Experimental Studies on the Application of Biomass Gasifier for Drying Tapioca in Remote Areas

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Abstract. Drying has a significant impact in the preservation of agricultural products. The dried foods have long shelf life because the moisture content is so low and the growth spoilage organisms are reduced. Although solar drying is a popular method, many rural places do not have a suitable climate for it. So it is important to develop a dryer that works with other technologies. This articles presents the design and fabrication of biomass based dryer which can be used to dry agricultural yield in rural areas. The biomass used in the gasifier is cheap and locally available. The dryer is designed to dry Tapioca and to test the effectiveness of the dryer at regular time interval during the whole drying process. The drying was carried between the temperature limits of 60°-70°C at constant mass flow of producer gas. The final moisture content of the Tapioca was recorded as 5% to 12%. The biomass based dryer reduces the drying time by 50% when compared with open sun drying. From experimentation it is observed that the biomass based dryer is more efficient than the traditional open sun drying.

Keywords- biomass gasifier; drying; moisture; producer gas; tapioca;

INTRODUCTION

Biomass gasification is used widely in high thermal applications. In the future, biomass will play a significant effect in the world energy infrastructure for heating and power generation as well as for the production of chemicals and fuels. [1]. Evidently, biomass is often the only usable and inexpensive source of energy for cooking and heating, for the rural community in developing countries [2]. It was reported that 64 percent of rural households in India are reported to depends on firewood for cooking and another 26 percent rely on residues of crops or animal waste. Furthermore, nearly 30% of households in the urban sector rely on conventional energy for cooking [3]. Biomass is also commonly used in various traditional and rural industries, in addition to household uses, such as brick manufacturing, boiling rice, hotels, restaurants, bakeries, pottery and charcoal making [4]. Biomass gasifiers are currently being used by some rice mills, ice factories and garment industry in Cambodia to operate the machine and office lighting [5].The feedstock that are available in the rural areas can be effectively used in a gasifier for various applications [6]. The rubber seed kernel shell has been experimentally tested as feedstock in a gasifier and found that it can be a potential feedstock for rubber cultivated regions [7]. On the paddy region, the rice husk can be used as feedstock and its performance on gasifier have been studied [8].

Drying is the most traditional method of preserving food and increases the shelf life of food. In order to minimise heat loss, most commercial dryers are insulated and they recirculate hot air to conserve energy. Software control of dryers is increasingly sophisticated and contributes to substantial energy savings, too. For grape drying, in order to achieve the desired moisture content, the grain should be kept as thin
layers on the floor where it is exposed to atmospheric air for a period of 10-15 days. The grain must be stirred frequently to encourage uniform drying, especially if it is in direct sunlight. In addition, the relative humidity of the air must not be greater than 70 percent [9] for drying to be efficient. The drying rate is determined for each unit of time by the loss of moisture from the wet solid. The evaporation of moisture from the grain is important in the process of drying and an increase in air flow is needed to carry away the high moisture [10]. In deciding the rate of moisture removal, the physical properties of the air around the grain are important factor [11]. A research on different agricultural products indicated that onions can be dried in tunnel solar dryers at 45-50 ° C for 3 days with a final moisture content of 15 percent [12]. The black pepper was dried from the solar tunnel dryer and found that 6 days were taken for the drying of commercial samples while it only took 8 hours in the solar tunnel dryer [13]. It should be put on a non-perforated material normally plastic sheet or concrete surface, when drying the cassava, so products at the base will not dry; thus, regular tumbling helps to reveal even drying products. Due to the excess size of the tapioca, the content was cut into rectangular pieces of 0.3 cm thick, 2 cm wide and 6-7 cm long in all the experiments [14]. The drying of tapioca is therefore experimentally investigated in this study on the producer gas-based dryer and performance parameters such as composition of producer gas, drying chamber temperature and weight loss are studied. Moreover, the results from the experimentation is to be compared with the open sun drying.

1. EXPERIMENTAL SETUP & PROCEDURE

The schematic view of the producer gas based dryer is shown in figure 1. Producer gas from the gasifier is mixed with the primary air in the air fuel mixing chamber. And the firing of the air fuel mixture is done in the combustion chamber. The hot flue gas produced continuously from the combustion chamber has very high temperature. In order to reduce the temperature of the hot flue gas secondary air is mixed in the mixing chamber and thus the required temperature is obtained. The primary and secondary air is supplied with the help of blower. Tray in the drying chamber can be easily removed so that loading and unloading will be much easier. PT 100 type RTD is used for measuring the temperature and it is connected with the data logger which displays the exact temperature. Three RTDs are used to measure the temperature inside the dryer, in which they are placed in the bottom

![Figure 1. Schematic diagram of the experimental setup](image-url)
Table 1. Combustion chamber specification.

| Parameters                                      | Specifications          |
|------------------------------------------------|-------------------------|
| Combustion chamber length and diameter          | 15 cm, 8.8 cm           |
| Air fuel mixing chamber length and diameter     | 10 cm, 5.08 cm          |
| Secondary mixing chamber length and diameter    | 30 cm, 20.32 cm         |
| Mass of water removed                           | 3.52 kg                 |
| Total energy required                           | 9243.32 kJ              |
| Mass flow rate of hot gas                       | 0.313 m³/min            |
| Mass of fuel required                           | 0.0017 g/sec            |
| Mass of excess air required                     | 184.36 kg               |

Table 2. Drying chamber specification

| Parameters                                      | Specification          |
|------------------------------------------------|------------------------|
| Length x Width x Height                        | 60 cm x 60 cm x 75 cm  |
| Chimney height and diameter                    | 45 cm, 12 cm           |
| Distance of first tray from bottom             | 25 cm                  |
| Distance between two trays                     | 25 cm                  |
| No of trays                                    | 2                      |
| Material used                                  | MS sheet               |
| Total loading capacity of each tray            | 2.5 kg                 |
| Thickness of drying chamber                    | 2 mm                   |

tray, middle tray and exit of the chimney. Velocity of the flue gas at the chimney exit is measured using AM 4201 anemometer. The filtered producer gas obtained from the gasifier is sent to the combustion chamber and the specifications are shown in Table 1. Required amount of air and fuel are allowed to enter the combustion chamber with the required mixing in the mixing chamber. Air and fuel flow was controlled with the help of control valve and ignited through the hole in the combustion chamber. The flue gas emerging from the combustion chamber has very high temperature which was reduced by adding air to flue gas in the secondary mixing chamber. Thus the required temperature was obtained from the outlet of the secondary mixing chamber. Hot gas was then allowed to enter the drying chamber. Tapioca was weighed and placed in the tray. Tapioca must be cut in pieces of average size of 2.5 by 2.5 mm of area 6.25 mm². When the hot gas enters it removes moisture from the tapioca. RTD were fixed at each tray and temperature was measured at particular time intervals. When the moisture content reaches the required amount drying was stopped. During drying the weight loss was also measured for a particular time interval. The exit velocity was measured using AM 4201 anemometer. Tray in the drying chamber is arranged in such a way for easy loading and unloading. As the drying is carried under closed environment there will be no dust precipitation. The technical specification of drying chamber is listed in Table 2.

2. RESULTS AND DISCUSSION

The drying of tapioca from the gas generated from the biomass gasifier is experimentally investigated. The parameters such as producer gas composition, temperature of the drying chamber, and weight of the product with respect to time are discussed in this section.
2.1 **Producer gas composition**

The composition of producer gas in the experimental sample is represented in figure 2. The gas producer consists of CO, H\textsubscript{2} and CH\textsubscript{4}, which are considered combustible gases and have also been examined in the same way. The producer gas starts coming out from the gas exit after minutes of the experimentation. It was observed that the composition of CO ranges from 20-24\% and 10-15\% for H\textsubscript{2} and 2-3\% for the CH\textsubscript{4} composition with a higher heating value of 5.25 MJ/Nm\textsuperscript{3} respectively.

![Figure 2. Producer gas composition from gasifier.](image)

2.2 **Influence of drying chamber temperature**

During the experimentation, the temperature of the drying chamber is measured by using PT 100 type RTD connected to a data logger. Three RTD where placed in the bottom tray, top tray. The variations of temperature with respect to time are depicted in figure 3 and 4. Figure 3. Shows that the maximum temperature at the bottom tray is observed as 75°C which is attained within 4 hours. When the maximum temperature is attained the drying chamber temperature remains more or less stable for the entire process. While the top tray shows maximum temperature of 63°C for the velocity 0.10 m/s.

![Figure 3. Variation of temperature with time for velocity 0.10 m/s](image)
Figure 4. represents the temperature variation on the drying chamber with a velocity of 0.15 m/s. It is observed from the figure that the increase in air velocity reduces the drying chamber temperature due to more air entry in the chamber. At a velocity of 0.15 m/s the maximum temperature achieved is 63°C at the bottom tray and 55°C at the top tray. Due to high thermal output in producer gas, the moisture is removed from the tapioca at duration of 4 to 6 hours.

![Figure 4. Variation of temperature with time for velocity 0.15 m/s.](image)

2.3 Influence of Weight loss

Weight loss in each tray at particular time interval has been measured during the whole process. Weight loss in the each tray is measured by taking particular amount of fixed samples from different areas of the tray. All the samples where measured at the particular time interval. From the weight loss of the fixed sample the total weight loss in the tray can be easily calculated. At the time of starting weight loss will be of much higher and later weight loss rate get lowered. During the experimentation the dry bulb, wet bulb temperature and velocity of the air of the surrounding where also measured for solar drying.

![Figure 5. Variation on the weight of the product with time for velocity 0.10 m/s.](image)
Figure 6. Variation on the weight of the product with time for velocity 0.15 m/s.

Figure 5 and 6 shows the weight loss in the biomass dryer drying with respect to time for varying air velocity. From the figure it is understood that the velocity of air increases and thus reduces the temperature and disturbs the weight loss. In order to attain better weight loss on the product the velocity of the air should be within 0.10 m/s. The results are compared with the open sun drying and observed that it takes about 20 hours for drying tapioca in open sun light. From experimentation biomass based dryer is much better than the traditional open sun drying.

3. CONCLUSION

Based on the experimental studies the following conclusions are drawn: Biomass dryer can replace other conventional drying methods. Tapioca can be dried using the producer gas. The tapioca dried in biomass based dryer is dried without much impact in the colour, flavour and the quality of the product. Final moisture content after drying was around 5 to 12%. From the results it is found that the drying temperature required is around 70°C for effective drying of tapioca. It is found that the drying temperature can be varied by providing additional air in the secondary mixing chamber. With biomass dryer, drying time required for drying can be reduced to a great extent because of constant heat flow. As the drying is carried in a close environment there will be no dust and other impurities. With this technique some cash crops such as black pepper, cardamom, chillis etc can be dried.

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