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STUDYING AND FABRICATING SIMPLE SMALL DRYERS APPLIED IN SMALL FARMS

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ABSTRACT

The Agricultural Engineering Division (AED) of Cuu Long Delta Rice Research Institute (CLRRI) has studied, improved, and fabricated some prototypes of simple small dryer suitable to small farms located in remote areas. During 2000 – 2002, three dryer prototypes which have perfectly fabricated are: (1) Tent house using fans combine, (2) Standing cylinder dryer, and (3) Lying drum dryer. These dryers' prototypes are well adapted to rice production at small holder level, especially in Cantho province. Their specifications included small dryer (drying capacity from 1.0 to 2.0 tons/batch), simple structure, easy fabrication, low investment, low drying cost, easy operation, short drying time and good grain quality (low broken rice percentage).

INTRODUCTION

Preharvest environment and postharvest handling influence grain quality. Rice breeding program has only concentrated varietal improvement on productivity, whereas all efforts of agricultural engineering has been paid attention to postharvest technology to enhance grain quality, mostly milling quality properties. Major grain quality problems can be listed as yellow and broken grain, risks in aging and storage, variety mixing and mislabeling, no discriminating different grain sizes for commercial request. Specific grain properties relevant in drying include moisture content (both critical and equilibrium moisture content), and hull or husk tightness. Delayed drying may result in sackburning of wet grain due to nonenzymic browning and microbial growth and mycotoxin production (in maize and parboiled rice). Improper and over drying may reduce head rice yield and aroma.

In the Mekong delta of Vietnam, drying of high moisture content paddy harvested in the rainy season has become a major need to reduce yield loss due to postharvest and to increase rice quality. Issues in grain drying have been discussed at harvesting time. Constraints could be identified as (1) lack of compatible technologies including hardware; (2) lack of understanding of the mechanical drying process in both design and operation; and (3) lack of extension activities.

In the other hands, we have to pay more attention to the current situation of small holders in which rice field varies from 0.5 to 1.0 hectare per farm, and almost farmers are poor so that they have not enough money to invest modern mechanical dryers. To meet the demand of these small-holders on post-harvest of rice production, studies on paddy dryers focussed some key features as low capacity (one to two tons per batch), simple structure, easy fabrication, low cost investment, low energy consumption, short drying time and good quality of drying product.

Thus, the three dryers as (1) tent house using fans combine, (2) standing cylinder dryer, and (3) lying drum dryer, have been set up to meet the demand of these small holders.

MATERIALS AND METHODS

A. Tested dryer:

The Agricultural Engineering Division of CLRRI studied and fabricated three small dryer models are: (i) tent house and blower combine type; (ii) standing drum type; (iii) lying drum type, and natural sunshine drying as control treatment.

Three dryer prototypes were improved with drying bin structure recalculated blower (airflow m^3/s, static airpress mmH_2O column); recalculated furnace (heat supply for air-drying).

B. Measuring items

- Efficiency: time study and moisture content;

- Uniformity: moisture content (every one hour);

- Air temperature and humidity;

- Grain temperature;

- Grain quality: broken rice percentage

C. Measuring methods

- Fuel and energy consumption:

- Start full fuel tank and end of drying full tank measure quantity of fuel (diesel fuel);

- Counting numbers of honeycomb coals, one unit weight of 2kg;

- Grain weight:

- Initial weight and final weight must be measure by balance;

- Grain moisture content:

- At the beginning everyone hour and later every two hours;

- Sampling: Tent house at 24 samples and 12 samples; Lying drum at 16 samples; Standing drum at 12 samples; and sunshine drying at 5 samples.

- Air temperature: continuously measured by thermos recorder:

- Ambient air: temperature and humidity;

- Heated air: temperature and humidity was controlled at 1 point / each dryer;

- Grain temperature was controlled at 12 sites for tent house; 2 sites for Lying drum; 2 sites for Standing drum; 2 sites for sunshine drying;

- Grain quality: counting broken rice among 200 pieces / each dryer over 48 hours after drying.

To compare rice-milling quality of dried paddy from dryer, pick up some paddy sample to dry in the sunshine (in shade). At last, to mill dried paddy samples and compare broken rice percentage among the treatments to control

TESTING RESULTS

1. Structure of simple small dryers.

A. Drying rice below tent house using fans combine improved

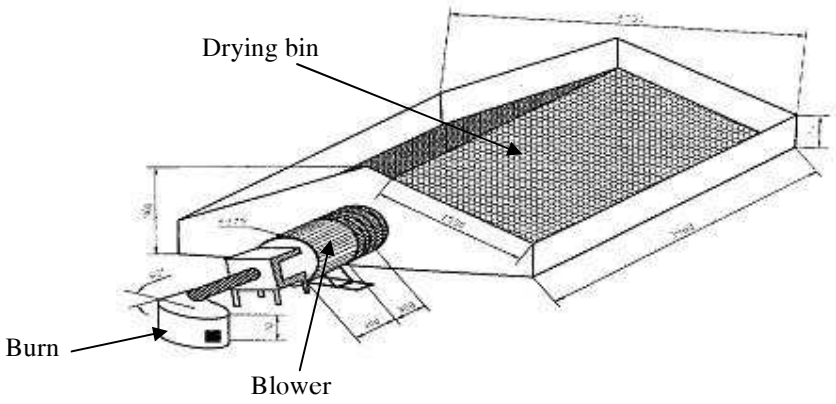


Fig.1. Schematic drawing of tent house using fans combine improved dryer-type (non express tent house part at here)

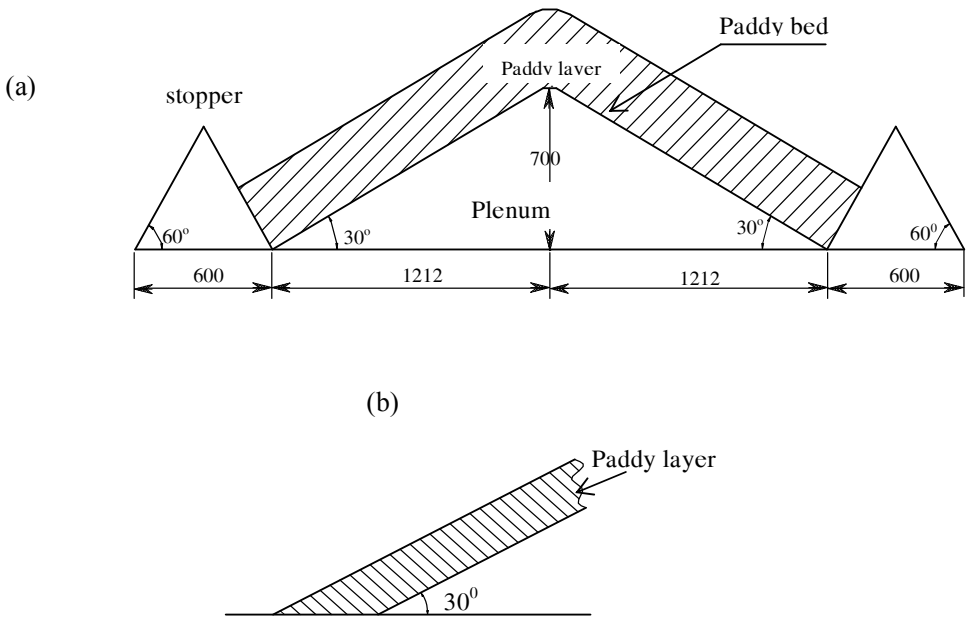


Fig. 2. Front Elevation of Paddy Bed of Tent house Drying
(a): Roof shape none stopper; (b): Roof shape with stopper

Fig. 3. Pictures of Tent house drying are operating

B. Lying drum dryer

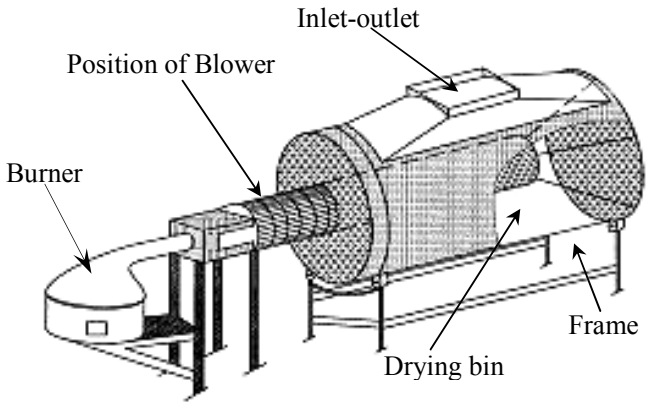
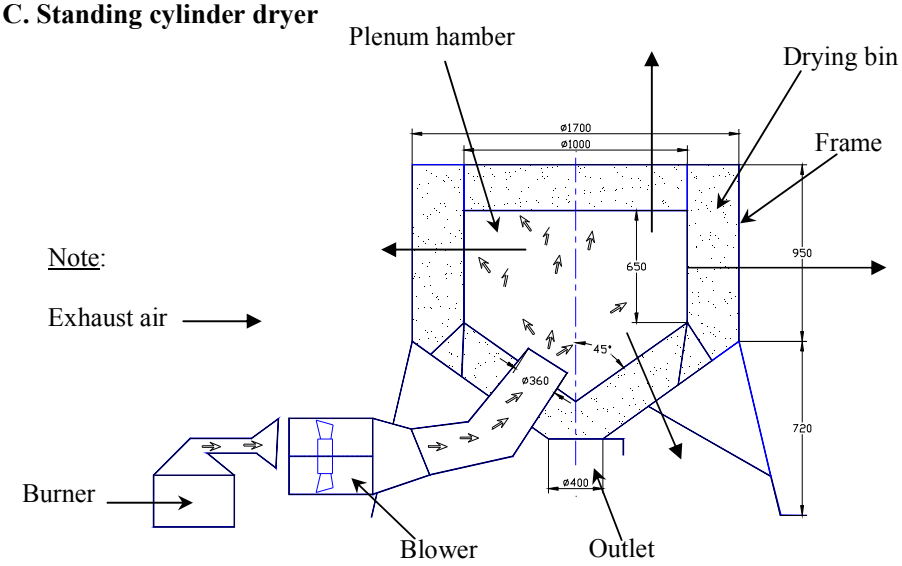


Fig. 4: Schematic drawing of Lying drum dryer (Non express mobile frame part with wheels at here)

Fig. 4: Lying Drum Dryer for Testing

C. Standing cylinder dryer



(a) Drying Bin Frame (b) Operating Dryer

Fig. 6. Pictures of Standing Cylinder Dryer

3. Testing, demonstration and transferring to farmers

3.1 Results of Drying Test on June, 13/6/2002

Table 1. Outline of Drying Performance of 3 Dryer types (Variety OM2512)

Parameters	Unit	Dryer Type		Note
		Tent house with fan combination dryer	Standing cylinder dryer	
Initial rice weight	kg	1,959.4	965.6	
Initial Moisture content	%	21.3	23.4	
Final Moisture content	%	13.9	14.4	
Final Dry rice weight	kg	1,542.0	739.6	
Drying time	h	9.2	14.4	
Drying rate	%/h	0.80	1.23	
Drying capacity	kg/h	167.6	101.3	
Consumption of fuel	liters	12.0	10.0	
Consumption of coal	unit	29.0	15.0	
Consumption of coal	kg	58.0	30.0	
Drying cost of fuel	VND	36,000.0	30,000.0	
Drying cost of coal	VND	58,000.0	30,000.0	
Total cost (drying rice base)	VND/Ton	60,979.0	81,145.0	
Total cost (15% rice base)	VND/Ton	51,830.0	68,969.0	
Percentage of broken rice	%	2.0	2.5	
Heated air temperature	^{0}C	48.8	43.9	at outlet of oven
Heated air humidity	%RH	21.8	27.0	at outlet of oven
Drying air temperature	^{0}C	34.4	34.1	in drying bin

Table 1 indicates that

1. Tent house prototype shows drying time of 9.2 hours per batch and drying rate of 0.80%/h. Percentage of broken rice is 2.0%, and shows no problem.
2. Standing cylinder type has drying rate of 1.23%/h. The percentage of broken rice is 2.5%.
3. Drying rate of natural sunshine becomes very high, and the percentage of broken rice also expresses very high value of 22%. This event could be explained as i) It was sunny and windy, ii) Dried rice layer was 4-5cm thin , and iii) Temperature in rice got over 45 ^{0}C (very high). But the meteorological value of that day is not clear, and it is necessary to check the air temperature, air humidity and wind velocity. (Table 1)
4. Mixing of 5 hours later after starting conducted high drying rate and the reduction of moisture deviation as shown in Fig.7.
5. The deviation of moisture content has two kinds. One is between the surface points and the bottom points, and the other is between the front points and the back points. When mixing, it is important to understand this matter.
6. The trend of the reduction of standing drum type and sunshine drying is shown in Fig.9 and Fig.10

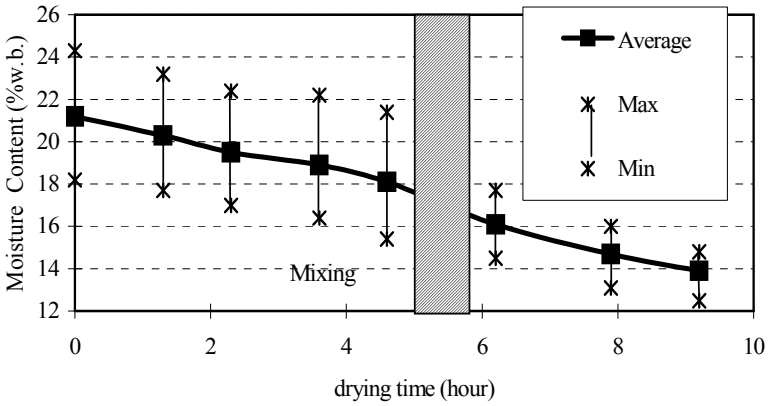


Fig.7 Drying Curve of Tent House Type

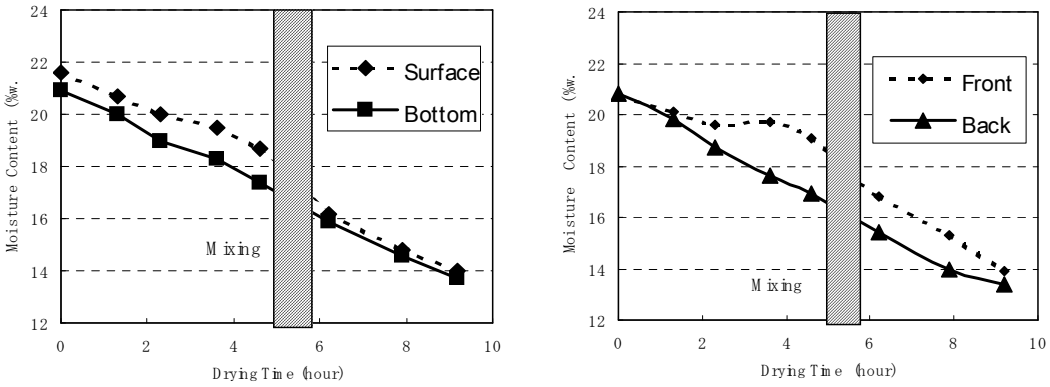


Fig.8. Difference of Drying Curve of Tent House Type among Sampling Points (13 June 2002)

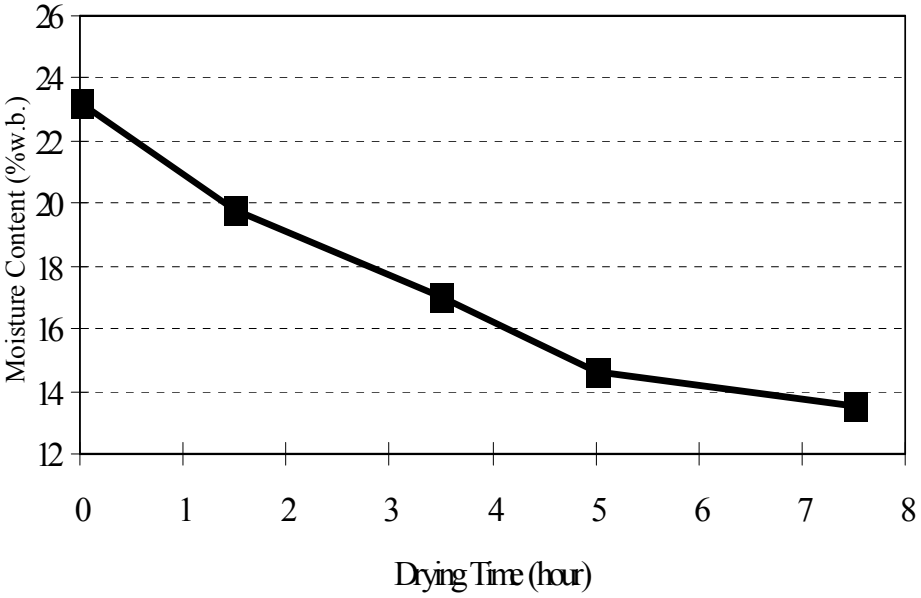


Fig.9 Drying Curve of Standing Type Dryer (13 June 2002)

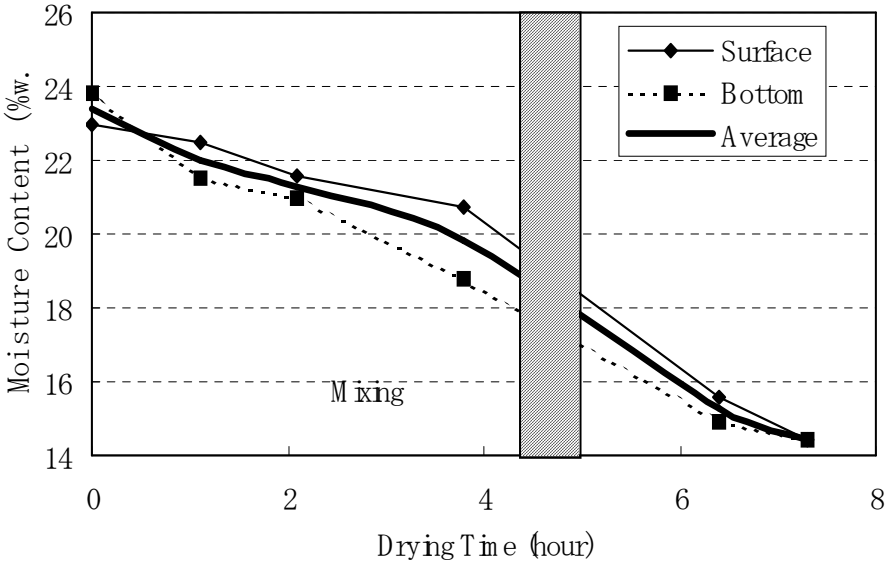


Fig.10 Drying Curve of Standing type Dryer (13 June 2002)

3.2 Results of Drying Test on 19 June 2002

Table 2: Outline of Drying Performance of tested 3 types (Variety OM1490)

Parameters	Unit	Dryer Type			Note
		Tent house with fan combination dryer	Standing cylinder dryer	Sunshine	
Initial rice weight	kg	2,063.0	1,731.0	118,4	
Initial Moisture content	%	24.7	28.8	27.5	
Final Moisture content	%	14.8	14.6	13.2	
Final Dry rice weight	kg	1,553.4	1,239.4	85.8	
Drying time	h	13.5	10.5	11.1	
Drying rate	%/h	0,73	1.31	1.29	
Drying capacity	kg/h	115.1	118.0	-	
Drying capacity (15% rice)	kg/h	135.4	138.9	-	
Consumption of fuel	liters	13.6	12.1		
Consumption of coal	unit	47.0	43.0		3kg/unit
Consumption of coal	kg	141.0	126.0		
Drying cost of fuel	VND	40,800.0	36,300.0		
Drying cost of coal	VND	94,047.0	84,042.0		
Total cost (drying rice base)	VND/T	86,808.0	97,097.0		
Total cost (15% rice base)	VND/T	73,785.0	82,533.0		
Percentage of broken rice	%	3.5	2.0	3.5	
Heated air temperature	^{0}C	37.1	38.2	31.2	at outlet of oven
Heated air Humidity	%RH	46.7	44.7	65,9	at outlet of oven
Drying air temperature	^{0}C	31.4	33.7	35.8	in drying bin
Environmental temperature	^{0}C	31.2	31.2	31.4	
Environmental humidity	%RH	65.9	65.9	71.2	

Table 2 indicates that

(1) Drying rate of tent house type is lower than that on 13 June as shown in Table 2. The reason is that (i) In the latter half of drying period, the burner of honeycomb coal had bad condition, and (ii) Sudden and strong rain fell at about 6 PM, and conducted high air relative humidity. The mixing method is recommended as shown in Fig.11, for reduction of two kinds of moisture deviation. The ratio of broken rice is small of 3.5%.

(2) Lying drum type has good drying performance of drying rate 1.31%/h. The ratio of broken rice is small of 2.0%

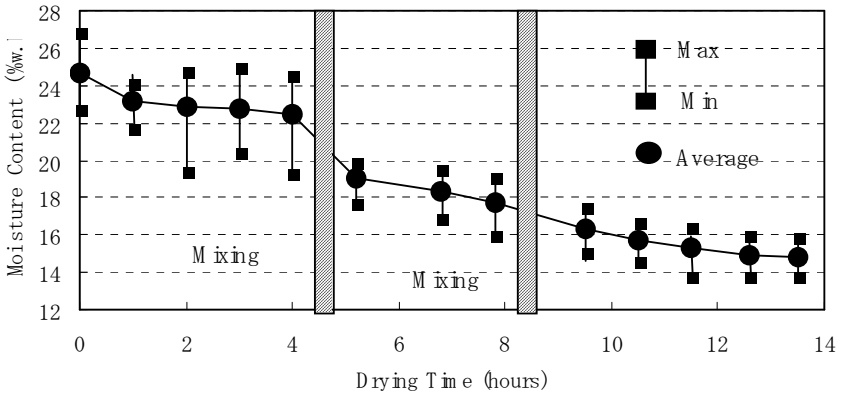


Fig.11 Drying Curve of Tent House Type Dryer

(3) In the test of tent house type, the mixing process has two times. The first mixing indicates that the drying rate increases so much, and the moisture deviation becomes so small. But the effect of the second mixing is not clear. (Fig.12) So, it take need only one mixing has an enough effect in the case of this moisture content.

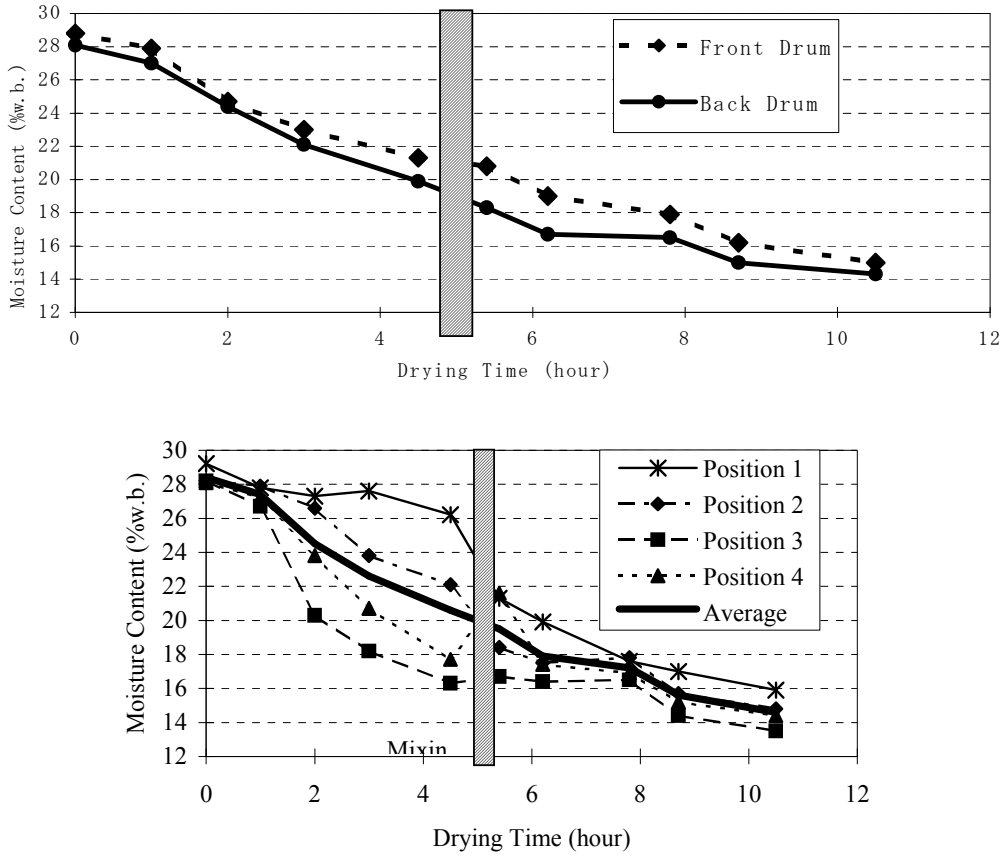


Fig.12 Drying Curve on Some Sampling Points of Lying Type Dryer

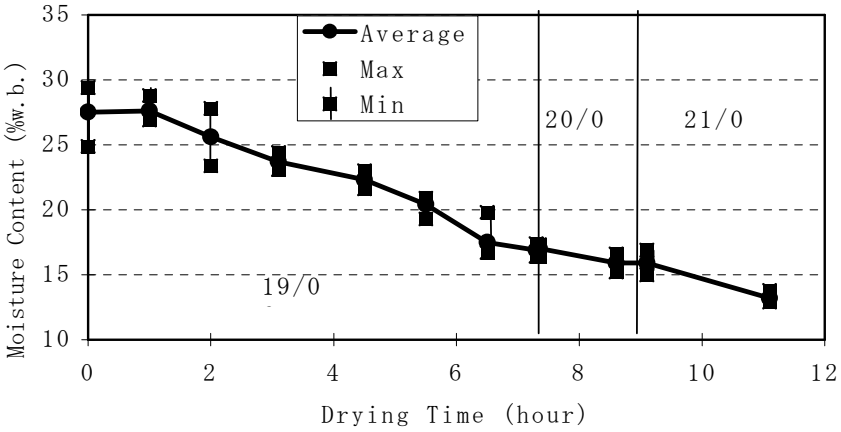


Fig 13: Drying Curve of sunshine drying during 19 – 21 June, 2002

4. Running cost

Table 3: Outline of Drying Performance of tested 3 type

Date of Tested		2002/6/13			2002/6/19			2002/6/14	
Rice variety		OM2512			OM1490			OMCS2000	
Type of Dryer		Tent	Standing	Sunshine	Tent	Lying	Sunshine	Tent	Lying
Initial rice weight	kg	1,959.4	965.8	129.4	2,063.0	1,731.0	118.4	1,880.0	385.0
Final dry rice weight	kg	1,542.0	739.6	99.4	1,553.4	1,239.4	85.8	1,331.0	320.0
Initial moisture content	%	21.3	23.4	23.2	24.7	28.4	27.5	29.2	29.2
Final moisture content	%	13.9	14.4	14.6	14.8	.14.6	13.2	15.4	14.5
Removed moisture	kg	168.4	101.5	13.0	239.7	.279.7	19.5	306.7	66.2
Drying time	h	9.2	7.3	5.0	13.5	10.5	11.1	12.98	5.12
Drying rate	%/h	0.80	1.23	1.72	0.73	1.31	1.29	1.06	2.87
Drying capacity	kg/h	167.6	101.3	19.9	115.1	118.0	7.7	102.5	62.5
Drying capacity (15% rice)	kg/g	197.2	119.2	23.4	135.4	138.9	9.1	120.8	62.6
Consumption of fuel	liters	12.0	10.0	-	13.6	12.1	-	9.0	3.0
Consumption of coal	unit	29.0	14,5	-	47.0	42.0	-	21.0	8.4
Drying cost of fuel	VND	36,000	30,000	-	40,800	36,300	-	27,000	9,000
Drying cost of coal	VND	58,000	29,000	-	94,000	84,000	-	42,000	16,800
Total cost (dry rice base)	VND /T	60,960	79,773	-	86,777	97,063	-	51,841	80,625
Total cost (15% rice base)	VND /T	51,814	67,802	-	73,759	82,504	-	44,063	80,453
Cost of removing moisture 01kg	VND	588.0	581.0	-	562.0	430.0	-	225.0	390.0
Percentage broken rice	%	2.0	2.5	22.0	3.5	2.0	3.5	8.0	19.5
Ambient air temperature	^{0}C	-	-	-	31.2	31.2	31.4	33.2	36.1
Ambient air humidity	%RH	-	-	-	65.9	65.9	71.2	71.6	58.5
Heated air temperature	^{0}C	48.8	43.9	-	37.1	38.2	-	38.7	41.4
Heated air humidity	%RH	21.8	27.0	-	46.7	44.7	-	-	-
Rice temperature during drying	^{0}C	34.4	34.4	45.5	31.4	33.7	35.8	-	-

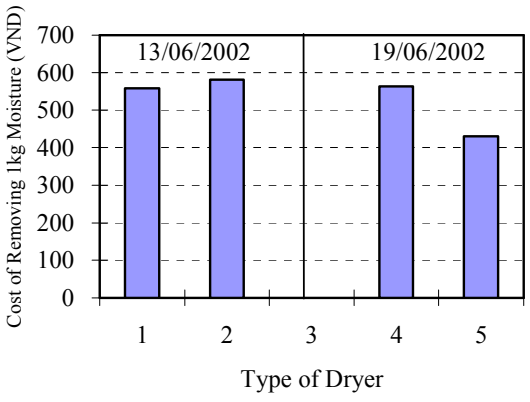


Fig.14: Running Total Cost of Removing 1kg Moisture of Tested Dryer

1: Tent House 1 13/06/2002 - 2: Standing 13/06/2002

4: Tent House 2 19/06/2002 - 5: Lying 19/06/2002

Table 3 indicates that:

(1) Capacity of tent house type is higher than that of the others, and so the total running cost is lower (shown to be kept in Table 1). But, capacity and total running cost do not count the initial moisture content. It should be the calculation of running cost of removing 1kg moisture is more accurate, as shown in Fig.15, reveals that lying type has the smallest cost performance.

(2) In tent house type, the air leak and the unbalance of the position of bottom is found. The air leak makes the static pressure lower, and the fluctuation of the rice layer depth according to the unbalance of the bottom level causes the drying speed not to keep constant among points. It is thought that these matters make drying performance of tent house prototype lower than that of lying drum prototype because lying drum did not create these problems. So, after these mistakes were adjusted, it has been operating well.

(3) Sunshine drying of over 27% high moisture rice could not be finished for a day. After all, it took 3 days to dry the high moisture rice sample because the second day became rainy. Thus, sunshine drying was affected by the climate so much that finishing time could not be expected and the quality did not keep constant. That was considered as a serious problem of sunshine drying.

(4) Fig.8 shows the trend of the moisture reduction each sampling point. The mixing was so effective that the moisture content became lower and moisture deviation between the surface and the bottom became smaller. The moisture deviation between front position and back position did not create serious problem because final moisture deviation was down less than 1%.

Table 4 shows the results of time study. It took 1.3 - 1.8 hrs for each dryer to work. On 5th work, lying drum and standing cylinder dryer expressed without problems, tent house dryer however must be adjusted its drying air duct, it took 0.2 hour to do.

CONCLUSIONS AND SUGGESTION

(1) Lying dryer prototype offerred good drying performance and mixing was easy, drying rate of 1.31%/h was possibly suitable to paddy drying. The broken rice percentage was small of 2.0%; drying cost was 82.53 VND/kg. But, this created some problems e.g.: (i) Drying bin must be always full before operating start, (ii) Investment cost was more expensive than two other dryer types in the test.

(2) Tent house dryer prototype offerred lower drying performance in this experiment. But, in terms of farmer practice improvement, its performance became higher. It was thought that this type can be commonly used because of (i) flexibility of the volume of input wet rice, (ii) multi use, (iii) cheapness, and (iv) easiness of taking apart; (v) low broken rice percentage (3.5%), relatively low drying rate (0.8%/h), the lowest drying cost (51.83 VND / kg).

(3) Standing dryer prototype addressed a feature investment cost of cheapness: drying rate of 1.23%/h, broken rice percentage of 2.5%, drying cost of 68,96 VND / kg. Mentioning to drying rice in terms of smallholders, this type could be useful.

(4) Three dryer prototypes offerred a good feature, suitable to small holders with low income. They need to be developed through training, demonstration, transferring to farmers.

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SUMMARY IN VIETNAMESE

Nghiên cứu và chế tạo máy sấy lúa phục vụ nông hộ có qui mô trang trại nhỏ

Bộ môn Cơ Điện của Viện Lúa Đồng bằng Sông Cửu Long đã nghiên cứu cải tiến và chế tạo một vài mô hình mẫu của máy sấy nhỏ phục vụ cho nôn dân cho diện tích ruộng ít, ở vùng sâu. Từ 2000 đến 2002, máy mô hình máy sấy theo yêu cầu như vậy đã được nghiên cứu và chế tạo. Đó là lều sấy sử dụng quạt thông gió, máy sấy trục đứng, máy sấy vĩ ngang. Những công cụ này đã đáp ứng được yêu cầu của sản xuất lúa trong vụ hè thu, đặc biệt tại tỉnh Cần Thơ. Đặc điểm của chúng là máy sấy nhỏ (khả năng 1 đến 2 tấn lúa / mẽ), cấu trúc đơn giản, dễ chế tạo, đầu tư vốn thấp, giá sấy thóc rẽ, dễ vận hành, thời gian sấy nhanh và phẩm chất lúa sấy tốt (tỉ lệ gạo gãy thấp)
