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Development of a Commercial Scale Must Flow Paddy Dryer

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Abstract: **Several drying methods which are used in industrial production of the fresh paddy today cannot reduce moisture content at the same level for all gain. Then it causes to stimulate the growth of bacteria, fungi and yeast. Therefore this research aims to develop the dryer which is namely "Must Flow dryer". This type of dryer is able to reduce the moisture content at the same level for all gain which is better than using the Fluidized Bed and the Relying Sunny Breezes method. The performance of the Must Flow dryer for drying can be accounted with a superior level because of the electrical power consumption can be save about 33 kW, and the head rice yield has met the criteria at the average of 58.3 %as well as the final moisture content can be control at the average of 15.0 %wb and the whiteness color index better than the Relying Sunny Breezes method (concrete patio) and the Fluidized Bed dryer, which is almost equal to amounts of rice, a fresh paddy quantity of 420tons. The developed "Must Flow dryer" also keeping the whiteness color index of dried paddy about 40.3.**

Keywords: **Paddy, Rough rice, Un-husk rice, Must Flow, dryer.**

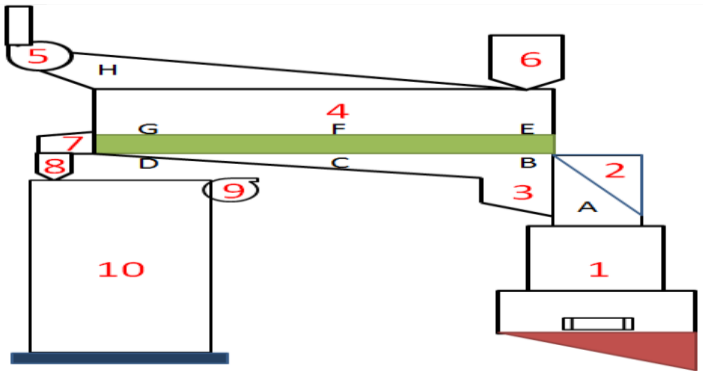
I. INTRODUCTION

Soponronnarit S. [1] studied drying of high moisture content Paddy which the fluidization technique. The factors affecting on the paddy rice quality and the electrical consumption to drying un-husk rice have not yet been solving. Therefore the fresh paddy harvest from the field to the drying process must be additionally done to reduce the moisture content before sending to the dry storage [2], [3]. Whenever the dehumidifier is dried quickly it must be using more energy. Nowadays, the dryer methods use the specific energy consumption in the range of 4 to15 MJ/kg $water_{evap.}$ [4], [5]. Fluidized Bed and Spouted Bed dryer which is used as an industrial drying dehumidifier able to dry quickly but they are sensitively effect to the product quality, however they given better performance for drying of the high moisture content un-husk rice grain[4], [6].Generally, the dryer machine can be divided into 3 types such as grain moving, grain static, grain combination. The grain moving dryer can be separated into two types which are LSU dryer and Fluidized Bed dryer. For LSU dryer, the fresh paddy drop through the air vertically by gravity force and flows through the baffles and moves in the horizontal plane pass through the horizontal flow air [7], [8]. Drying process to reducing moisture content in fresh paddy is needed to used high temperature and short residence time in order to keep high nutrition value as well as to maintain the qualification of paddy to protecting bacteria or fungi harmful to consumers. For all paddies drying machine using in rice mills normally produce the different of the final moisture content grain at the high level. It is likely to be hazard to various microorganisms [9].This problem can be eliminated by using the drying process to meet standard moisture content. If the fresh paddy reaches the standard moisture content, it will reduce the long-term impact to the consumer's health problems in the future. Then the "Must Flow dryer" has been developing to substitute the previous ones. It is able to use the renewable energy which is taking from rice mills (husk) to produce the hot air for entering the dryer zone.

II. MATERIALS AND METHOD

A Must Flow Paddy dryer with capacity of 20 tons/h was fabricated by Musta Engineering Company limited, Bangkok and tested at Nathong Rice Mill, Chacheoungsaow Province, Thailand. The Must Flow paddy dryer has been divided into ten units, each unit comprised of a husk furnace and combustion chamber, a backward curved blade centrifugal blower

driven by the motor 7 kW, the steel sheets screen size 1.2 x 7.0 x 1.4 m which has the thickness 5 mm and diameter holes 1.8 mm. The chamber unit comprised of revolution cams, watch springs motor 3 kW with vertical amplitude of 12.5 cm, feed hopper, feed valve, discharge valve, the detail as show in Fig. 1 and Fig. 2.



1. Husk Furnace
2. Safety valve
3. Main hot air
4. Must Flow chamber
5. Exhaust blower
6. Fresh paddy Hopper
7. Discharge Valve
8. Shutter elevator
9. Suction blower
10. Silo tank

Fig.1: Diagram of a Must Flow paddy dryer.

During drying process, is picked up ovary30 minute to investigate their moisture content and test quality. The sampling paddy positions temperature measuring are were shown in Fig. 1, temperatures were measured(A,B,C,D,E,F,G,H) by a thermocouple type K, connected to a data logger with an accuracy of ± 1oC. An electrical power was measured by a clamp-on meter with an accuracy of ± 0.5 %.

Fig. 2: Photograph of a Must Flow paddy dryer.

III. MUST FLOW PADDY DRYER

The proposed process which is called Must Flow paddy dryer is expected to dry fresh rough rice in short time period without damage [10]. The advantage of this process are able to reduce the side effects, energy consumption, and environmental friendly, It also give high head rice yield, as well as concern the quality of rice. Fig. 2, illustrates the feature of Must Flow paddy dryer. The hot air flows from the husk furnace through the rough rice layer and leaves at the top of chamber through the hopper unit. The high moisture content rough rice fed into the drying chamber and controlled by feed valve. Density of the paddy is used as the selective criteria for the final product. The dried paddy is fed from the chamber by discharge valve then stored in silo tank. During the drying process, the paddy will be separated into short grain, medium grain, long grain, and damaged grain. The beginning stage of drying process is mainly involved in heat exchanging which is able to separate into 3 phases namely preheat, moisture content discharge, and moisture content blowout. The overall process takes time 120 second for long grain paddy. The heat exchanging process is derived from the thin layer theory. The hot air vertical flow of 0.48 m/s is force to flow through the layer of paddy. Fresh paddy is slowly fed forward and be sorted by density and porosity of paddy layer. Heat exchanging and moisture releasing are appearance completed vertically. Relative velocity between hot air and paddy inside Must Flow dryer is very high so that moisture content is removed continuously at very high rate in the chamber while the hot air as well as moisture content flow throughout the chamber's section. Paddy is lifted and dropped in relative to the moving forward direction because

the moisture paddy will drop to the below of grill. The relative velocity drop is very high in short residence time. All grain is forced to move forward by the particular temperature strictly control at mention above, the quality of dried paddy and head rice yield is high. The hot spot phenomenon is rarely occurring. The moisture content is controlled well then the growth of micro-organism, fungus and bacteria is limited.

IV. RESULT AND DISCUSSION

In this research, Must Flow paddy dryer with were tested the total fresh rough rice sample 420 tons. The characteristics of the paddy drying are as follows: paddy feed flow rate at 20 t/h, drying hot air velocity in chamber at 0.48 m/s, drying air temperature setting at 150 ^{o}C, revolution drying chamber at 280 rpm, and vertical amplitude at 12.5 cm. Experimental results shown is table 1, 2 and 3. Initial moisture content of paddy is 27- 30 %wb, final moisture content of paddy is controlled at 14.9 - 15.1 %wb. The dryer operate continuously, the paddy will be clean by using pre-cleaner. The sampling 300 g of high moisture rough rice and dried paddy has been tested to find the average time and the moisture content by using the G won/GMK- 303 standards. This experimental was conducted for 10 hours. Before drying, the head rice yield, whiteness color index and gum gelatinized has been measured [11], [12]. The moisture content must be measured continuously to adjust the proper temperature in the drying chamber for each batch of paddy .The physical properties and testing conditions of the Must Flow paddy dryer shows in Table I and its properties is compared to the Relying Sunny Breezes and the Fluidized Bed dryer as show in Table II and Table III respectively.

Table I. Quality of paddy by Hom Pathum rice dehumidifier with Must Flow paddy dryer capacity 20 t/h, Drying Temperature 150^{o}C, and paddy sample 300 g. where BR = Brown Rice, HRY = Head Rice Yield.

Sampling	MC_i (%)	MC_f (%)	BR (g)	Husk (g)	HRY (g)	Whiteness
1	29.9	14.9	240.2	60.6	57.7	40.2
2	29.7	14.9	240.3	61.1	58.2	40.2
3	29.4	15.1	240.1	61.3	58.9	40.1
4	27.3	15.1	240.3	60.8	58.3	40.5
5	28.6	14.9	240.2	60.7	58.6	40.1
6	27.1	15.0	240.1	60.9	58.7	40.4
7	28.2	15.1	240.2	61.4	57.9	40.3
8	28.7	14.9	240.3	61.3	58.4	40.2
9	27.9	15.0	240.3	61.1	58.2	40.4
average	28.61	14.99	240.22	61.02	58.32	40.27

Table II. Quality of paddy by Hom Pathum rice dehumidifier with Relying Sunny Breezes, using paddy sample 300 g. where BR = Brown Rice, HRY = Head Rice Yield.

Sampling	MC_i (%)	MC_f (%)	BR (g)	Husk (g)	HRY (g)	Whiteness
1	27.2	15.1	230.1	64.5	54.72	42.8
2	28.1	15.3	231.3	64.6	54.44	43.7
3	27.4	15.4	230.6	65.1	54.56	42.6
4	27.6	14.8	229.9	64.8	54.32	42.9
5	27.7	15.2	229.5	65.2	54.92	43.4
6	28.3	14.9	230.6	64.7	54.24	43.1
7	27.9	15.5	231.2	65.2	54.33	42.7
8	27.8	15.2	229.8	65.2	54.41	42.3
9	27.3	15.5	229.7	64.9	54.46	42.8
average	27.7	15.21	230.30	64.91	54.49	42.92

Table III. Quality of paddy by Hom Pathum rice dehumidifier with Fluidized Bed dryer capacity 20 tons/h, Drying Temperature 150°C, and paddy sample 300 g. where BR = Brown Rice, HRY = Head Rice Yield.

Sampling	MC_i (%)	MC_f (%)	BR (g)	Husk (g)	HRY (g)	Whiteness
1	28.5	15.2	225.2	66.2	55.12	38.3
2	28.4	15.6	221.4	66.4	55.34	38.5
3	28.2	14.4	229.3	65.7	55.17	38.7
4	27.5	15.3	222.4	66.8	55.41	35.2
5	27.6	15.6	224.1	66.9	55.39	33.1
6	27.4	14.8	230.6	65.4	55.46	37.6
7	27.7	14.9	221.7	67.1	54.67	38.6
8	28.3	14.3	223.5	67.8	54.78	38.4
9	28.2	14.1	229.8	67.3	55.23	38.2
average	27.98	14.91	225.33	66.62	55.17	37.40

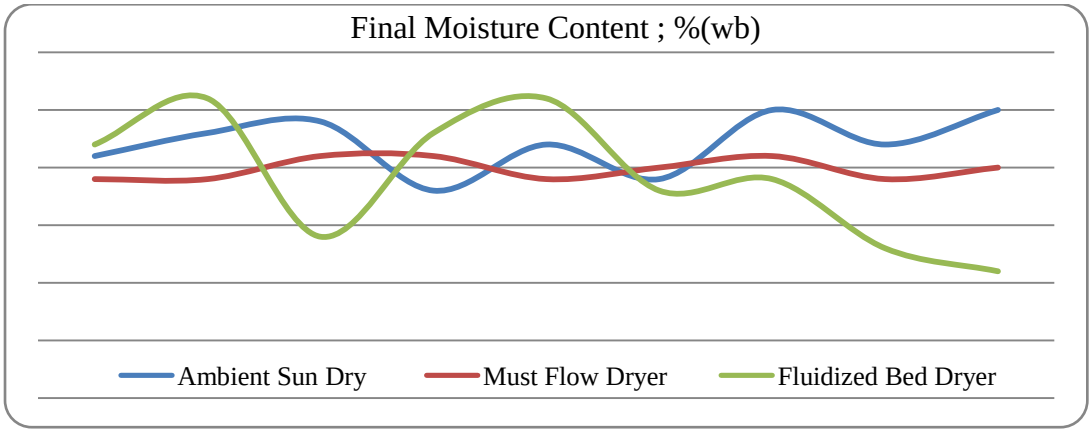


Fig.3: Comparison of the final moisture content of paddy.

Table IV: Comparing the energy consumption of the grain drying process.

Item	Description	Must Flow Dryer 20 t/h		Fluidized Bed Dryer 20 t/h	
		Name Plate (kW)	Current (amp.)	Name Plate (kW)	Current (amp.)
1	Elevator 1	3	4.92×10^{-3}	3	4.88×10^{-3}
2	Cleaner	3	4.73×10^{-3}	3	4.79×10^{-3}
3	Elevator 2	3	4.66×10^{-3}	3	4.71×10^{-3}
4	Poro Dryer	5	8.43×10^{-3}	-	-
5	Blower Dryer	7	0.012×10^{-3}	45	11.52×10^{1}
6	Elevator 3	3	4.61×10^{-3}	3	4.59×10^{-3}
7	Blower Cond.	5	8.36×10^{-3}	5	8.41×10^{-3}
8	Shuttle Vale	3	4.23×10^{-3}	3	4.22×10^{-3}
9	Belt Elevator	5	8.16×10^{-3}	5	8.22×10^{-3}
10	Feed Husk	3	3.96×10^{-3}	3	3.89×10^{-3}
11	Blower Husk	1	1.42×10^{-3}	1	1.46×10^{-3}
12	Screw Ash	1	1.42×10^{-3}	1	1.45×10^{-3}
Summation		42		75	

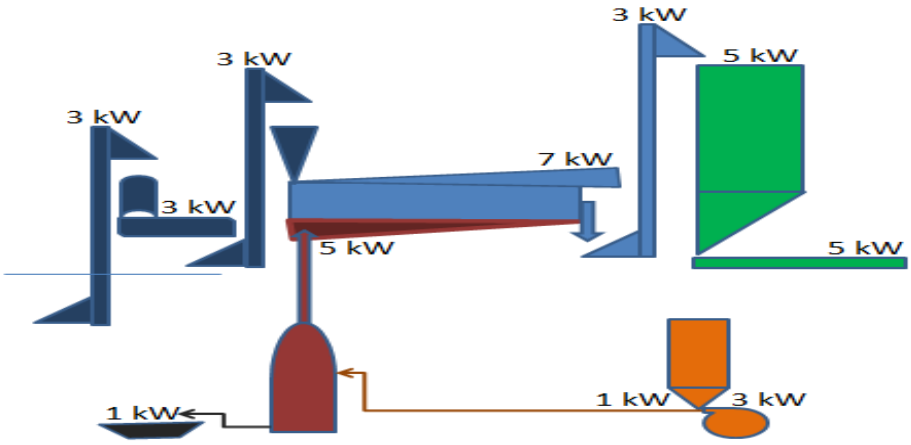


Fig.4: N Electrical power consumption diagram of Must Flow paddy drying process.

The quality of fresh paddy is tested, this research using in three types of paddy dryers to remove the moisture. First type, using Relying Sunny Breezes or with an outdoor concrete patio to dry for 3 days (from 9.00 am to 17.30 pm).Second type, using Fluidized Bed dryer to dry fresh rough rice capacity 20 t/h at drying temperature 115 ^{o}C. And third type, using Must Flow dryer to dry fresh rough rice capacity 20 t/h at drying temperature of 150 ^{o}C. In this research, using the fresh rough rice Hom Pathum rice from Chacheoungsaow Province, Thailand. Table II shows quality of paddy Hom Pathum rice dehumidifier using relying sunny breezes dried, this method drying on concrete patio thickness 2 cm and then the grain yield spread back with the bulldozer every 30 minutes. Distinguish of nine times were used to sampling the grain at the same place. The final moisture content fall into the range of 14.2 – 15.5 %wb, which is a gap of 1.3 %wb, the head rice yield fall into the range of 54.32–54.92 %, and the whiteness color index fall into the range of 40.1–40.7 (show in fig. 3). Table III shows the final moisture content of the Fluidized Bed dryer with nine sampling, the final moisture content fall into the range of 14.1 - 15.6 %wb, which is a gap of 1.5 %wb. The head rice yield fall into the range of 54.67 – 55.46 % and the whiteness color index fall into the range of 33.1–38.7. Table I shows the final moisture content of the Must Flow dryer which nine times sampling, the moisture content fall into the range of 14.9-15.1%wb which is a gap of 0.2 %wb, the head rice yield fall into the range of 57.7 % to 58.9 % and the whiteness color index in range 40.1 to 40.5. It can concluded that the method of drying dehumidifier of Must Flow dryer is able to make the final moisture content close to the same value, and derive the head rice yield higher than Fluidized Bed and concrete patio dryer. And found that the whiteness color index value of its fall into between the exposed concrete patio and Fluidized Bed dryers. In term of electrical energy, for the exposed concrete patio does not require electricity but it use a lot of labour force (about 50 persons per concrete patio) and must take time to reduce humidity for 3 days (about 26 hours). For the Fluidized Bed data as shown in Table 4, which can combine the total electric power consumption of the drying process 75 kW, the main power of its use for drive the fan to create a pressure drop in the drying chamber to achieve a phenomenon fluidized bed most about 45 kW. Must Flow dryer using the total electric power consumption 42 kW, regarding the main power for 12 kW, 5 kW uses for a phenomenal Must Flow in a drying room and for moving the drying chamber to create porosity drying bed and 7 kW uses for move the moisture out of the chamber by the blower

For above mention found that the techniques to reduce the moisture content between Fluidized Bed dryer and Must Flow dryer are different, as shown in Fig. N. The electrical power consumption of Must Flow dryer using less than Fluidized Bed dryer about 33kW and economize 12 men per shift operations to maintain control of the drying process and collect samples for analysis.

V. CONCLUSIONS

By using Hom Pathum rice which is grown in Chachoengsao province at the quantity of 420 tons to be the sample to test for drying dehumidifier. It found that the moisture content is able to be reduced into different level due to the different methods such as Relying Sunny Breezes or concrete patio dryer will provide the head rice yield average 54.62 %, can reduce the humidity to final moisture content at the average of 14.85 %wb, and give the whiteness color index at the average of 40.4.Fluidized Bed dryer the time taken of drying process shorter and using less lab or force than the Relying Sunny Breezes or concrete patio dryer. It can produce the head rice yield at the average of 55.06 %, the final moisture content at the average of 14.85 %wb, and give the whiteness color index at the average of 35.9. Regarding the Must Flow

dryer for drying, it can operated at superior level because of it can save the electrical power consumption 33 kW, the final product has met the criteria of the head rice yield at the average of 58.3 %, the final moisture content at the average of 15.0 %wb, and give the whiteness color index at the average of 40.3 which is fallen in between the concrete patio and the Fluidized Bed dryer.

Notice that the results of analysis from the operator's questionnaires, the response found that the Must Flow dryer is more convenience use and easier control of the drying process than the Fluidized Bed dryer.

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