Design and Modeling of Solar Bagasse Dryer

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ABSTRACT

The utilization of bagasse as a fuel in sugar cane based industry is well known. The moisture content of fresh bagasse is relatively high which lowers the total heat available from bagasse and affects its combustion efficiency. Therefore, bagasse drying has become a necessity in order to improve its combustion efficiency and the environmental conditions, and to reduce the bagasse quantities used as a fuel. This work presents the technical possibility of bagasse pulp drying using solar energy. Bagasse pulp was dried by two methods, one using natural air convection and the other using forced air the moisture content deals with drying rate were calculated. In case of using forced air, air temperature and bagasse pulp temperature were calculated. The advantages of the bagasse pulp solar drying in the present study were illustrated. The results indicate that the useful solar energy was perfect for bagasse pulp drying. The maximum permitted drying temperature was 52oC during the solar drying process using natural air convection. Using forced air saved the drying time.

Keywords: ***Bagasse, Indirect Bagasse dryer, Solar Bagasse dryer.***

1.INTRODUCTION

The export of surplus electricity from sugar industry cogeneration is becoming the norm in many parts of the world. Cogeneration systems are composed of a steam generation system, turbines and, of course, the process plant that acts as the condenser for the LP exhaust steam. The need to keep generating beyond the end of crop means that many systems also have water cooled condensers, typically integrated with a turbine which is then a pass-out condensing machine. The steam generation system is the principle source of losses from modern cogeneration stations. It has a boiler, an air pre-heater, an economiser and sometimes a bagasse dryer. The bagasse dryer, like the pre-heater and economiser, increases the steam generation efficiency but it only becomes a significant influence when flue gas is used as the heat source for drying, the steam generation efficiency being directly related to the final gas temperature. It must be remembered that, even though bagasse drying is a means of making more energy available from the cogeneration station, the net increase in electricity generation depends on the characteristics of the entire plant, which is also a function of mainly the turbine inlet steam condition, the temperature and pressure of the exhaust and the turbine efficiency.

1.1. OBJECTIVES

The main objective of this project is to dry bagasse by using solar energy. The sugar industry utilizes the by-product, bagasse, as a fuel. The boiler is fed with bagasse having a moisture content of 50% . The moisture content on the bagasse is effort on the calorific value (CV) of bagasse and boiler efficiencies. Drying of bagasse increases its calorific value thereby improves the boiler efficiency. Industries and research institutes have been working to reduce the moisture content of mill wet bagasse.

2.BASIC COMPONENTS OF SYSTEM

1. Solar Collector
2. Drying Chamber
3. Blower
4. Duct
5. Heater coil.

1. SOLAR COLLECTOR

A solar thermal collector is a solar collector specifically intended to collect heat: that is, to absorb sunlight to provide heat. Although the term may be applied to simple solar hot water panels, it is usually used to denote more complex installations. There are various types of thermal collectors, such as solar parabolic, solar trough and solar towers. Flat type and box-type collectors are typically used in domestic and light industry applications.

A solar collector is basically a flat box and is composed of three main parts, a transparent cover, Black Plate and an insulated back plate. The solar collector works on the green house effect principle; solar radiation incident upon the transparent surface of the solar collector is transmitted through though this surface. The inside of the solar collector is usually evacuated; the energy contained within the solar collect is basically trapped and thus heats the black coated plate. The plate is usually made from mild steel, and the back plate is painted black to help absorb solar radiation. The solar collector is usually insulated to avoid heat losses.

2. DRYING CHAMBER

A drying chamber is basically a flat box, due to the high air resistance encountered when forcing the air through the drying product, only a few numbers of drying shelves can be stacked without significantly affecting the air movement. Three drying shelves forming three horizontal planes. The drying shelves are kept on the wooden frame fixed to the inner side walls of the drying chamber and can be easily removed to load or unload the drying product from the door, which represents one side of the drying chamber.

3. BLOWER

A centrifugal fan is a mechanical device for moving air or other gases. The terms "blower" and "squirrel cage fan", (because it looks like a hamster wheel), are frequently used as synonyms. These fans increase the speed and volume of an air stream with the rotating impellers. Centrifugal blowers provide directional air flow by maximizing static pressure, making them optimal for spot cooling and for air flow through a duct. Alternatively, their high suction can be used to hold an object in position or their directed air flow can be used to move objects.

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Fig. 1. Blower

4. DUCT

Ducts are used in heating, ventilation, and air conditioning (HVAC) to deliver and remove air. The needed airflows include, for example, supply air, return air, and exhaust air. Ducts commonly also deliver ventilation air as part of the supply air. As such, air ducts are one method of ensuring acceptable indoor air quality as well as thermal comfort.

A duct system is also called ductwork. Planning (laying out), sizing, optimizing, detailing, and finding the pressure losses through a duct system is called duct design.

Fig. 2. Duct

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5. HEATER

Electric heating is a process in which electrical energy is converted to heat. Common applications include space heating, cooking, water heating and industrial processes. An electric heater is an electrical device that converts electric current to heat. The heating element inside every electric heater is an electrical resistor, and works on the principle of Joule heating: an electric current passing through a resistor will convert that electrical energy into heat energy. Most modern electric heating devices use nichrome wire as the active element; the heating element, depicted on the right, uses nichrome wire supported by ceramic insulators.

Alternatively, a heat pumpuses an electric motor to drive a refrigeration cycle, that draws heat energy from a source such as the ground or outside air and directs that heat into the space to be warmed. Some systems can be reversed so that the interior space is cooled and the warm air is discharged outside or into the ground.

Fig. 3. Heater

3.2D MODEL:-

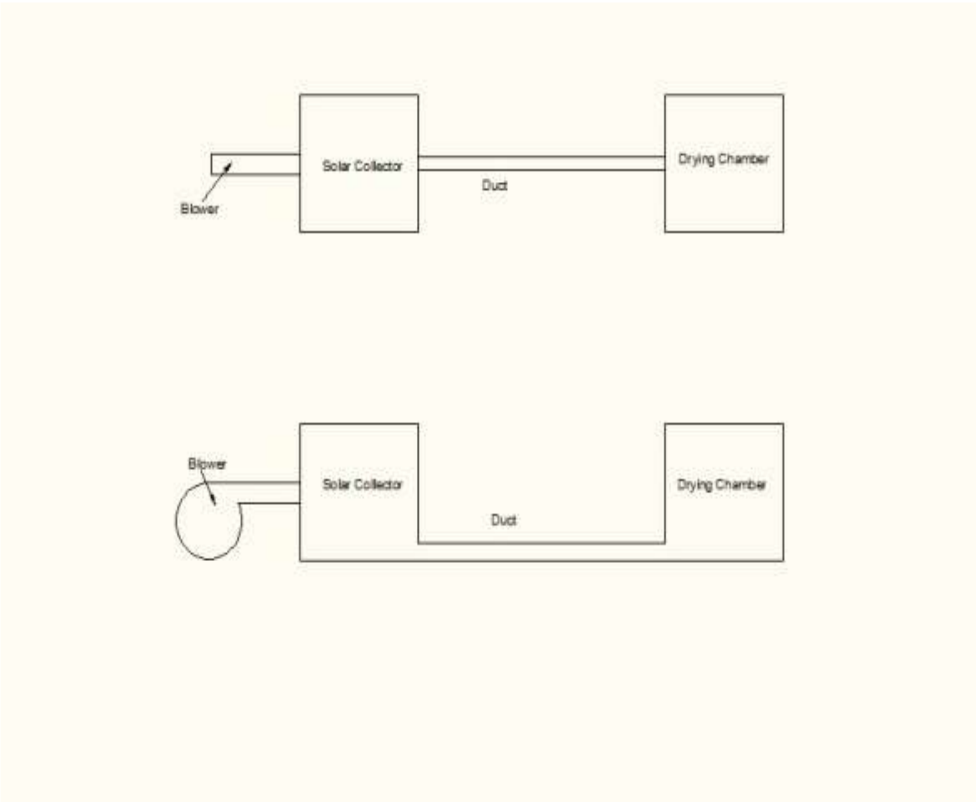

Fig. 4. Experimental setup(2D Model)

4. CALCULATIONS

4.1 SOLAR COLLECTOR

Area of the solar collector- 300mm*300mm

Height of the solar collector =300mm

Volume of the solar collector= 300*300*300

= 27*10^-3m^3

4.2. DUCT

Area of the duct – l*b= 300*300

Height of the duct -150mm

Volume of the duct= 300*300*150

= 13.5*10^-3m^3

4.3. BAGASSE DRIER

Area of the Bagasse drier- 300mm*300mm

Height of the Bagasse drier=300mm

Volume of the Bagasse drier= 300*300*300

= 27*10^-3m^3

The design of solar collector and bagasse drier setup is based on the amount of solar energy accepted.Total area is 180000mm2. The constraint we are giving on the calculation is compact in size.

4.4. SPECIFICATION OF BLOWER

230V, 50Hz

Power- 400W

Speed, N =12000rpm

Volume flow rate of blower= 2.2m^3/min

$= {}^{2.2}/_{60}\ \mathrm{m^3/s}$

=0.0366 m^3/s

Density of the air, $\rho = 1.25\ {}^{\mathrm{Kg}}/_{\mathrm{m}^3}$

Mass flow rate of blower,$\dot{m}$= Volume flow rate of blower × Density of air

Mass flow rate of blower,$\dot{m}$= 0.0366*1.25= 0.0458Kg/s

Specific heat of air, C_p= 1000J/KgK

4.5. DUCT CALCULATION

(From user's handbook on solar water heater)

We get the maximum achievable temperature at pune region by solar energy as 60℃

Temperature at solar heater, T2= 333K = 600 C.

Ambient temperature or temp of bagasse, T1= 303K = 300 C.

We are considering the duct surface area as perimeter of the duct multiply with the length of the duct

Perimeter of the duct opening, P= $2\times 150 + 2\times 300 = 900$mm

Length of the duct, L=300mm

Heat lost at duct can be calculated by the air which is contact with duct.

Area of air in contact with duct= Perimeter of duct= $2\times 150 + 2\times 300 = 900$mm

Cross section of air flow= 150*300= 45000mm2

Air -duct contact= $\text{Perimeter of duct}/\text{Cross section area of duct}$

$=900/45000$

=0.02

So that we are considering the heat gained by air's0.02 is lost at duct

Heat gained by air, $\dot{Q} = \dot{m}C_p(T2 - T1)$

= 0.0458*1000 *(333 - 303)

= 1374 J/s

$Q_{conv} = Q^{\cdot}/50 = 1374/50 = 27.48$ J/s

Surface area, $A_s = 900\times 300 = 270000\text{mm}^2$

Convective heat transfer coefficient air over surface, h= $100\,W/m^2k$(From Heat transfer- B. L Singal)

$27.48 = 100\times 270000\times 10^{-6}\times (60 - T_\infty)$

$T_\infty = 58.98°C$

Temperature at outlet of the duct, $T_\infty = 58.98°C$

4.6.SPECIFICATIONS OF HEATER

Power and Voltage- 500W, 230V

Maximum temperature- 200°C

Diameter of the coil- 10mm

Length of coil- 10inch =254mm

According past research there are lot of method to find out moisture contains in bagases,

Some method is not most accurate

It is possible to determine the better results by two method

1) Rapid Drying

2) Oven Drying

Since rapid drying method is not feasible for our model hence; We are going to use the oven dry method for better results of our model. Our model will work as oven for drying bagases

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$$\text{Moisture contains} = \frac{\text{intialweightofbagases (wetbagases)} - \text{bagasesweightaftertesting (drybagases)}}{\text{drybagsesweight}} * 100\%$$

Sample selection:-

we are going to use sugar mill bagases. According to past research mill bagases contains 48% of moisture of 1Kg of sample

Scale Requirements:-

The accuracy required for the scale depends on the size of the samples to be dried and accuracy to which moisture content is to be determined.

For testing we took 1000 gm of mill bagases.

After testing we find weight of bagases is 856.35gm

$$MC = \frac{\text{intialweightofbagases (wetbagases)} - \text{bagasesweightaftertesting (drybagases)}}{\text{drybagsesweight}} * 100\%$$

$$MC = \frac{1000 - 856.35}{856.35} * 100\%$$

MC= 16.77%

As we have use mill bagases which contains 48% moisture

Hence,

Total moisture reduced = (% moisture of sample) - (% moisture reducedby model setup)

= 48%- 16.77%

= 31.23% = 32%

5. ADVANTAGES

Increment in the calorific values

Increment the vaporization coefficient

Increment the energy production

Reduction of the losses

Decrement the flue gases volume

Reducing the losses of sensible heat

6. DISADVANTAGES

Efficiency reduced in rainy season

7. RESULTS

we have successfully reduces 32% moisture from 1 kg of mill bagases sample with 2.3 m3/min flow rate of air blower and 700 C temperature.

8. REFERENCES

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