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Fluidization Study of Rice Husk, wheat Straw and Cotton Stalk in a Cold Fluidized Bed

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Abstract—*Biomass fuel is a promising alternative to fossil fuels and for its efficient and clean combustion, fluidization bed combustor is a suitable choice. Biomass fuels have different sizes and densities, due to which these fuels behave differently during fluidization. In this paper, fluidization characteristics of three different biomass fuels viz, rice husk, wheat straw and cotton stalk has been analyzed experimentally. A cold bed fluidization apparatus consisting of a 2m long and 0.065m diameter acrylic tube has been used for the present analysis. It has been found that these biomass fuels are difficult to fluidize alone and a suitable bed material like silica or alumina sand will support their fluidization. Wheat straw has been found to be most difficult to fluidize due to its low voidage. Rice husk in small quantity showed minor fluidization but got elutriated very soon. Cotton stalk showed relatively better fluidization due to its high voidage and larger density*

1. INTRODUCTION

In the world, after coal and oil, biomass is the third largest primary energy resource [1]. About 14% of the world's annual energy consumption is provided by biomass [2]. In developing countries, biomass contribution is as large as 35% of all the energy requirements.

Fluidization refers to tendency of a solid substance to behave as fluid, under controlled conditions. The science of fluidization has been excellently used in fluidized bed combustors (FBC). Fluidized bed combustors are best suited for the efficient combustion of low grade energy sources such as biomass fuels, cow dung, poultry litter and forest residues. These low grade energy sources differ in terms of their density and particle size. Fluidized bed combustor has several unique characteristics for using biomass in small-scale energy conversion operations [3]. The performance of the biomass fired fluidized bed combustor depends largely upon the fluidization characteristics of the biomass. For efficient fluidization of the biomass and their sustainable combustion, bed material like silica sand and alumina sand are used in fluidized bed combustors. The selection of appropriate size of bed material is most important for good fluidization of bed material and biomass mixtures [4].

In this paper, fluidization behavior of three biomass fuel rice husk, cotton stock and wheat straw has been studied using a lab scale cold bed fluidization apparatus.

2. MATERIAL PREPARATION

Samples of rice husk, cotton stock and wheat straw were collected from the farmers around Rajpura, District Patiala, Punjab, India. These samples were used in the same condition as they were received from without processing. These samples were selected on the basis of their shape, weight and availability.

3. EXPERIMENTAL SETUP

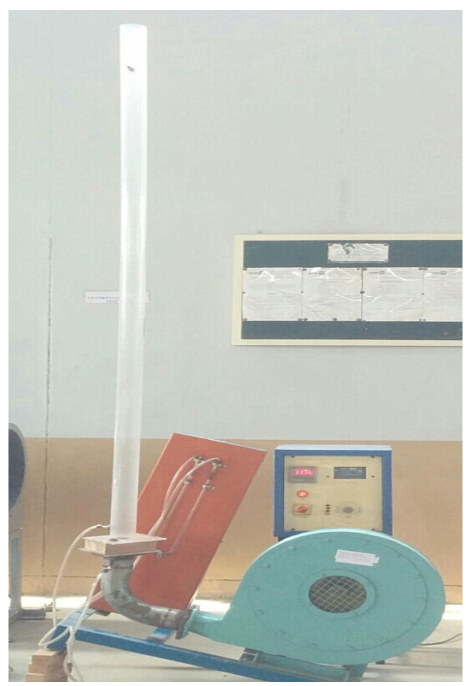

Fig. 1: Experimental setup.

The experimental setup is as shown in Fig. 1.The experimental setup consists of a acrylic tube with 0.065 m internal diameter and 2 m height. A mild steel distributor plate is used for uniform distribution of fluidizationair. Two pressure tapping are provided to measure the pressure drop across the bed. U-tube manometers are used to note the pressure drop across the bed. A butterfly valve operated centrifugal blower is used to supply air. Butterfly valve is used to regulate the flow rate.

Biomass is introduced from the top opening of the acrylic tube. Bed of biomass particles is set up in the acrylic tube above the distributer plate and corresponding bed height is noted. Then fluidization air is supplied from centrifugal blower. The velocity of fluidization air is gradually increased and pressure drop across the bed is noted. Changes in fluidized bed are observed and corresponding pressure difference below the distributer plate and above the bed is noted. Velocity is increased until fluidization occurs.

4. RESULT AND DISCUSSIONS

4.1 Rice husk

Rice husk was filled in the acrylic tube unto 4 cm. Centrifugal blower speed was increased and fluidization behavior of rice husk was observed. The various stages of fluidization of rice husk are shown in Fig. 2, air velocity, very minor movements were observed in the rice husk bed as shown in Fig. 2a (Stage I). Movement of rice husk particles was noticed close to the distributor plate. No significant movement was seen at the top of the rice husk bed. With further increase in the fluidization airvelocity, rice husk particles from the bottom started moving towards the top of the bed and partial mixing of the particles was observed as shown in Fig. 2b (Stage II).

Fig. 2a: Rice husk fluidization- Stage I

Air passages were noticed with further increase in fluidization air velocity as shown in Fig. 2c (Stage III). Two distinct zones can be seen in stage III. One zone has rice husk particles and other zone has fluidizing air passage. These zones became more distinct and clear when fluidization velocity is further increased as shown in Fig. 2d (Stage IV). With further increase in fluidization velocity, all the rice husk particles got elutriated from the bed.

Fig. 2a : Rice husk fluidization- Stage II

Fig. 2a : Rice husk fluidization- Stage III

Fig. 2a: Rice husk fluidization- Stage IV

4.2 Wheat straw

Wheat straw was also filled in the acrylic tube unto 4 cm. Centrifugal blower speed was increased and fluidization behavior of rice husk was observed. The various stages of fluidization of rice husk are shown in Fig. 3.Wheat straw fluidization behavior is different from rice husk. Wheat straw fluidization can be divided into three distinct stages. With low fluidization air velocity, wheat straw is observed to be distributed in a random manner in the bed as shown in Fig. 3a (Stage I). It can be observed from Fig. 3b (Stage II), with further increase in fluidization air velocity, wheat straw particles align in the direction of fluidizing air. When the fluidization velocity is further increased, wheat straw particles showed some fluidization as cane be observed in Fig. 3c (Stage III). Wheat straw was elutriated immediately after showing fluidization.

Fig. 3a: Wheat straw fluidization – Stage I

Fig. 3b: Wheat straw fluidization – Stage II

Fig. 3c: Wheat straw fluidization – Stage III

4.3 Cotton Stalk

Acrylic tube was filled with cotton stalk up to a height of 4 cm. Cotton stalk behaves quite differently from rice husk and wheat straw. Cotton stalk bed showed negligible movement initially as can be observed from Fig. 4a (Stage I). At low fluidization air velocities, cotton stalk showed no fluidization because of its high density in comparison to rice husk and wheat straw. As the fluidization air velocity is increase further, cotton stalk bed showed fluidization (refer Fig. 4b Stage II). Elutriation tendency of cotton stalk was observed to be lower in comparison to rice husk and wheat straw.

Fig. 4a: Cotton stalk fluidization – Stage I

Fig. 4b: Cotton stalk fluidization – Stage II

5. CONCLUSION

- Cotton stalk showed better fluidization in comparison to the rice husk and wheat straw.
- Elutriation was observed to be least in cotton stalk and maximum in rice husk. This might be due to the higher density of cotton stalk in comparison to rice husk and wheat straw.
- Wheat straw particles got aligned in the direction of fluidization air. This is due to unique shape of wheat straw (flat rectangular) in comparison to cotton stalk (cylindrical) and rice husk (elliptical).

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