Design of Flash Dryer for Cogeneration Plant

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***Abstract*— Huge quantity of bagasse which is produced after the extraction of sugar from the sugarcane will be a promising biomass fuel for cogeneration plant. It has been established from the combustion studies that the percentage moisture content influence the calorific value of by-product (bagasse). As an received basis bagasse with 50% moisture content has calorific value of 9400 KJ/Kg. On reducing the moisture content of the bagasse to 40% the calorific value increases to 11300 KJ/Kg. Hence for every 1% reduction in moisture content, the boiler efficiency increases by 0.6%. Hence it is essential to decrease the moisture content in bagasse. To dry up the bagasse, Flash dryer is designed in this project. The calorific value of bagasse is raised on drying up. Hence low amount of coal can be used in Co-firing of bagasse with coal in cogeneration plant. Hence cost of fuel can be reduced.**

Keywords—Bagasse Drying; Flash Dryer; Bagasse Moisture; Co-generation

I. INTRODUCTION

In cogeneration power plant 60% coal and 40% bagasse is being used as the fuel for power generation. In that bagasse is in wet condition, so more heat is required to change condition of the bagasse. Hence more amount of coal is required. Since the cost of coal is high, it is desirable to develop a method which can reduce the overall cost of power generation. Bagasse was a by-product/waste of sugarcane in the sugar industry. Bagasse was a fuel of varying composition and heating value. These characteristics depended on the climate, type of soil upon which the cane was grown, variety of cane, harvesting method, amount of cane washing, and efficiency of the milling plant. In general, bagasse has a heating value between 1,600 and 2,200 kcal/kg on a wet, as fired basis. Here flue gas heat was at 190°C to the bagasse at 45°C [1]. Most bagasse had moisture content between 45 and 55 percent by weight. Sugar cane production takes place year round, sugar mills operate seasonally from 2 to 5 months per year. Sugar cane was a large grass with a bamboo-like stalk that grows 8 to 15 feet tall. The three most common methods of harvesting were hand cutting, machine cutting, and mechanical raking. The cane that was delivered to a particular sugar mill will vary in trash and dirt content depending on the harvesting method and weather conditions. Inside the mill, cane preparation for extraction usually involves washing the cane to remove trash and dirt, chopping, and then crushing. Juice is extracted in the milling portion of the plant by passing the chopped and crushed cane through a series of grooved rolls. The cane remaining after milling was bagasse [2].

1.1 What is Bagasse?

Whatever bagasse may be to the sugar technologist, to the combustion engineer it was cellulose fibre fuel which is made up essentially of 50 percent of water, approximately 2 percent of ash and the remaining 48 percent was combustibles [3]. The fibre or combustible portion of the sugarcane forms, on an average 16.2% on weight of cane and also that it contains from 47% to 50% of moisture when entering the furnaces. Water forms generally nearly half of the weight of the bagasse, varying between 45 and 51 or 52%, the balance being fibre which ranges between 43% and 48% and the solids from 4 to 7% of the bagasse [4]. The bagasse was fed with a moisture content of 50% (wet basis). An average bagasse composition of 47% Carbon, 6.5% hydrogen, 44% Oxygen and 2.5% ashes, classical cyclone dimensions were adopted (Lapple type). The cyclone inlet temperature was adopted as 215°C to avoid particle mass losses and spontaneous combustion. In the pneumatic duct a gas velocity of 2.5 m/s and the performance improvement was evaluated [5].

1.2 Cogeneration

A process in which an industrial facility uses its waste energy to produce heat or electricity, cogeneration is an energy-efficient, environmentally friendly method of producing electricity (power), steam or hot water at the same time, in one process, with one fuel. Cogeneration or combined heat and power (CHP) is the describing the process of simultaneously generation of electricity and heat. The production of electricity from waste heat is meant. Any fuel

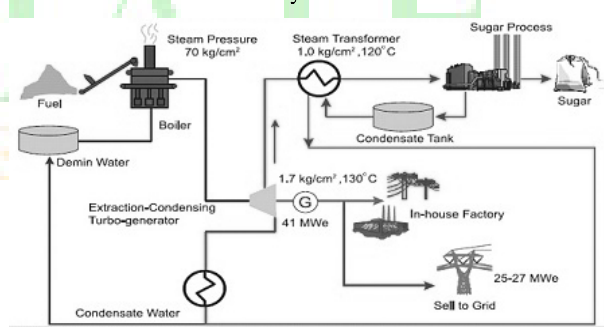

Fig.1.1: Process diagram of Cogeneration in sugar industry (Quaintenergy.com, 2014)

(coal, husk, bagasse or furnace oil) as an energy source. The process diagram of cogeneration in sugar industry is shown in Fig.1.1. Generating steam at higher pressure and temperature in a cogeneration system, adds just 10 to 20% on the fuel costs, but economical by-product electrical energy is produced enhancing overall energy efficiency significantly. In steam based cogeneration systems, back pressure turbines are deployed, where high pressure, often superheated steam from efficient boilers, is expanded in a turbine to generate power, and back pressure exhaust steam is utilized for process requirements. Higher the inlet pressure and temperature, higher the power output and likewise, lower the back pressure, higher the power output.

1.3 Benefits of cogeneration

Bagasse drying technology- mill bagasse using waste heat from the boiler flue gas, The hot and de-dusted flue gas from the boiler are made to pass through the flash tower under induced / forced draft. The wet mill bagasse is fed through a rotary air lock feeder at the bottom of the tower. It is then carried upward in a co – current mode with the hot flue gas at a calculated velocity bassed on Average Particle Residence Time (APRT). During the process, bagasse moisture evaporates and the dried bagasse is subsequently separated through a high efficiency cyclonic separator. The dried Bagasse is continuously evacuated from the bottom of the cyclone(s) through air-lock valves for onward feeding to the Boiler. The flue gas are released to the chimney through ID fan. Adequate automation is proper interlocking and protections.

II. MATERIALS AND METHODS

2.1 Flash Dryer Setup

All bagasse dryers using flue gas as the drying medium will have five main components

i. A feed unit to place bagasse in the flue gas,
ii. A drying tube
iii. Cyclones to remove bagasse from the flue gas
iv. A fan to overcome pressure drops in the drying tube and
cyclones
v. Bagasse conveyors to and from the dryer

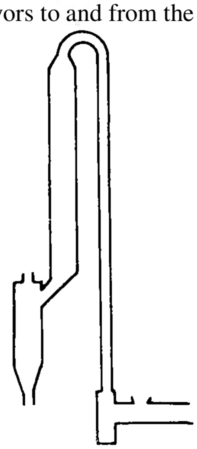

Fig.1.2: Schematic view of bagasse flash dryer [7]

An important feature of the dryer design is the fan position in the dryer. Two options are available: the fan can be located where it does not handle the bagasse, which requires that both bagasse feed units and cyclone unloading assemblies have large pressure drops across them and thus star feeders will be necessary; or the fan can handle the bagasse with obvious maintenance problems. Sugar research designs have selected the first option[7]. The wet bagasse falls down by gravity from the normal conveyor passing by a feeder that blocks the inlet of false air instead of going to the spreaders and diverted by a bypass porthole to the bagasse blending chamber with the hot gases. The schematic view of bagasse flash dryer is shown in Fig.1.2.

The dry bagasse falls down by gravity into the cyclone and goes down by an air locker through the spreaders and feeds the furnace. The dryer utilizes only 60 % of total flue gases to dry bagasse. The remaining 40 % of flue gases are used in the air heater to warm the burning air. The final temperature of flue gases is about 135 °C [8].

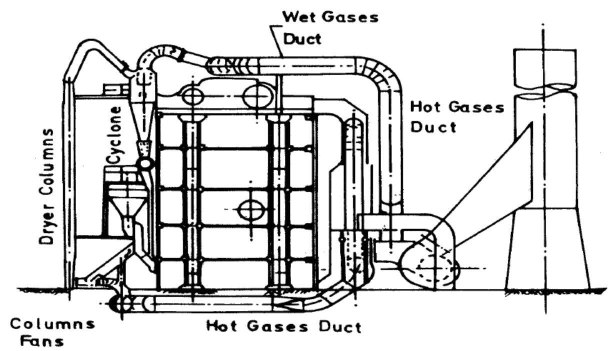

Fig.1.3: Individual Dryer [9]

Luiz Maranhao [9] carried out experimental tests on an industrial scale using an individual dryer developed in 1979 (such as the one shown in Fig.1.3). The obtained results can be summarized as [9]:

1. Bagasse drying was done utilizing flue gas temperature of 220 °C and 300 °C. The efficiency of drying was increased by 68 % using hotter gases.

2. Using flue-gas temperature 300 °C, the dried bagasse left the dryer at 40 °C and the wet gases at 100 °C.

3. The system can be controlled easily, because it only requires a depression of air on the top exit of the cyclone.

4. The total investment cost is 50 to 60 % of the existing fluidized-pneumatic dryers and the total power consumption is roughly 55 %. The efficiency is the same as with others.

5. The individual dryer can be installed on any existing boiler, and it is possible to dry a portion of the bagasse, or all the bagasse of the boiler, and so auxiliary bagasse conveyor is unnecessary.

6. It consumes 50 to 60 % of the flue gases from the same boiler, in which it is installed. The rest 40 to 50 % is used to mix with the wet gases to avoid corrosion in the ducts and chimney.

7. If the hot gases are taken after air preheater at 220 °C, the moisture can be decreased by 10 points. But, if the gases are taken before the air preheater which has a temperature of 300 °C, the moisture will be decreased by 15 points.

Luiz Maranhao [9] reported that the payback period for a dryer would be 5 months, if the excess steam produced by the dried bagasse is totally utilized.

2.2 *Features of Flash Drying*

- High reduction in Moisture – up to 15 units
- Higher heat Transfer – Adiabatic process
- Short residence Time – Flash Drying
- Regulated Feeding – No threat to Chocking
- High efficiency Cyclone – Negligible loss of fine Bagasse
- No air infiltration – Restricted Fire Hazard
- Corrosion/erosion Resistant – Superior material of Construction.

2.3 *Advantage of Flash Drying*

- Enhanced Steam Generationion
- Increased Boiler Efficiency
- Faster Boiler Pick up
- Reduced Excess air in the Fumace
- No adverse effect on Boiler
- Quicker return on Investments
- Prolonged Co-generation through Bagasse Saving

2.4 *Design of Flash Dryer*

A detailed literature review is given below table 2.1. This table mainly depends on drying parameters and type of dryer used, the important parameters like type of dryer, gas inlet temperature, bagasse feed rate and yield moisture %.

TABLE 2.1: INDUSTRIAL BAGASSE DRYING SYSTEMS [11]

S.No	Author	Year	Dryer Type	Dryer Size	Gas Inlet Temp.	Fuel (Bagasse) Feed Rate	Yield Moisture
				(m)	(°C)	(t/hr)	(wt %)
1.	Massarani and Valenca	2004	Pilot moving bed dryer	2*0.5*6	218	3.8	55-35.2
2.	Furines	1976	Rotary drum	-	218	333	54-46
3.	Gamgami	1991	Rotary bagasse dryer	-	220	14	53-40
4.	Salermo	1986	Fluidized bed dryer	-	250	10	47-35
5.	Colombres	2004	Pneumatic dryer	-	280	38	52-38
6.	Arrascaeta	1987	Pneumatic dryer	-	280	7	48-21
7.	Aralde et al	1993	Pneumatic dryer	-	291	13	53-40
8.	Nebra and Macedo	1989	Pneumatic dryer	-	300	20.4	50-23.2
9.	Paz et al	1998	Pneumatic dryer	-	320	17	54-40

After the detailed analysis a pneumatic dryer is the best one to reduce higher rate of moisture content. The design of flash dryer is shown in Fig.2.1.

Dryer size

i. Dryer height 1000 mm

ii. Diameter 50 mm

Cyclone Size

i. Cyclone height 500 mm

ii. Inner diameter 200 mm

iii. Outer diameter 50 mm

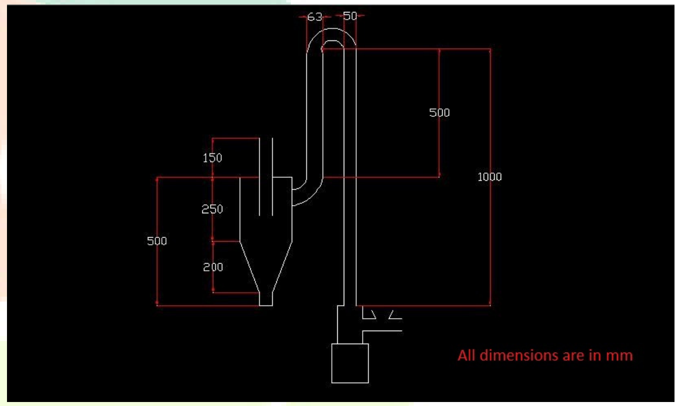

Fig.2.1: Design of flash dryer

2.5 *Equipments Used*

Fig.2.2.Equipments required for flash drying

1. Temperature gun is used to measure the air temperature
2. PVC heat pipe is used as a drying tube
3. Cyclone is used to separate the hot air and bagasse

particles

4. Air heater is a medium to produce hot air
5. Ball valve is used to adjust the inlet air velocity
6. Anemometer is used to measure the air velocity

III. Experimental Setup

Fig.3.1: Experimental Setup

The experimental setup is shown in Fig.3.1. The air heater is placed at the bottom of the drying tube, the inlet hot air velocity is 7 m/s. The cyclone is connected to the end of the setup.The wet bagasse particles having 50% of moisture content was feeded from the feeder unit. Now the bagasse particles are contact with the hot air in the drying tube,and free falls in a certain time. After the drying tube the bagasse particles are goes to the expansion tube. During expansion process the hot air velocity is reduced. After expansion process the bagasse particles enters in to a cyclone. In cyclone during centrifugal effect, the bagasse particles are collected from the bottom and the hot air is passed out from the top opening. The experimental results are shown in table 3.1.

IV. RESULTS

Table 3.1: Experimental result

Feed rate (Kg/hr)	Residence time (sec)	Hot air Temperature (°C)		Moisture (%)	
		Inlet	Outlet	Inlet	Outlet
18	8	120	80	50	42

V. Conclusion

Flash drying is an efficient technique to reduce the moisture content of bagasse particles.The high air flow rates ensure high rates of moisture removal even at relatively low temperature.Flash dryers are operating under temperature just above the wet bulb temperature, such as 70°C. The drying time is less when compared to other dryers and uniformity of drying is attained.

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