The Andhra Agric. J 65 (4): 943-947, 2018

Performance Evalution of On-Farm Paddy Dryer Coupled with a Gasifier

R Swamy, K Sivala, D D Smith, K Sadasivarao and R Lakshimipathy
College of Agricultural Engineering, Bapatla, A.P.

ABSTRACT

Freshly harvested paddy with high moisture content should be dried to a moisture content of 12 per cent (w.b) approximately within 24 hours for safe storage and milling of paddy. It was observed that to bring down from a high moisture content of 25 % (w.b) to a final moisture content of 12.6% (w.b.), it took 13 h at 45 °C drying air temperature, 9 h at 52.5 °C and 8 h at 60 °C respectively. The overall thermal efficiency of the developed dryer was found to be 46.83%. The average heat utilization factor was found to be 0.86, 0.69 and 0.46 for drying air temperatures 45 °C, 52.5 °C and 60 °C respectively. The average values of coefficient of performance for on-farm paddy dryer coupled with a gasifier was found to be 0.5, 0.3 and 0.4 for drying air temperatures of 45 °C, 52.5 °C and 60 °C respectively.

India has the largest area under paddy and second largest producer of paddy accounting 22.40 percent of total world production. Food grain production in the India, 2016 was estimated at 273.38 million tonnes which was higher by 8.34 million. Andhra Pradesh is the third largest producer of paddy in India and production was 128.95 lakh tonne during the year 2014-2015, with an average productivity of 3.15 tonne per hectare from 34.40 m ha.

Presently farmers are using combine harvesters to harvest paddy at higher moisture content ranging between 21% to 25 % (w.b.) to avoid shuttering losses. Farmers were slowly inclined towards use of paddy combine harvesters due to shortage of labour, human drudgery and bad weather conditions. Harvesting of paddy at higher moisrure content leads to rapid deterioration in quality such as discoloration, yellowing, germination, and damage to milling quality.

It was reported that approximately 9 per cent of paddy was lost due to outdated drying methods, milling, unscientific method of storage, transport and handling (Basavaraj *et al*., 2015). The moisture content at harvest, paddy has a high respiration rate and is very susceptible to attack by micro-organisms, insects and pests. Freshly, harvested paddy grain with high moisture content must be dried to about l4 per cent (d.b) within 24 hours for safe storage and milling or 18 (d.b) per cent for temporary storage of up to two weeks. The moisture content of paddy to be dried 12 % (w.b) for more than six months storage period. Minimization of post harvest losses has always been a key issue in management of stored grain. It is also a matter of concern when crops are wet by rain during the harvest, leading to the presence of mycotoxins.

Drying paddy is one of the major problems in India. Often grains become deteriorated due to improper drying which results in a poor germination. The use of mechanical drying is an alternative method to dry grains in order to assure good quality. Hence, drying by bio-energy through gasification process is economically a viable solution for drying high moisture content of paddy. However under present conditions, economic factors seem to provide the strongest augment for considering gasification for drying of paddy. In many situations where the price of petroleum fuels are high or where supplies are unreliable the biomass gasification can provide an economically viable system.

MATERIAL AND METHIDS

Freshly harvested, local paddy variety *RNR-2458* was selected and procured from Agricultural Research Station, Rajendranagar Hyderabad to conduct experiments. Initial moisture content was recorded as 25.0 % (w.b) and considered for the study of drying characteristics by using gasifier.

Moisture Content

The moisture content of paddy samples were determined by drying 10g samples in an oven at 105 ± 1°C for 24 hours (Araullo *et al.* 1976). The samples were weighed on precision electronic balance having least count of 0.001g. The moisture content was calculated by the loss in moisture per unit weight of paddy.

$$m.c = \frac{W_m}{(W_m + W_d)} \times 100 \quad \text{.....(1)}$$

where,

m.c. (w.b) = Moisture content, %
W_m = Weight of moisture content, g
W_d = Weight of bone dry material, g

Drying Characteristics of Paddy

Drying characteristics of paddy in bin dryer was studied using heating source of gasifier at different air temperatures of 45, 52.5 and 60 °C.

Moisture ratio

Moisture ratio (MR) of paddy during drying was calculated using the following equation

$$MR = \frac{M - M_e}{M_o - M_e} \quad \text{.....(2)}$$

where

M = Instantaneous moisture content %, (d.b.)
M_o = Initial moisture content %, (d.b.)
M_e = Equilibrium moisture content of the material %, (d.b.)

Drying rate

Drying rate (DR) is approximately proportional to the difference in moisture content between the product being dried and EMC at the drying air state. Drying rates were estimated by differentiation of moisture content with respect to time as

$$DR = \frac{M_t - M_{t+dt}}{dt} \quad \text{.....(3)}$$

where

DR = Drying rate %, (d.b.) h^{-1}
Mt = Moisture content at time t %, (d.b.)
M_{t+dt} = Moisture content at time t +dt %, (d.b.)
dt = Time of successive measurements (h)

Heat utilization factor

H.U.F. may be defined as the ratio of temperature decrease due to cooling of the air during drying and the temperature increase due to heating of air.

Heat utilisation factor

$$= \frac{\text{Air temperature decrease during drying}}{\text{Air temeprature increase during heating}} \quad \text{....(4)}$$

$$H.U.F = \frac{\text{Heat utilised}}{\text{Heat supplied}} = \frac{t_1 - t_2}{t_1 - t_0}$$

H.U.F. may be more than unity under certain drying conditions.

The coefficient of performance

The coefficient of performance (C.O.P.) of a paddy dryer is expressed mathematically as follows:

$$C.O.P = \frac{t_2 - t_0}{t_1 - t_0} \quad \text{.....(4)}$$

where

t_2 = Dry bulb temperature of exhaust air, ˚C
t_0 = Dry bulb temperature of ambient air, ˚C
t_1 = Dry bulb temperature of drying air, ˚C

RESULTS AND DISCUSSION

Freshly harvested local paddy variety *RNR-2458* was used for conducting the drying experiments. In order to prevent excessive moisture gradients through the bed, the depth of grain in the bin was kept 0.84 m and the air velocity was maintained at 0.15-0.25 m/s.

Based on investigations three different levels air heating temperatures 45 ˚C, 52.5 ˚C, and 60 ˚C were taken to analyse the effect of temperature on drying characteristics. Ambient air temperature, grain temperature and exhaust air velocity was measured at every one hour interval. Drying characteristics of the developed paddy dryer at 45 °C, 52.5 °C and 60 °C temperatures by using developed gasifier were presented in Table.1, Table. 2 and Table. 3.

Variation of moisture content with drying time at 45 °C drying air temperature

It was observed from the Fig. 1 that 13 hours were required to dry paddy from initial moisture content of 25.1% w.b to final moisture content of 12.6 % w.b. Initially only a very slight change in moisture content ranging from 25.1% to 23.6 % w.b. was observed after 2 hours of drying because heat directed from cooling chamber to dryer plenum chamber to heat up the grain to the drying temperature as shown in the Fig.1

Rapid change of moisture content from 23.6 % to 16.6 % was observed first 3 hours of drying, because moisture removal occur at surface by evaporation and the internal moisture movement is high enough to maintain the saturated surface and rate of moisture removal is independent of internal moisture movement. The rate of moisture content removal in line with Srikiateden and Roberts, 2007.

It was observed that after 8 hours of drying, moisture content attained equilibrium moisture content of 12.5 % (w.b) from 16.6% (w.b) It reveals that more time taken for removal excess moisture content due to diffusion phenomenon for the internal movement of moisture from the centre of the grain to the surface of the grain, evaporation of water from the surface was no longer constant as result drying rate was declined. The highest drying rate was achieved was 20.80 kg h^{-1}.

Variation of moisture content with drying time at 52.5 °C drying air temperature

It was observed form the Fig. 2 that 9 hours were required to dried paddy from initial moisture content of 25.1% w.b to final moisture content of 12.3 % w.b. Initially only a very slight change in moisture

Fig 1. View of developed gasifier for heat supply

Fig 2. Paddy dryer coupled with gasifier

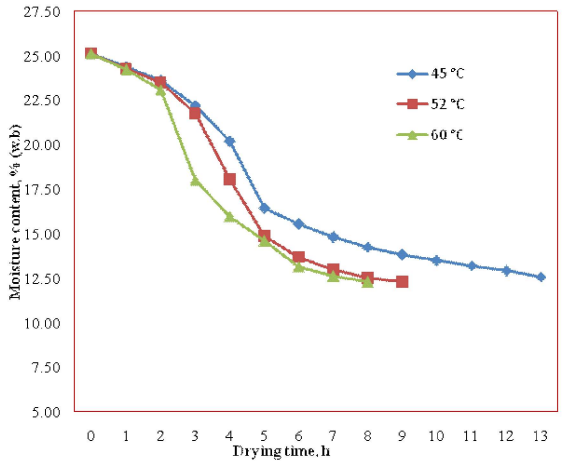

Fig 3. Variation of moisture content of paddy with drying time at different drying air temperatures

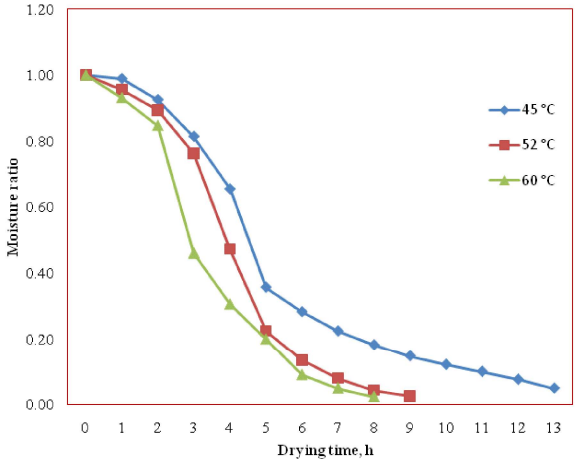

Fig 4. Variation of moisture ratio of paddy with drying time at different drying air temperatures

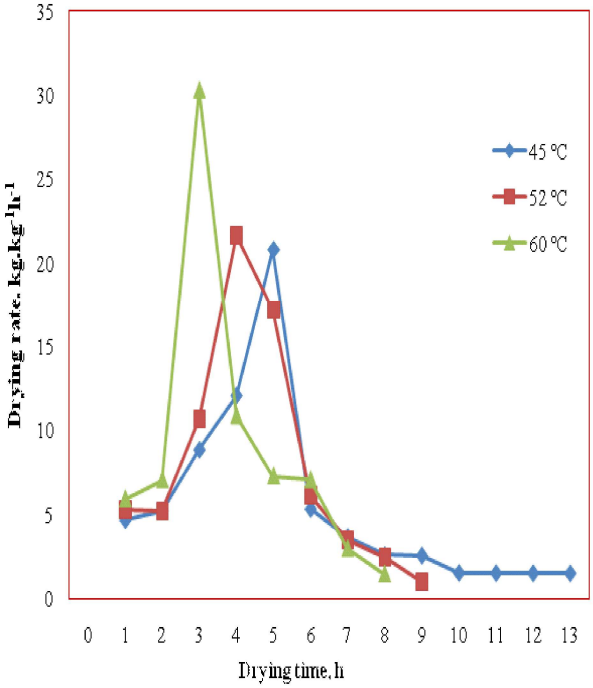

Fig 5. Variation of drying rate of paddy with drying time at different drying air temperatures

Table 1. Drying characteristics of developed paddy dryer at 45 °C temperature by using developed gasifier

Time (h)	M.C. % (w.b.)	M.C. % (d.b.)	Hot air inlet temperature (°C)	Hot air outlet temperature (°C)	Drying rate, R (kg/h)	Moisture Ratio
0	25.1	33.6	46.0	32.0	---	1
1	24.4	32.3	45.5	33.0	4.63	0.9894
2	23.6	30.9	45.0	33.0	5.19	0.9255
3	22.2	28.5	45.0	34.5	8.82	0.8138
4	20.2	25.3	47.0	35.0	12.06	0.6543
5	16.5	19.7	46.0	36.0	20.80	0.3564
6	15.5	18.4	45.0	36.0	5.30	0.2819
7	14.8	17.4	45.0	36.0	3.64	0.2234
8	14.3	16.6	44.8	36.0	2.56	0.1809
9	13.8	16.1	46.0	36.0	2.53	0.1463
10	13.5	15.6	45.0	35.0	1.50	0.1197
11	13.2	15.3	44.0	36.0	1.49	0.0984
12	12.9	14.9	44.4	36.0	1.48	0.0745
13	12.6	14.4	45.3	35.0	1.47	0.0479

Table 2. Drying characteristics of developed paddy dryer at 52.5 °C temperature by using developed gasifier

Time (h)	M.C. % (w.b.)	M.C. % (d.b.)	Hot air inlet temperature (°C)	Hot air outlet temperature (°C)	Drying rate, R (kg/hl)	Moisture Ratio
0	25.1	33.6	52	33		1
1	24.3	32	53	35	5.28	0.9558
2	23.5	30.7	52	34	5.16	0.8935
3	21.8	27.8	52	35	10.63	0.761
4	18.1	22.1	52	37	21.63	0.4727
5	14.9	17.5	53	39	17.19	0.2234
6	13.7	15.9	52	39	6.11	0.1325
7	13	14.9	52	39	3.49	0.0779
8	12.5	14.3	53	39	2.46	0.0416
9	12.3	14	53	39	0.97	0.0234

Table 3. Drying characteristics of developed paddy dryer at 60 °C temperature by using developed gasifier

Time (h)	M.C. % (w.b.)	M.C. (d.b.)	Hot air inlet temperature (°C)	Hot air outlet temperature (°C)	Drying rate, R (kg/h)	Moisture Ratio
0	25.1	33.6	60	35	----	1
1	24.2	31.9	61	43	5.93	0.9313
2	23.1	30	60	45	7.06	0.8473
3	18	22	59	46	30.29	0.4606
4	16	19	59	46	10.86	0.3053
5	14.6	17.1	60	47	7.3	0.1985
6	13.2	15.2	60	46	7.07	0.0891
7	12.6	14.5	61	46	2.96	0.0483
8	12.3	14	60	47	1.46	0.0229

content from 25.1% to 23.5 % w.b. was observed after 2 hours of drying.

Rapid change of moisture content from 23.5 % to 14.9 % was observed after 3 hours of drying. It was observed that after 4 hours required, changing of moisture content from 14.9 % to 12.3 % w.b as time passes, drying rate was declined and the removal of moisture content was progressively lower and attained equilibrium moisture content 12.3 % (w.b). The highest drying rate was achieved was 21.63 kg h^{-1}

Variation of moisture content with drying time at 60 °C drying air temperature

It was observed that 8 hours were required to dry paddy from initial moisture content of 25.1% w.b to a final moisture content of 12.1 % w.b. Initially only a very slight change in moisture content from 25.1% to 23.1 % w.b. was observed first 2 hours of drying.

Rapid change of moisture content 18 % was observed after 3rd hour of drying. It was noticed that after 3 hours required changing of moisture content from 18.0 % to 12.3 % w.b as time passes, drying rate was declined and the removal of moisture content was progressively lower and attained equilibrium moisture content 12.1 % (w.b). The highest drying rate was achieved in dryer was 30.29 kg h^{-1}.

The overall thermal efficiency gives an idea about the amount of heat utilized against amount of heat available. The overall thermal efficiency of this dryer is 46.83%. The heat utilization factor of a dryer shows the amount of heat utilized during drying. The average heat utilization factor of this dryer was found at 0.86, 0.69 and 0.46 for 45 °C, 52.5 °C and 60 °C respectively, which indicates high heat utilization efficiency. The average value of coefficient of performance for on-farm paddy dryer coupled with gasifier was about 0.5, 0.3 and 0.4 for 45 °C, 52.5 °C and 60 °C respectively. The results are in accordance with the results reported by Dissanayake *et al*., 2016.

LITERATURE CITED

Anonymous 2015 Annual report 2014-15, Department of Agriculture and cooperation, Ministry of Agriculture, Government of India.

AOAC 1985 Official methods of analysis. Association of official analytical chemists, Washington DC.

Araullo E V, De Padua D B and Graham M 1976 Rice post harvest technology. International Development Research Centre. Ottawa, Canada. ASAE Standards. 1991.38 ed.St.Joseph. MI:ASAE.

Basvaraj, Ravireja G, Srinivas D, Ramappa K T and Sharanagouda H 2015 Compartive study of manual and mechanical rice puffing methods. International Journal of Agricultural Science and Research. 5(5): 209-216.

Chakraverty A 1995 Post harvest technology of Cereals, Pulses and Oilseeds. Oxford & IBH Publishing Co. Pvt Ltd, New Delhi.

Dissanayake T M R, Bandara D M S P, Rathnayake, H M A P, Thilakarathne B M K S and Wijerathne D B T 2016 Development of mobile dryer for freshly harvested paddy. *Procedia Food Science*. 6: 78-81.

FAOSTAT 2017 Food and Agriculture Organization of the United Nations.

Siebenmorgen T J and Jindal V K 1987 Airflow resistance of rough rice as affected by moisture content, fines concentration and bulk density. *Transactions of the American Society of Agricultural Engineers.* 30(4):1138-1143.

Srikiateden J & Roberts J S 2007 Moisture transfer in solid food materials: A review of mechanisms, models, and measurements. *International Journal of Food Properties.* 10:739-777

Received on 16.02.2018 and revised on 15.03.2018