transferred to the cold fuel entering the reactor, improving the thermal efficiency of the system (Reed and Das, 1988; Mukunda *et al.,* 1994). The pyrolysis components were cracked in the oxidation zone, as gas travels along the bed of hot char without any low temperature zones, therefore the tar generated was low 0.05 kg tar kg^{-1} gas. A throat less open core downdraft gasifier is selected proposed for the produce of producer gas by using briquette which was composed of 5 crop residuals, viz. saw dust, corn cobs, chilli waste, cotton stalks and red gram stalk

Constructional details of the bi-reactor open core gasifier

Open core gasifier was developed in prototype mode to conduct experiments at College of Agricultural Engineering, Sangareddy.

Bi-reactor open core gasifier was built up with the capacity to process approximately 15 kg of briquettes per hour. The reactor was made up of double walled cylindrical body with 300 mm of outer cylinder diameter and 244 mm of inner cylinder diameters excluding the thickness of sheet 6 mm**.** Both the cylinders were made up of 3 mm M.S. sheet 18 SWG was used. The height of outer cylinder and inner cylinder reactors were 920 mm and 720 mm, respectively, are shown in Figures 1 and 2. Inner cylinder was placed inside the outer cylinder to the height of 720 mm from the top.

The annular space of 50 mm between inner and outer cylinder was closed at the top by extending inner flange over outer flange and both were fixed air tight by using nut and bolt. Grate was fixed from the bottom in between cylinders. Grate was the component which holds the biomass material and withstand at higher temperatures. Grate spacing has direct impact on the generation of quality producer gas. The gap between rods to rod governs the flow of material downward into the ash pond. The rods used in the grate were selected based on the size of the feedstock material (Singh *et al.,* 2014). The grate was supported by a bottom lid and entire bottom unit was connected with adjustable links to the reactor. Another reactor was fabricated with same specifications and both outlets were interconnected. Gate valves were fixed to regulate the air flow rate and control the producer gas. Both the reactors were mounted on a mobile supporting frame. During gasification, the amounts of hot gases produced in the reactor, leaves through the grate and move upwards through the annulus space. Blower was used to suck the generated gas through the GI pipe which was connected to the annulus space of the reactor. The limited supply of air was allowed through the open top of the gasifier for partial combustion depending on flow rate and controlled by the gate valves.

The sub- components of gasifier were fabricated and constructional details are explained below:

a) Grate
b) Cyclone separators
c) Pipe lines
d) Suction blower
e) Burner
f) Four wheel stand

Grate

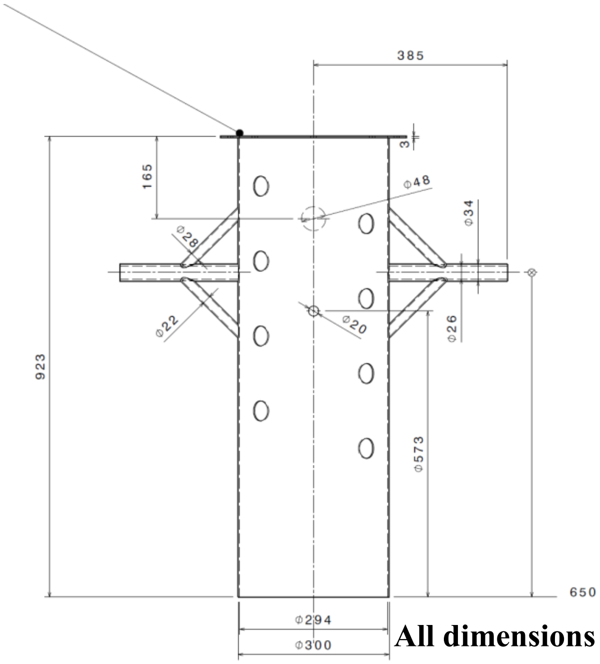
Grate selection is very important in gasifiers. Grate was fabricated with 250 mm diameter and 200 mm height as shown in Figure 3. The surface of the grate was fitted with 8 mm stainless steel rods and 20 mm distance between rod to rod provided to facilitate entry of gas and ash. The gap of 25 mm between each rod ensures that the ash formed by feed stock goes smoothly through grate without any chocking (Nikhil and Sanjay, 2016).

Cyclone separators

The gases coming out of the gasifier normally have dust particles and condensable tar particles with the producer gas. The generated producer gas cleaned by passing through primary cyclone separator and secondary cyclone separator before it was being put into gas burner. The line diagram and constructional details of primary and secondary cyclone separators were shown in Figure 4. The raw gases from reactor were entered into cyclone separator through G.I. pipe of size 63.5 mm tangentially and passed out.

Table.1

Components	Dimensions, mm		
i) Reactor			
Inner shell			
	Diameter	=	250
	Height	=	720
Outer shell			
	Diameter	=	300
	Height	=	920
ii) Grate			
	Diameter	=	250
	Height	=	200
	Hole size	=	2
iii) Bottom lid (outer shell)			
	Diameter	=	530
	Height	=	130
iv) Bottom lid (inner shell)			
	Diameter	=	323
	Height	=	27
v) Blower capacity			
	HP	=	0.5
	Air flow rate	=	510 $m^3 h^{-1}$
vi) GI Pipes			
	Diameter	=	63.5 and 50 mm



All dimensions are in 'mm'

Fig.1 Side view of outer cylinder

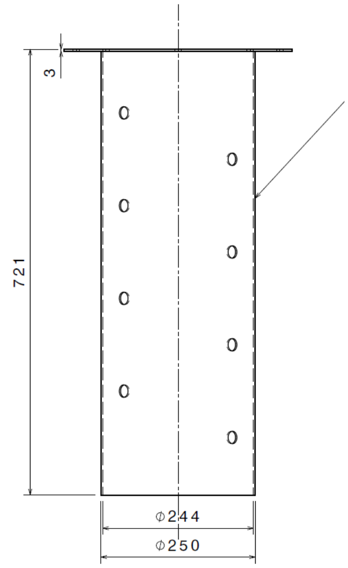


Fig.2 Side view of inner cylinder

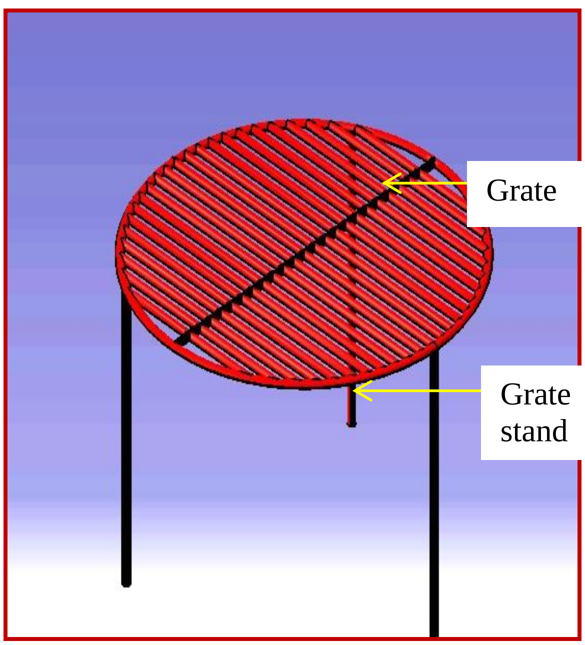


Fig.3 Isometric view of the grate

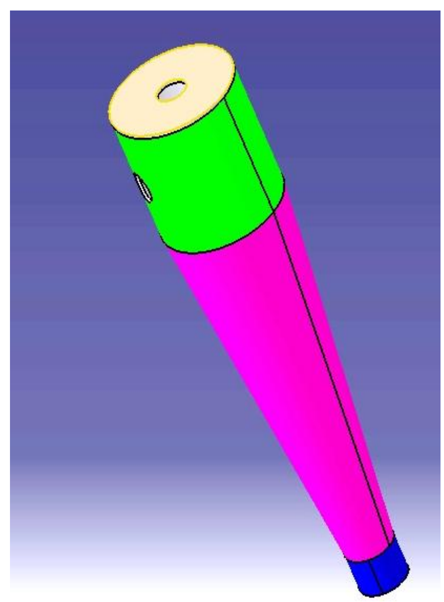
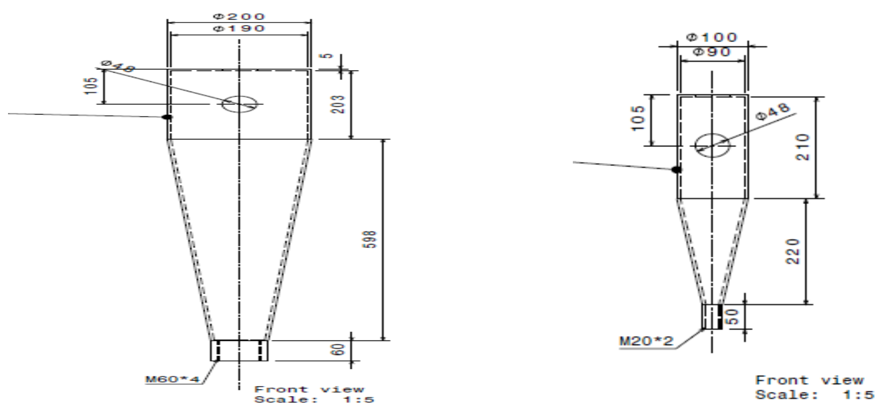


Fig.4 Isometric view of primary cyclone



All dimensions are in

Fig.5 Constructional details of primary and secondary cyclone separators

Primary and secondary cyclone separators are provided to remove soot, ash, unburnt fuel particulates, organic vapours and tar. At first cleaning the hot fuel gas from the gasifier was made to pass through a primary cyclone to remove the larger particles (Fig. 5). After passing through the primary cyclone, the gas still contained dust particles and tar and hence, it was further cooled and cleaned by passing through a secondary cyclone separator where in medium sized and fines are removed.

Suction blower

The suction blower was used to draw sufficient air flow into the reactor and take out generated producer gas from the reactor through controlled gate valves.

The blower was operated by electrical source with speed of 2800 rpm. When the blower operated, it sucks the gas and facilitates air entry from the open top of the cylinder for gasification and supplies gas to the burner.

Four wheel stand

Four wheel stand was fabricated using MS angle iron, Iron flat plates and roller castor wheels. It was able to withstand reactors load and easily transported entire unit from one place to another place.

Pipe lines

Producer gas was conveyed through GI pipe diameter 50 mm from the blower to burner. GI pipes have other striking characteristics such as long life, versatile and reliable nature and outstanding performance over long period of time. All the components of the gasifier system were inter-connected by GI pipes of diameter 63.5 mm.

Burner

The burner is made up of 18 SWG stainless steel in cylindrical shape. The outer wall was provided for heat recirculation required for combustion of gas and flame stability. Burner gas inlet provided at 50 mm height from the bottom order to avoid contact with tar.

It is concluded that bi-reactor open core gasifier was built with the capacity to process approximately 15 kg of briquettes per hour. The reactor was made up of double walled cylindrical body with 300 mm of outer cylinder diameter and 244 mm of inner cylinder diameters excluding the thickness of sheet 6 mm. Both the cylinders were made up of 3 mm M.S. sheet 18 SWG. Another reactor was fabricated with same specifications and both outlets were interconnected. Gate valves were fixed to regulate the air flow rate and control the producer gas. The generated producer gas cleaned by passing through primary cyclone separator and secondary cyclone separator before it was being put into gas burner. After passing through the primary cyclone, the gas still contained dust particles and tar, hence it was further cooled and cleaned by passing through secondary cyclone separator, where in medium sized and fines are removed.

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