CFC Biomass Gasifier

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The increasing demand of energy along with reduction in the supply of fossil fuels, the researchers on the entire globe are trying to knock out such type of energy resources that are affordable. Due to an abundant quantity of biomass produced annually (82 million ton). Biomass gasification is an appropriate technology for getting energy from the generated syn gas. A downdraft biomass gasifier was designed and fabricated in the Agricultural Engineering workshop at the University of Agriculture, Faisalabad. The objective of adopting this technology is to use the agri-waste produced at farm level for thermal and power applications

Gasifier Design and Operation

The reactor of continuous feeding and cleaning (CFC) gasifier is made of MS sheet having thickness of 10mm. Height of the reactor is 2438 mm. The reactor is equipped with feed hopper, vacuum valve, throat, air inlet nozzles, water seal, spark ignition system and grate. Feed hopper is provided at the top of the reactor for continuous operation of gasifier. Water seal is provided at the cap of the hopper to release the positive pressure developed inside the gasifier. Similarly vacuum valve is provided at the top of the gasifier to release the excess gas from the reactor during shut down mechanism. Air inlet nozzles are provided in the combustion zone that helps in supplying air in the gasifier under starved conditions. The number of nozzles are seven, each nozzle having 12 mm diameter. A cyclone separator is designed and developed for removing ash from the producer gas. The separator is made up of MS sheet (3 mm thick) having length 1168 mm and137 mm diameter. The separator is divided into a cone and a barrel. Inlet is provided parallel to the axis of the cyclone separator at the barrel while outlet is provided at the top of the cyclone separator.

Wet scrubber is provided to remove the tar, H_2S and CO_2 from the producer gas. The wet scrubber is made up of MS sheet of thickness 3 mm having height 900 mm and 225 mm diameter. Four nozzles are provided at the top side of the scrubber that spray water on the producer gas coming from the upper side of the scrubber. Biomass filter is designed and developed to remove the remaining fine dust particles from the gas in order to make it suitable for the utilization in IC engines as shown in the schematic Figure 1.

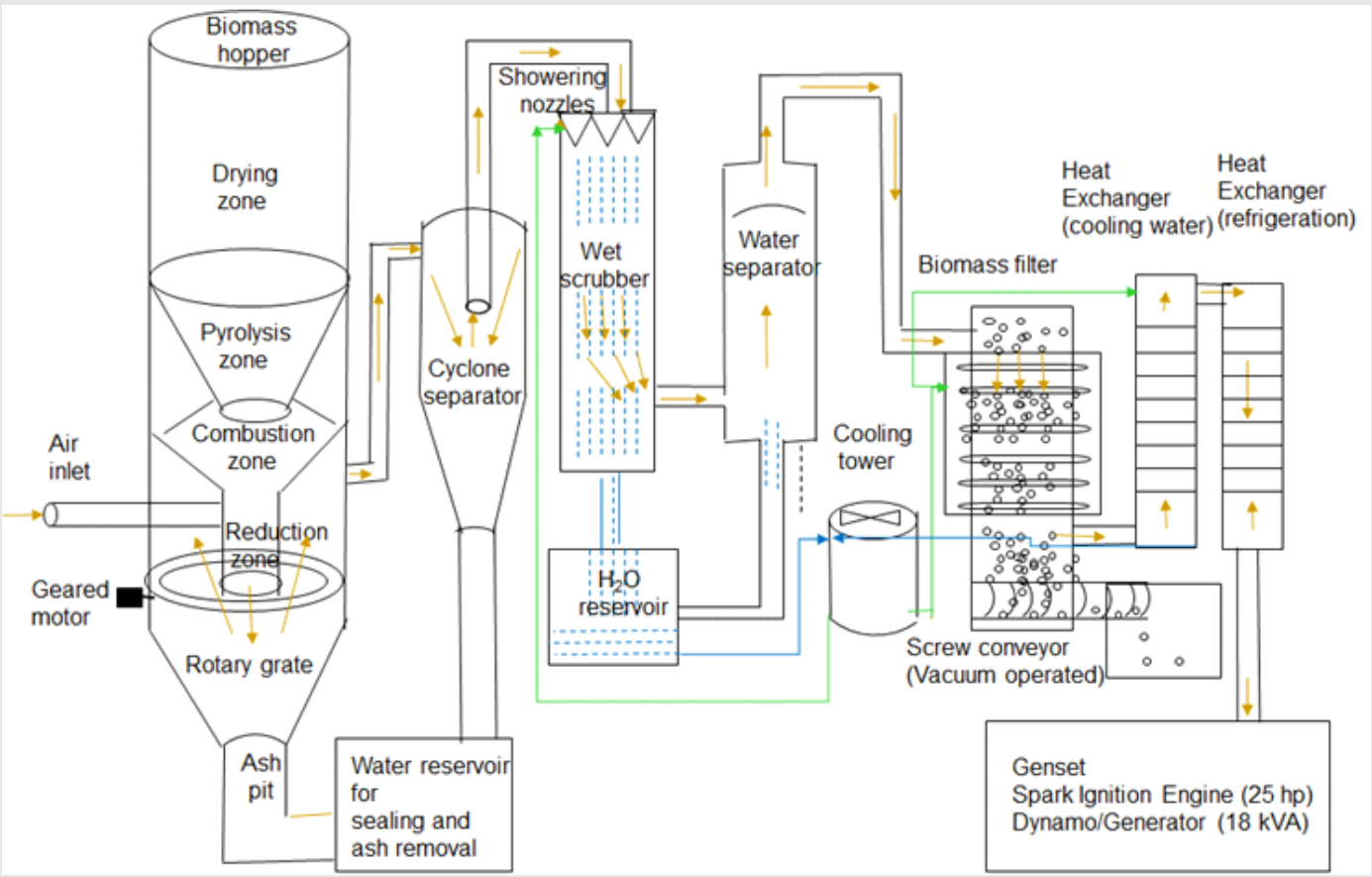

Figure 1: Schematic diagram of down draft gasifier with cleaning system

Two heat exchangers have been provided, one is operated on cooling water and other is operated by vapor compression refrigeration system (VCR). In cooling water system, a cooling tower is used employing an axial flow fan having 1450 RPM which cools the spayed water in this chamber to cool the gas. Refrigeration system is provided at the end of the gasifier system to further cool the gas to about 14°C in order to bring the gas to optimum temperature for its utilization in IC engines. The gas enters from the bottom and leaves the refrigeration system from top after achieving temperature below 30°C. A 0.25 hp fan is provided at the top of cooling tower to cool down the spayed water in the cooling tower. The height of the cooling tower is 1200mm while the diameter is 450mm. The cooling tower is made up of MS sheet having 3 mm thickness as shown in Figure 2.

Figure 2: Developed downdraft gasifier at UAF

Operation

The reactor provides favorable conditions to biomass, so that biomass undergoes successfully through pyrolysis process and reduction process in starved oxygen conditions. The first zone is the combustion zone where the biomass is burnt under controlled conditions to produce CO_2 and H_2O. During this process a large amount of heat is released. The heat produced besides utilizing in minimizing biomass moisture in drying zone also utilizes in breaking of biomass in the pyrolysis zone as well as in reduction zone for thermal cracking of byproducts of combustion and pyrolysis zone. In the reduction zone the thermal cracking and thermochemical reactions result in the production of methane, carbon monoxide and hydrogen along with non-burnable gases like nitrogen, hydrogen sulfide and traces of nitrogen dioxide.

The produced gas is taken out from the gasifier through bottom. The gas temperature of the producer gas at the outlet of the reactor is at 250°C. For utilization of producer gas in IC engines, there is a need to minimize the temperature below 25°C, which is done through wet scrubber, biomass filter and heat exchanger. Cyclone separator is provided to remove ash contents from the gas to avoid its entering into the engine.

Gasifier Specifications

Gas output	20-24 kWe	Fuel consumption	1:1
Thermal	90000 kCal/h	Feeding	Manual/Automatic
Gas production	90 m^3	Gas Cooling	Refrigeration System
Parasitic load	5.5 hp	Biomass to Power	1.25 kg/kW

The producer gas calorific value is dependent on fuel moisture content. High moisture content declines the gas calorific value. The declining heating value of the gas is shown in Figure 3.

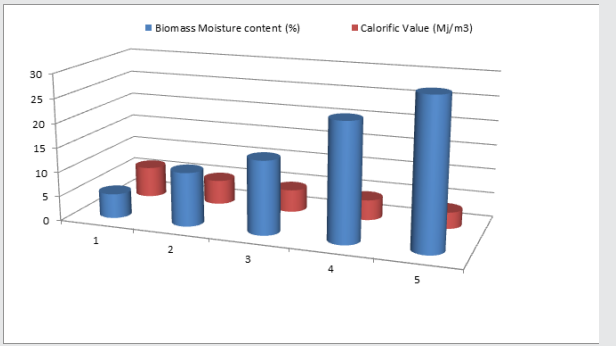

Figure 3 : Effect of biomass moisture on producer gas calorific value

Table 1: Effect of fuel type on gas composition

Fuel Type	GasTemp (°C)	SO_2 (ppm)	NO_2 (ppm)	NO (ppm)	$C0_2$ (%)	CO (ppm)	Gas Volume (m^3)
Corn Cobs	71	4000	94	200	0.1	937	46
Bagasse	52	3980	50	203	0.3	877	31.37