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Solar and Open Drying Characteristics of Sugarcane Trash and Rice Straw

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Abstract

The production of bio oil by fast pyrolysis method using agricultural residues needs control in moisture content of the feedstock; higher in moisture content lowers the stability of burning results high CO emissions. The drying characteristics of rice straw and sugarcane trash with size of 1inch are done in both open and solar drying and the mathematical equations are made using experimental data. The values of R are reduced as much as possible to equal the experimental and theoretical data. The theoretical equations are valid for atmosphere temperature of 30-35^{0}C and global radiations of 300-850W/m^2.

Keywords: Drying rate, sugarcane trash leaf and straw, rice straw leaf and stalk, solar drying and open drying.

Introduction

The vehicles running using the crude oil products, increases due to increase in population, create more pollution and these products will be completely removed from the earth in coming years. The researchers and scientists are trying to find the alternate fuel for the vehicles and the availability of the resource should be high. The availability of biomass is high and it is used to produce the bio oil, the fast pyrolysis method helps to produce more quantity. For the fast pyrolysis method the biomass should be dry and the moisture content should be low to avoid the improper flame temperature and more emissions of CO. Hence the drying of the biomass is pre-process for the production of the bio oil that refers to any organic material derived from plants that use sunlight to grow. When burned, the energy stored in biomass is released to produce heat or electricity. The solid biomass like agricultural waste, forestry waste and crops etc are used to produce the bio oil products but it contain high in moisture[1]. Usually the biomass has more moisture content in which reduces the flame temperature and decrease in combustion rate[2]. It is well known that the moisture removal from the bios mass is on the surface of the product and by the principle of diffusion[3].

Chandrakumar achieved the maximum moisture removal from 84.4% to 18.6% for 3kg of grapes with four days of drying and maximum air temperature of 69^{0}C, it is good to use the forced convection for fast drying of bio product[4].The rice straw is well suited for the biooil and power production and is more abundant also it renewable [5,6]. The authors presented the constants values for the standard formula which shows more deviation to experimental value[7-12]. Kavak Akpinar made the open drying characteristics of parsley leaves at the variable temperature of 56, 67, 85 and 93^{0}C at 1m/s velocity and achieved R value of 0.87729[13].

Material and Methods

The incident beam radiations are falling on the collector area of 0.43m^2 which is inclined at an angle of 17°, coated with black at the bottom of the surface. The air is blown from the bottom of the collector at constant velocity of 18.7 m/s and the drying product is kept at the end of the collector with aluminium tray, hence the heated air helps to remove the moisture content from the drying product. The fresh rice straw and sugar cane trash is made into equal size of one inch for both open and solar drying. The open and solar drying experimental are run simultaneously, the velocity of the air at the open drying is maximum of 1.2m/s and the for solar it is 18.7m/s.

Results and Discussion

The mathematical equations for the sugarcane trash and sugarcane leaf for open and solar drying is shown in the Figure. The curve is plotted for both theoretical equations and experimental equations in which both are matching closest to the fifth cubic equations. The drying rate of sugarcane trash leaf gradually decreases for the first three hour of solar drying and later it shows the different in drying rate is slow down. The drying is done on the surface of the product by dispersion of water removal, hence initially the water removal rate is high and then the removal rate is reduced. Figure 1(a) and (b) shows the drying rate removal by the solar method is high and also fast compared to the open drying. It also shows that the sugar cane trash stalk and leaf does not have the same moisture removal rate. The sugarcane trash stalk needs more exposure to dry compared to the sugarcane trash leaf to avoid the carbon dioxide formation in combustion process of bio oil production. The sugarcane trash stalk has more water content and the removal of is high compared to the sugarcane trash stalk in the solar drying as shown in the figure 1(a). But in the open drying, the drying rate for the sugar cane trash stalk and the leaf is vice versa because of more surface area in open drying and more air flow velocity and temperature in the solar drying.

The same experimental procedure for the rice straw also done as per the sugarcane trash and the variation of drying rate in open and solar is shown in the figure 2 (a) and (b). The drying rate in the first hour itself is high as compared to the sugarcane trash because of the size of the rice straw. After some removal of moisture from rice straw the drying rate removal for both the open and solar is constant as shown in the figure 2. Usually the moisture removal for any species is done up to the initial and final moisture become the same and it happens in rice straw leaf and stalk nearly close to each other in open drying and there is difference in solar drying. This difference is high for the sugar cane trash leaf and stalk as compare the rice straw leaf and straw. It concludes the sugarcane trash straw and leaf has more moisture content and consumes more time.

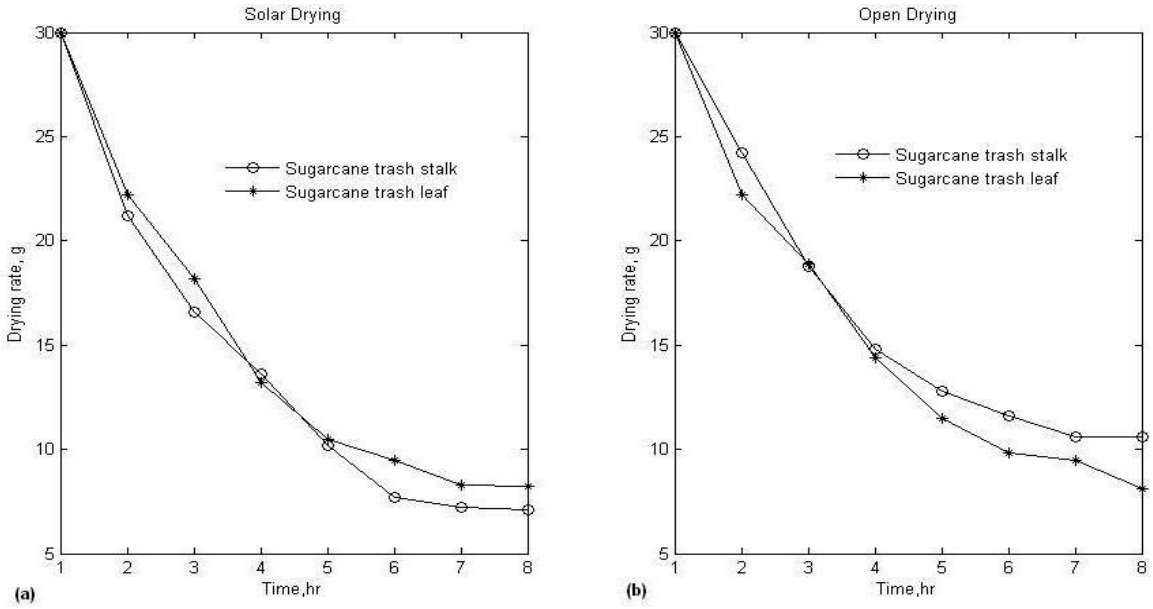

Figure-1
Drying rate characteristics of sugarcane in solar and open drying

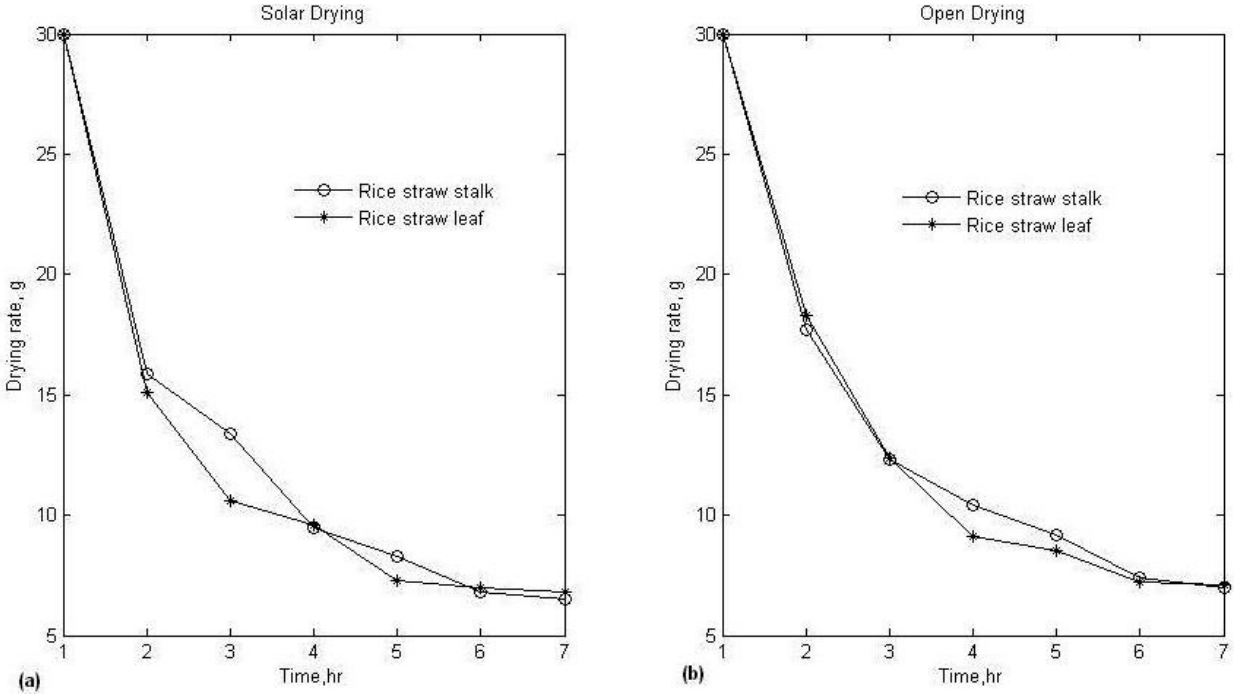

Figure-2
Drying rate characteristics of Ricestraw in solar and open drying

Mathematical equation for open drying:
Rice straw leaf:

$$DR = 0.011T^5 - 0..15T^4 + 0.24T^3 + 4.8T^2 - 26T + 52$$

Rice straw stalk:

$$DR = 0.022T^6 - 0..51T^5 + 4.8T^4 - 23T^3 + 59T^2 - 87T + 76$$

Sugar cane trash leaf

$$DR = 0.0079T^5 - 0..19T^4 + 1.6T^3 - 5.7T^2 - 25T + 32$$

Sugar cane trash stalk

$$DR = 0.0058T^6 - 0..18T^5 + 2.1T^4 - 12T^3 + 38T^2 - 61T + 64$$

Mathematical equation for solar drying:
Rice straw leaf:

$$DR = -0.03T^5 + 0.73T^4 - 6.7T^3 + 30T^2 - 69T + 75$$

Rice straw stalk:

$$DR = -0.052T^5 + 1.2T^4 - 9.8T^3 + 40T^2 - 81T + 79$$

Sugar cane trash leaf:

$$DR = 0.011T^6 - 0..32T^5 + 3.4T^4 - 18T^3 + 52T^2 - 77T + 70$$

Sugar cane trash stalk:

$$DR = -0.0036T^6 + 0.084T^5 - 0.071T^4 + 2.4T^3 - 0.94T^2 - 14T + 44$$

Table-1

Samples	Bulk density (kg/m^3)		% of increase in bulk density
	Before drying	After drying	
Rice straw leaf	73	75.4	3.2877
Rice straw stalk	56.5	59.2	4.7788
Sugarcane trash leaf	63.8	65.4	2.5078
Sugarcane trash stalk	63.3	65.2	3.0016

Table shows the difference in bulk density before and after drying and it shows the maximum increase of bulk density is 4.77 % for the rice straw stalk. It is less for the sugar cane trash leaf and shows 2.50 % at the same atmosphere conditions for all. This analysis of % increase in bulk density for the bio products helps for Industrialist to identify the time of drying for the rice straw and sugarcane trash.

Conclusion

The drying rate characteristics for the rice straw and sugar cane trash are done separately for leaf and straw. The variations in the solar drying and the open drying for the Indian condition are clearly discussed whish results, the difference in the moisture content removal in rice straw leaf and stalk is less. But it is high for the sugarcane trash leaf and stalk, hence consumes more drying time and suggested for the solar drying. To find the no of hours for drying rate theoretically, the mathematical correlation is made in terms of time for both solar and open drying and it valid for atmosphere condition of 30-35 °C and the global radiation of 300-850W/m^2. The variations of bulk density also given for rice straw and sugarcane trash which helps to avoid the carbon dioxide formation in the pyrolysis process.

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