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Drying of Parboiled Paddy Using AIT-Type Solar Dryer

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Abstract

The Asian Institute of Technology (AIT) in Thailand has developed a mixed-mode passive solar dryer which is known as AIT-type dryer. This was designed for drying paddy. The dryer was tested at BAU and in the premises of a rice mill near BAU. The dryer could develop sufficient temperature for drying paddy. It was capable of generating a temperature rise of 10-25°C depending on the solar radiation. Air flow by natural convection and pressure developed was insufficient to cause air flow across the 75 mm bed. As a result, the drying rates were not convincingly higher than open air sun-drying to justify an investment of Tk. 6,500.00 (US $ 200.00) for construction of the dryer. During testing in the premises of a rice mill some other drawbacks were identified. Loading, unloading and stirring were not at all convenient due to high temperature and raised bed. The cover polyethylene became dirty with ash coming out from the boiler furnace. Cleaning of the cover was also difficult. The cover material was not durable. Hailstorms in the month of April caused wearing out of the polyethylene cover. The loading capacity of the dryer was very low (1 ton) in comparison to the amount of paddy required to be dried by the miller.

Introduction

The soil and climate of Bangladesh is favourable for growing paddy in all areas of the country, Depending on the growing season this major crop in Bangladesh are classified as (1) Aus (2) Aman and (3) Boro. Sowing and harvesting period of these crops are shown in Table 1.

Aus paddy is usually rain-fed. Aman paddy requires partial irrigation and Boro paddy is entirely dependent on irrigation.

The relative importance of different kinds of paddy is reflected in the annual production figures shown in Table 2. More than half of the total production of paddy is Aman paddy (54.7%). Aus and Boro paddy constitute 22.2% and 23.1% of total production, respectively[1].

Harvesting and Post-harvest Processing of Paddy.

Paddy is harvested manually by means of sickles. The plants after cutting are sometimes

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TABLE 1

Time of sowing and harvesting of paddy[1]

Crop	Time of sowing/ transplanting	Time of harvest
Aus Paddy		
Broadcasted	Mid March to Mid May	July to Mid August
Transplanted	Mid April to Mid June	—do—
Aman Paddy		
Broadcasted	March	Mid November to Mid January
Transplanted	Mid June to Mid August	—do—
Boro Paddy		
Local	Mid November to Mid January	Mid April to June
HYV	Mid December to Mid February	—do—

left in the field for drying in the sun. The harvested plants are bundled and then transported to the threshing floor. The harvested crops are generally carried on shoulders by the labourers, bullock carts or boats according to convenience. Beating the bundles on logs and animal treading are the common methods of threshing paddy in Bangladesh. Pedal threshers are being

TABLE 2

Annual production of Paddy (1983-84 data)[1]

Crop	Production (— 000 tons)	Percent of total
Aus Paddy	3171	22.2
Aman Paddy		
Broadcasted	1515	10.6
Transplanted	6297	44.1
Total	7811	54.7
Boro Paddy		
Local	510	3.6
HYV	2787	19.5
Total	3297	23.1
Total	14279	100.0

used in some areas (Comilla and Noakhali) of the country.

Winnowing or cleaning of threshed paddy is done manually by the housewives or the female labourers. Paddy after threshing are dried on bare grounds, mats or roadways under the open sun.

The farmers stored their paddy for family consumption, sale and seeds, Dried paddy is stored in earthen pots and bamboo baskets. Large farmers keep their paddy in barns

When paddy is consumed as food, drying is followed by parboiling. The farmers parboil paddy either by themselves or get it done by the rice millers.

Dehusking of paddy is either done manually by the farmers or get it done from the rice mills.

Problems of Drying Paddy

Paddy is traditionally dried in Bangladesh under the open sun. This method is widely used by the rural farmers as because they are satisfied with this simple method which requires no fuel or equipment and they have sufficient labour force (housewives and children are usually employed) required for sun drying.

Most of the farmers do not consider drying as a problem except for Aus paddy which is harvested in July-August. At this time there is frequent rain and the sky remains cloudy for which bright sunshine is hardly available. Moreover, the moisture absorbing capacity of the air is decreased due to high relative humidity. So adequate drying for safe storage is difficult. There is also problem with Boro paddy which is harvested in May-June. These are also rainy months. A huge amount of Aus and Boro paddy is lost due to mold growth and sprouting when they are stacked in heaps for threshing and subsequent drying[2]. The losses also occur in storage due to inadequate drying.

The problem of drying parboiled paddy in the wet season is much more accute due to high moisture content (about 40.0 percent w. b.) of parboiled paddy and high relative humidity of ambient air.

Problems of the Rice Millers in Drying Parbeiled Paddy

Rice millers in Bangladesh are generally engaged in parboiling, drying and milling of paddy all the year round. Most of the millers use cemented floors for drying. Evidently they face the climatic problems as discussed earlier.

Solar Drying of Paddy

The problems of sun-drying can be effectively solved by means of mechanical drying using conventional fuel sources such as petroleum, gas or electric energy, But the initial and the operating costs of these dryers are very high. In recent years efforts are being made to develop solar dryers and solar-assisted drying systems to reduce dependance on conventional fuel sources which are being depleted very rapidly. Solar-assisted low temperature grain drying systems have been developed in western regions (MWPS, 1980)[6]. In Asian region, large scale commercial solar dryers have been developed in India, China and the Philippines (ESCAP, 1986)[3].

The Asian Institute of Technology (AIT) in Thailand has developed a mixed-mode passive solar dryer which is known as AIT-type dryer (Exell et al., 1979)[4]. This dryer has drawn the attention of the researchers because it is comparatively cheap and simple to construct using locally available materials such as bamboo, polyethylene sheet and rice husk or charcoal.

A scheme was undertaken by the authors to study the suitability of the AIT dryer for parboiled paddy in Bangladesh conditions.

Description and Working Principle of the AIT dryer

The AIT-type solar dryer is composed of three components, namely (i) solar collector, (ii) dryer box and (iii) chimney. The solar collector consists of a layer of black burnt rice husk spread on the ground and a transparent polyethylene cover on the top and on the sides. The clear cover slopes up from the air inlet towards the dryer box. The box has a perforated floor over which wet paddy is spread for drying. The top and the sides of the box are covered by transparent polyethylene sheet. The chimney consists of a light, strong frame covered with black polyethylene sheet and a cover on the top of the chimney to keep out rain.

The transparent cover admits solar radiation to pass through it. The black burnt rice husk absorbs the solar radiation and changes the radiation into heat. The ambient air which enters through the air inlet passage, is heated in the collector. The warm air becomes lighter and passes through the paddy mass in the dryer box picking up moisture from paddy and escapes through the chimney.

Testing of AIT Dryer for Parboiled Paddy

A AIT-type dryer was installed in the premises of a rice mill near BAU. A schemetic diagram of the dryer is shown in Fig. 1. The photograhs of the bamboo-made frame of the dryer and the

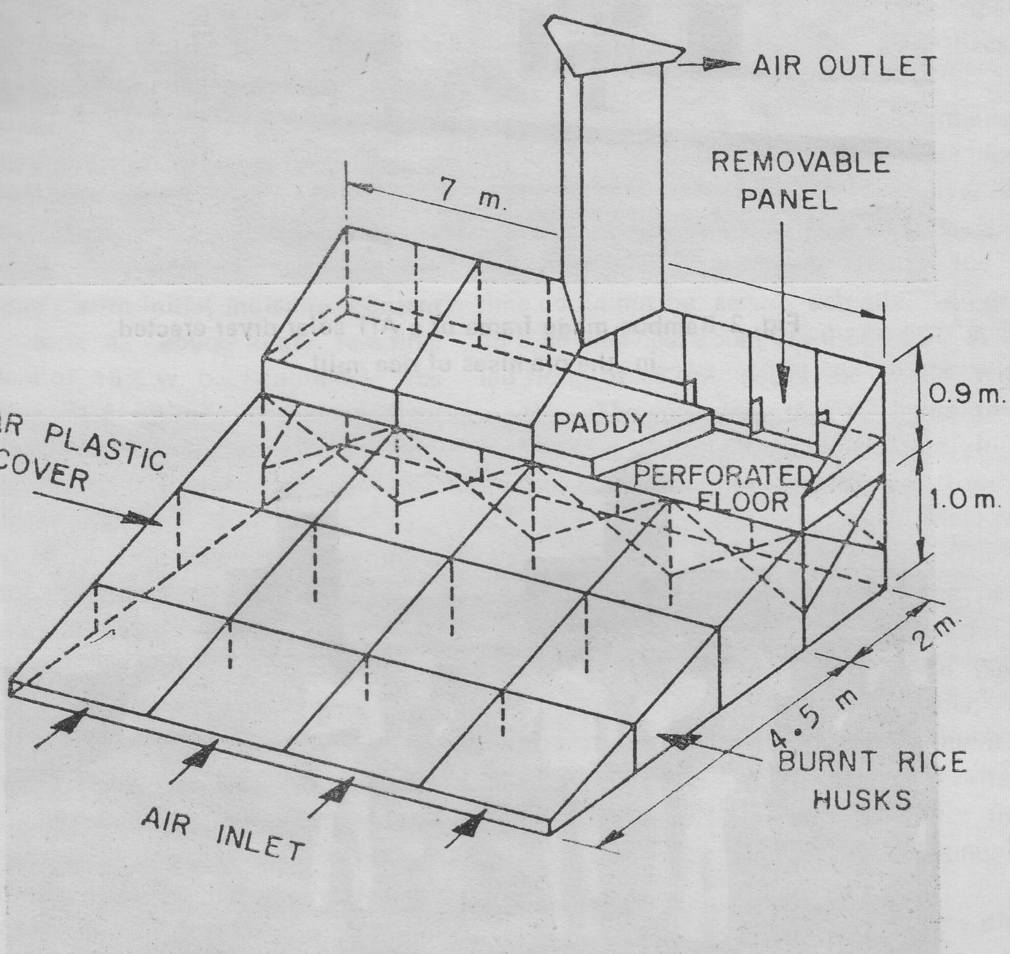

Fig. 1 A schemetic diagram of the AIT solar dryer

dryer in action have been shown in Fig. 2 and Fig 3 respectively. The dryer was constructed according to the following specifications :

Total area : 7.0 m x 6.5 m = 45.5 m^2

Collector area : 7.0 m x 4.5 m = 31.5 m^2

Drying floor area : 7.0 m x 2.0 m = 14.0 m^2

Size of air inlet passage : 7.0 mx0.14 m=0.98m^2

Cross-sectional area of chimney : 0.42 m^2

Height of the chimney : 4 m from ground level

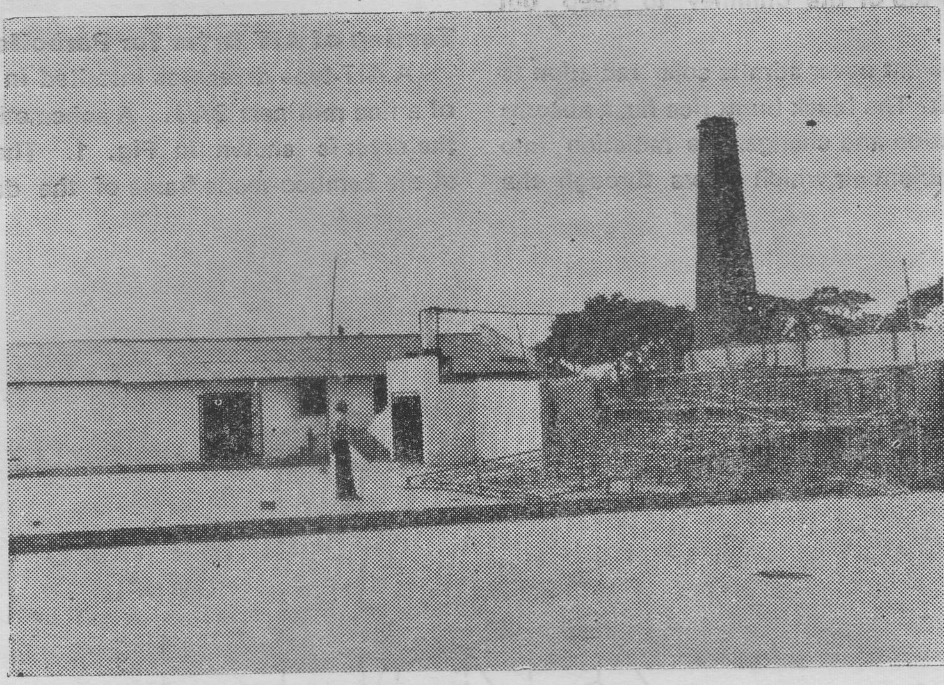

Fig. 2 Bamboo made frame of a AIT solar dryer erected in the premises of rice mill

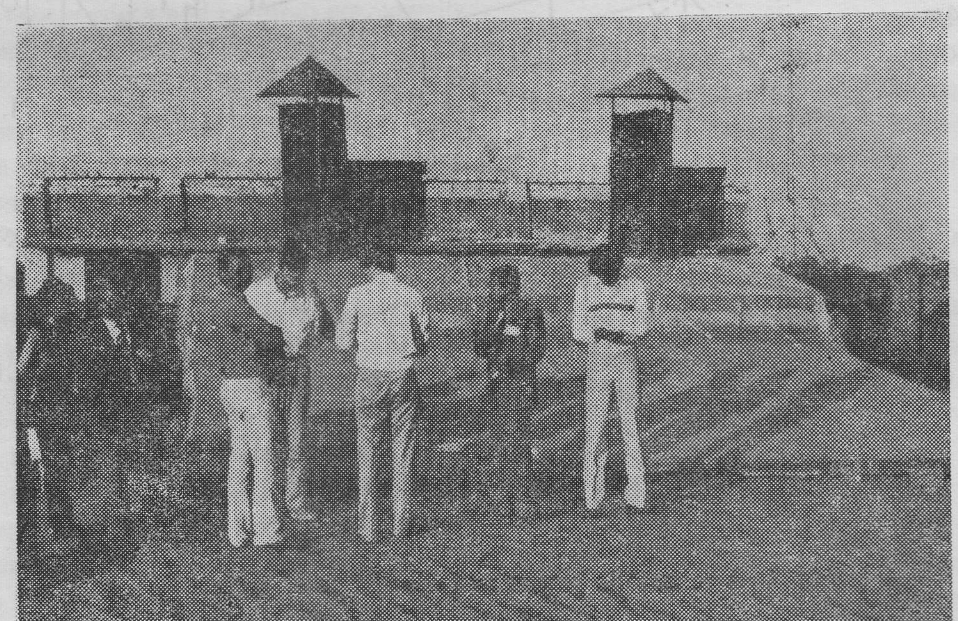

Fig. 3 AIT solar dryer with two chimneys

Several tests were conducted in July and August in 1985. Hourly values of solar radiation, dry bulb and wet bulb temperature and temperatures of air at different places in the collector and the dryer box were measured. Moisture content was determined at an interval of two hours.

During the tests, average daily solar radiation was 9.0 MJ/m²/day. Depending on the solar radiation and ambient air conditions, a temperature rise of 10 to 25°C was observed in the dryer. The drying tests were made simultaneously with the dryer and the open floor. The rates of drying and the drying time were observed to vary with varying thickness of rice bed and varying loads. The results are shown in Table 3. With equal loads, the drying rates in the dryer were faster than those in the open floor.

In another set of tests, the performance of the dryer was compared with the open floor sun-drying method. The open floors are usually loaded with 4.9 kg wet parboiled paddy per m². The solar dryer, when loaded with 1 ton wet paddy (with initial moisture content of 40.0% w. b.) took 42 hours to dry to a final moisture content of 16% w. b. (Table 4) ; the loading rate was 71.5 kg/m². The open floor drying time was only 12 hours because of low loading rate and drying in thin layers. Open floor requires larger area than the dryer. For a total load of 1 ton (1000 kg) open floor required 204.0m² whereas the dryer required 45.5 m² including a collector area of 31.5m².

The overall efficiency of the dryer was about 50 percent. Clark (1982) reported an efficiency of 52% when a similar dryer was tested at Maizdi, Noakhali in August 1980[2]. The overall efficiency was calculated using the following equations.

$$e = (m_w . L)/(I_T . A_C) \quad \text{(in decimal)}$$

where, m_w =weight ot moisture evaporated from paddy in time t hours (kg)

L = specific latent heat of vaporization of paddy moisture (2.8 MJ/kg)

I_T = total insolation during time t (MJ)

A_C =collector area (m²).

Experiences of Using AIT Dryer

The rice miller recognised the advantages of using the solar dryer. The advantatages, as he identified, were as follows :

(1) Cleaner and better quality rice.

(2) Reduced losses.

(3) Protection from rewetting and losses due to rain.

(4) Reduced drying time.

(5) Easy construction, operation and maintenance.

Inspite of these advantages, the rice miller was not convinced to use the dryer because of the following reasons :

(1) The rice miller was interested to dry more paddy using smaller area for maximum profit. But the use of the dryer did not actually show any benefit. The tests results presented in Table 4 indicated that the drying time could not be saved actually. A dryer of 45 5 m² area cost about Tk. 6,500.00. A cemented floor of 62m² could be made with this money. The solar dryer took 42 hours to dry 1 ton paddy. Within this time sun-drying on a floor of 62 m² could dry more than 1 ton (1064 kg) in more than three batches. Moreover the cost per m² area for the dryer was Tk. 140.00 whereas the cost per m² area for the cemented floor was Tk. 105.00.

(2) The area of the grain bed in the dryer was less than half of the collector area. So the thickness of the grain bed was much more higher than that on the cemented floor. Increased thickness resisted the flow of air across the dryer resulting in reduced drying rate and nonuniformity of drying.

(3) The cover polyethylene became dirty due to accumulation of dusts coming out from the drying floor and due to ash coming out from the rice husk-fired boiler furnace. Cleaning of the cover was also difficult.

(4) The plastic cover was not durable. It

TABLE—3

Variation of drying time with thickness of grainbed and loading rate for dryer and the open floor

Thickness of grainbed (mm)	Capacity (kg)	Loading Rate (kg/m²)	Drying Dryer	Time (hours) Floor
50	420	30	18.0	29.0
75	630	45	27.0	44.0
100	840-	60	35.0	59.0
150	1260	90	53 0	88.0

TABLE—4

Comparison of drying time and area required for the dryer and th? Cemented floor

Total Capacity (kg)	Loading Rate (kg/m²)	Area required (m²)	Drying Time (hours)
1000 (floor)	4.9	204.0	12.0
1000 (dryer)	71.5	45.5 (including collector)	42.0

was torn by the hailstorm in the beginning of the rainy season.

(5) Replacement of polyethylene cover once or twice a year involved additional costs,

(6) The cost of the dryer was high (Tk. 6,500 00) in comparison to its capacity (1 ton).

(7) The capacity of the dryer was very low in comparison to the amount of paddy the miller was to dry (7500 kg per day).

(8) Loading, unloading and stirring were not at all convenient due to high temperature in the dryer and due to raised bed.

(9) The price received by the rice miller for solar-dried rice was not higher than that received for the sun-dried rice.

Conclusions

The performance of the AIT-type solar dryer and the problems which were identified in course of use of the dryer for parboiled paddy clearly indicated that this type of passive dryer was not suitable for drying high moisture parboiled paddy.

Acknowledgement

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