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RESEARCH ARTICLE :

Study on inter-granular temperature and grain moisture changes during deep bed drying of high moisture paddy

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SUMMARY : Grain moisture and temperature changes during drying of high moisture paddy in pilot scale deep bed drying bin was studied. Drying trial was conducted at inlet air temperature: 40^0 C and air flow rate: 0.4 m^3 s^{-1} m^{-2} in 90 cm deep cylindrical drying bin. Varying ambient temperature caused the fluctuation of bed temperatures in bottom, middle and top layer of the bin. High values of air relative humilities in drying bin were observed throughout the drying trial. Moisture differential between bottom and top layer was 5% at end of drying experiment. Paddy in bottom layer dried faster than middle and top layer of the bin. These findings are important in view point of formulating the operating strategies for blower, selection of air flow rate and depth of grains in drying bed to achieve the uniform drying in deep bed dryer.

KEY WORDS :
High moisture paddy, Drying bin, Deep bed, Temperature, Moisture

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BACKGROUND AND OBJECTIVES

Harvesting paddy at high moisture is essential for better milling yield and to reduce shattering losses at the time of harvesting. Early harvesting of high moisture paddy at 25 to 30% (wb) requires availability of suitable drying facility at farm level. Freshly harvested high moisture paddy needs immediate drying to safe moisture level upto 12 to 14% (wb) in order to prevent quality deterioration and germination in field itself. The advantage of In-bin deep bed drying system is that same bin can be used for storage of grains for temporary period.In bin drying of freshly harvested crop is suitable and economic while temporary storage of the grains until marketing and processing (Jia *et al*., 2016). However performance of in-bin drying system depends on ambient conditions (Temperature and relative humidity), drying air temperature, fan air flow rate and depth of the grains in storage bin. Satisfactory drying of high moisture grains in bin depends on selection of drying air temperature as well as air flow rate with respect to ambient air conditions. During drying of high moisture grains in storage bin, drying rate depends on outside ambient conditions such as temperature and relative humidity of air. In order to form the operating strategies for uniform in-bin drying, effect of varying ambient temperature and relative humidity on drying rates of high moisture paddyneeds to be studied at pilot scale.

Several workers have investigated the grain drying at laboratory scale as well as at farm level to know aboutdrying kinetics and behaviour of the material under set conditions(Naghavi *et al*., 2010; Ranjbaran *et al*., 2014 and Srivastava and John, 2002). Mehdi *et al.* (2014) had investigated drying kinetics of rough rice at thin layers in deep bed dryer anddrying behavior of rough rice was investigated under different drying conditions. Morteza *et al.* (2016) studied intermittent drying of paddy in lab scale fluidized bed dryer and effect of tempering time on drying kinetics was investigated. Jian *et al.* (2009) had investigated temperature and moisture fluctuations inside the metal silo filled with 20 t wheat for 15 months. Burrel and Laundon (1967) had studied thecooling of grains in refrigerated stores and observation were made ontemperature, moisture distribution and air flow patterns.

The present study was aimed to study the effect of varying ambient air temperature and humidity on drying of high moisture paddy in deep bed drying bin. Observations were made to gather the information on temperature changes, grain moisture changes, relative humidity changes during drying the high moisture paddy at 27% (wb) in 90 cm deep bed drying bin.

RESOURCES AND METHODS

This study on inter-granular air temperature and grain moisture changes during drying of high moisture paddy in deep bed dryer was carried out during June 6, 2017 in the Department of Food and Agricultural Process Engineering, Tamil Nadu Agricultural University, Coimbatore.

Description of pilot scale deep bed in-bin dryer :

Experimental deep bed dryer as shown in Fig. 1 was fabricated for carrying out experiments on drying of high moisture paddy. Drying bin of diameter 30 cm and 90 cm height was mounted on perforated floor. Perforated floor consisted of circular mild steel screen of diameter 30 cm and diameter of hole was 1.5 mm to

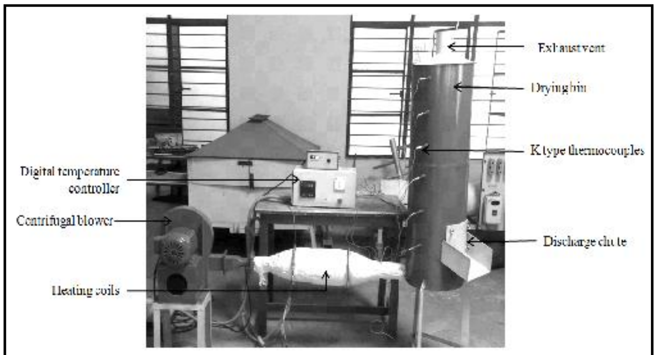

Fig. A : Experimental deep bed drying bin

prevent the fall of paddy grains through. Centrifugal blower of capacity 0.75 kW was attached along with the heater arrangement. Digital temperature controller was fixed for controlling the inlet air temperature. In order to monitor the temperature and relative humidity at various depth of drying bin three USB data loggers were placed at bottom, middle and top section of cylindrical drying bin.

Drying methodology :

Raw paddy grains were procured from Department of Farm Management of Tamil Nadu Agricultural University, Coimbatore. Paddy was conditioned for high moisture content (Upto 27 % wb). Conditioned paddy was stored inside cooling chamber at 10^0 C for 24 h in order to equilibrate moisture content of paddy material. Paddy samples were allowed to reach ambient temperature prior to drying experiments. Inlet air temperature: 40^0 C and air flow rate 0.4 m^3 s^{-1} m^{-2} was set for conducting the drying trial. In order to determine the moisture content of grains paddy samples were collected from bottom, middle and top layer of the bin at the interval of 5 h.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Temperature and relative humidity changes in deep bed dryer :

Experimental trial was conducted for 74 h duration. Trial was started on June 6, 2017 at 2:00 PM. As depicted in Fig. 1 temperature of air inside drying bin was highly influenced by varying ambient temperature. Similarly,

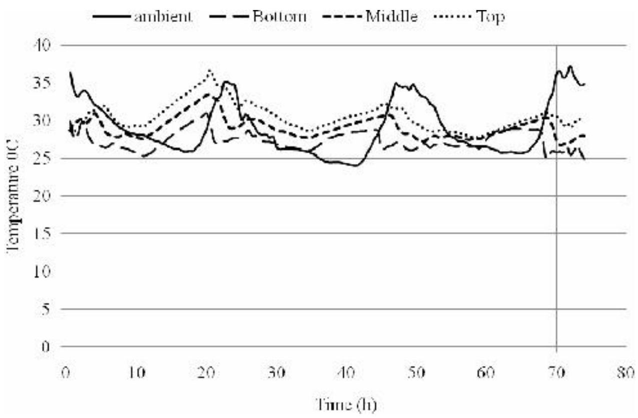

Fig. 1 : Temperature changes in deep bed drying bin

Sanderson *et al*. (1988) had reported that, inter-granular temperature in ventilated grain bulks changes if grains and incoming ambient air are at different temperatures. Temperature fluctuations were observed in almost entire depth of the paddy in drying bin. During night hours lowest ambient temperature of 25^0 C and highest day temperature 37^0 C was recorded. As depicted in Fig. 2 highest ambient humidity of 80% during night hours and lowest 40% was recorded during day hours. Unlike ambient temperature, relative humidity of ambient air did not affect variations in RH% in drying bin.

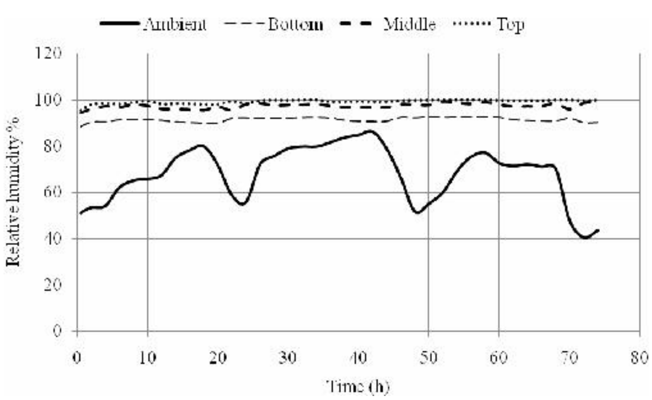

Fig. 2 : Air relative humidity change in deep bed drying bin

Grain moisture changes in deep bed drying bin :

It is evident from Fig. 3 that, drying of high moisture paddy was not uniform in deep bed drying bin as moisture differential between bottom and top layer was observed. Drying rates in middle and top layer almost followed similar trend whereas faster drying was observed in bottom layer of the bin. These profiles of moisture content of paddy and bed temperature inside drying bin implied that uniformity of drying depends not only on ambient conditions but also on other drying conditions such as inlet air temperature, air flow rate and depth of grains which has to be carefully controlled. Similar study on drying uniformity of wheat in deep bed dyer was conducted by Jia *et al*. (2016) to see the effect of swing temperature on drying uniformity. Further in depth investigation is required to see the effect of operating conditions such as tempering time, inlet air temperature, air flow rate and depth of paddy on drying uniformity and drying rates in deep bed dryer.

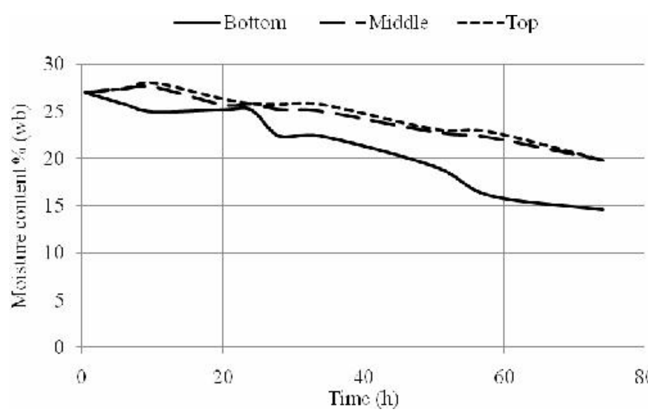

Fig. 3 : Change in moisture content of paddy in deep bed drying bin

Conclusion :

Temperature fluctuation during drying of high moisture paddy in deep bed dryer was imparted to the varying ambient air temperature. No fluctuation of air relative humidity inside bin was observed. However huge variation of ambient relative humidity was recorded during night and day hours. Moisture differential between bottom and top layer was observed and paddy in bottom layer dried faster than middle and top layer. Also it was observed that inlet air passing through bottom layer became saturated before leaving from top and added moisture in top layer. Therefore grain moisture trends in middle and top layer showed similar pattern than in bottom layer. Based on the findings of this study, operating strategies for blower operation can be formulated. Also information about variation of temperature and grain moisture inside drying bin would be useful for selecting the optimum airflow rate as well as depth of paddy in deep bed drying bin.

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