DEVELOPMENT of CONTINUOUS GRAIN DRYER

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ABSTRACT

Post harvest processes for rice include drying, storage and processing. Drying has a great effect on the quality of the grain. The existing rice centers are with the ill equipped, especially with drying and storage facilities. The rice harvesting has bully mechanized, a large volume of rice with high moisture content are taken to the rice processing complex(RPC). Three, the need for drying and storage facilities becomes more urgent. At present the daily drying capacity of RPC can't exceed over 40～50 M/T. Therefore new technology and facilities for a high quality and main efficient drying should be introduced one such technology is the continuous flow drying system.

This research, aims to test performance efficiency the mixed continuous flow grain dryer was whose daily drying capacity is 100 M/T. The results of the performance tests of the dryer are shown as follows;

(1) The temperature distribution of the drying modules were measured by a temperature recorder. The fifth module showed the highest value, followed by the seventh and the third.
(2) When the intake air temperature was 55℃, the drying rates were 1.7 and 2.6%,wb/pass in the exhaust temperatures of 20 and 22℃. And when the intake air temperature was 60℃, the drying rates were 1.7 and 2.3%,wb/pass in the exhaust temperatures of 22 and 25℃.
(3) The average increased rate of cracked grains after the drying process was 0.7% which is below the tolerance limit (2.0%) of the continuous grain dryer.

INTRODUCTION

Post harvest processes for rice consist of drying, storage and processing with the drying has a great influence on the quality of the grain. Mechanization of harvesting of rice, it is necessary that rice be dried fastest possible time because of the large volume of rice that has to be dried daily capacity and shortened the harvest time. To maintain quality of rice, drying must be done as soon as the grains are harvested from the farm. RPC has been in existence for ten years, and there are 312 centers nation established. There is an urgent need of a large grain dryer in RPC.

What it is installed presently at the RPC a small scale drying which is used that drying and storage. The government is targeting to install drying and storage facilities -- 360 sites by year 2004. At present the daily drying capacity of RPC can't exceed over 40～50M/T therefore new technology for high quality and more efficient will be promoted drying should be introduced and the continuous flow drying system.

In this research the continuous drying of mixed type was developed and it is proved drying performance will be tested and quality.

MEHTODS AND MATERIALS

Test materials

Fig. 1 Schematic design of the continuous grain dryer.

Variety of rice used for the experiment was "CHUCHUNG", cultivated in Nonsan of Chungnam Province, harvested in the tenth of October 1999. The inlet air temperature of the drying chamber was set at 60 and the outlet air temperature of cooling chamber was set in 25℃. The drying capacity was over 100 tons/day. The initial moisture content of rice was 21.3, 18.6 and 17.8% at wet base, respectively.

Drying apparatus

a. Equipment

Fig. 1 and Table 1 show schematic design and specifications of the continuous grain dryer. The prototype grain dryer consists of eight parts: storage, drying and cooling modules, heater, turbo cleaner, discharge equipment and outlet and inlet duct. The air duct of the drying module was designed into a triangle type. We can see the drying room though the perspective windows. The ambient air inducing duct consisted of a variable damper to control the airflow rate for drying. To remove the dust, it has three gates at the bottom part of outlet duct.

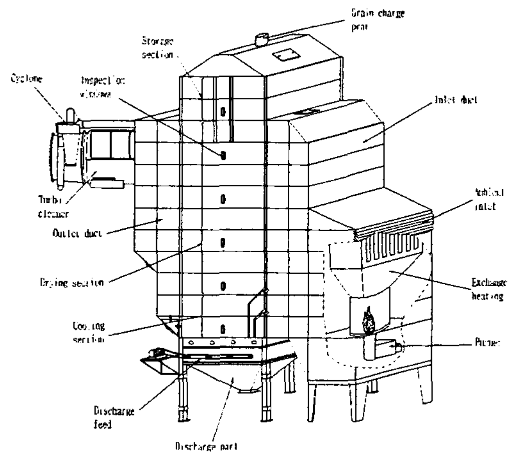

Fig. 1. Schematic design of the continuous grain dryer.

b. Continuous drying system

Fig. 2 is a photograph of commercial continuous drying system. When the continuous the dryer turns on, it works in an automatic mode. And then rough rice is put into dryer and the weight is measured in the hopper scale, then it flows into the dryer. At first the cooling module was filled with rough rice, then the drying and the storage modules were filled to signal turns. And when a signal was generated from a low-level sensor in the storage modules, the burner was ignited and the discharge feeds were operated. In the drying chamber, when the rough rice drops though the gravity, the heated air pass through them in the horizontal direction.

Table 1. Specifications of the continuous grain dryer.

Items			Specifications
Total system	Dryer	Size(L× W× H)	8,751× 1,992× 8,440mm
		Capacity	10ton/batch
	Tempering bin type & capacity		Cylinder type, 100ton× 2sets
Storage module	Size(L× W× H)		1,992× 1,992× 1,510mm
	Level sensor		2(upper/lower)each
	Module number		3 stage
Drying module	Size(L× W× H)		1,992× 1,992× 4,000mm
	Module number		8 stage
	Air duct type		Triangular type
Chilling module	Size(L× W× H)		1,992× 1,992× 1,000mm
	Module number		2 stage
Heated inlet duct	Size(L× W× H)		1,992× 945× 5,000mm
Heated outlet duct	Size(L× W× H)		1,992× 1,009× 5,000mm
Discharge apparatus	Motor power		1kW
	Motor speed reduction ratio		1:150
Turbo cleaner	Air flow rate		565cmm
	Motor power		30kW
Heating apparatus	Burner capacity		650,000~750,000kcal/hr

The storage chamber consist of two modules, it has no air duct. And the distance between the low and high level sensor is 300mm in the storage section. The level sensors control the rough rice supplying device and the burner. The drying chamber consists of eight modules, each module has a pair of air duct. The inlet and outlet of hot air duct are opened in the opposite direction with triangular shape. The height difference between them is 250mm. Therefore, the rough rice during drying moves down as a zigzag line. The air ducts were designed with taped angle of about 1° considering the pressure loss. The cooling chamber consists of two modules. In this chamber, the rough rice heated during the drying process cools down. The significant temperature difference between discharge grains and ambient air causes the grains to crack. The discharge equipment controls the volume of rough rice that settles to the bottom of dryer. If the outlet temperature is lower than the setting temperature, the discharge amount of rough rice will be less. A turbo cleaner exhausts the moist air from the drying room. It is designed that the airflow in the drying chamber was equivalent in every point. A cyclone beside of the turbo cleaner is located. It removes the dust from the exhaust air. Two thermostats are installed in inlet and exhaust duct to prevent overheating or burning. The system is controlled by a central control panel, and in case is an emergency, an alarm will sound off from a speaker of the control panel.

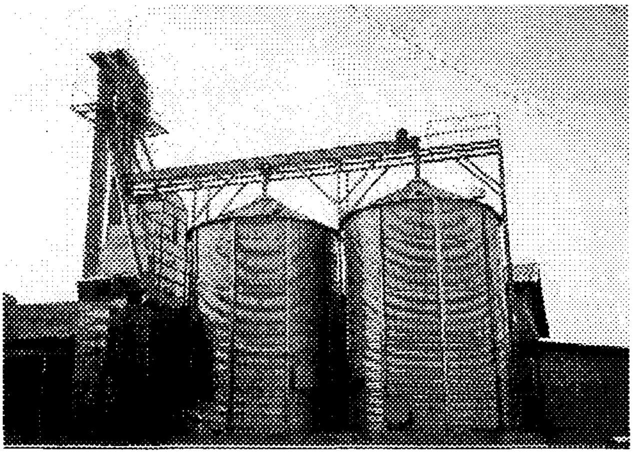

Fig. 2 Photograph of the continuous grain drying system.

Methods

a. Moisture

The moisture content was measured every five minute by picking up the ten samples during the drying time and calculation was made using the arithmetical mean method. It was measured using electronic resistance moisture meter, CTR800(manufactured by HAN SUNG Co., Korea) which can count single grain.

b. Temperature

The temperature distributions in the dryer were recorded with thermocouples of 30 equipped with a hybrid record(YOKOGAWA, DR242). Fig. 3 shows the measuring positions in the continuous dryer. The temperatures were measured every 10 minutes.

c. Performance of drying

Drying performance was expressed into the drying ratio which indicates the reduced moisture content when the rough rice passed through the dryer. The time for one cycle is 30 minutes. The rough rice discharged during the first 15 minutes has to be recirculated.

d. Crack ratio

The rough rice was sampled before and after drying and the crack ratio of samples was evident in the appearance of brown rice. The crack ratio indicates the number of cracked grains among 1,000 grains. The measuring tool was TX-200(KETT, Japan) which can measure 50 grains in a time.

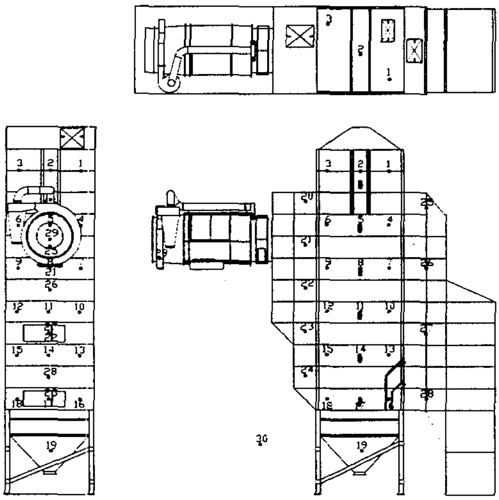

Fig. 3. Position of temperature measurement for the continuous grain dryer.

e. Performance of turbo cleaner

The static pressure and airflow rate were measured on the performance test of turbo cleaner when the grain was not charged and when charged whether operating or not. The static pressure was measured by the manometer of U type(YOKOGAWA, Japan). The air flow rate was measured by the velocity meter(Testo-452, Germany). The measuring positions were located at the inlet and outlet duct and the measuring method used one of Korean Standards. Fig. 4 shows the velocity measuring positions in the turbo cleaner.

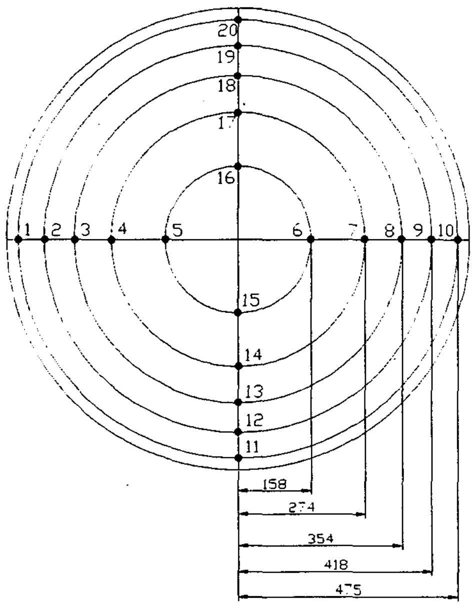

Fig. 4. Position of static and velocity measurement in turbo cleaner for the continuous grain dryer.

RESULTS AND DISCUSSIONS

Drying Experiment

a. Moisture content

Fig. 5 shows the change of moisture content during the drying process. In the first and second experiment, the drying air and discharge grain temperature were 55℃, 22℃ and in the third experiment, 60, 25℃ respectively. In the first experiment, the initial MC of rough rice was 21.3%,wb. When it passed through the dryer one time, the MC decreased 18.6%,wb, and when it poured into the tempering bin. In the second experiment, the initial MC was 18.6%,wb. The change of MC showed an easy slope until 10 minutes after it start drying, and then it slighty decreased 18.2%,wb. The initial moisture content in the third experiment was 17.8%,wb. The first half of drying curve shows the constant-ratio period of drying and the second half shows the falling-rate period.

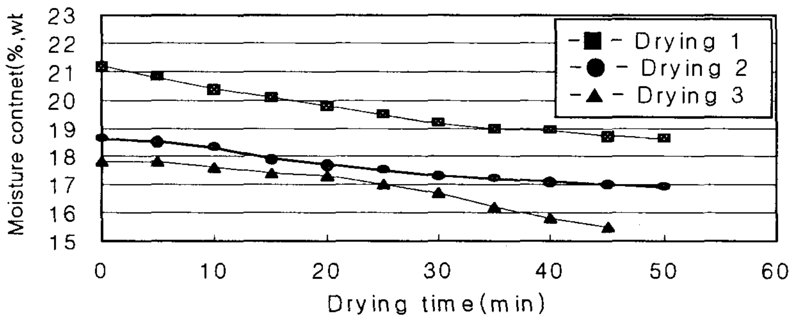

Fig. 5 Change of moisture content within rough rice during time.

b. Performance of drying

Table 2 shows the drying ratio. The first and second experiment showed that the drying ratio was 2.6, 1.7%,wb/pass, respectively. And though the initial MC was a low value, moisture ratio shows 2.3%,wb/pass.

Table 2. Drying rate of the rough rice.

Drying time	Drying conditions	Initial MC	MC after one pass	MC rate after one pass	Remarks
First drying	Drying temp.:55℃ Discharge air temp.:20℃ Discharge grain temp.:22℃	21.2	18.6	2.6	Design Value : 2~3 %/pass
Second drying	Drying temp.:55℃ Discharge air temp.:20℃ Discharge grain temp.:22℃	18.6	16.9	1.7	
Third drying	Drying temp.:60℃ Discharge air temp.:22℃ Discharge grain temp.:25℃	17.8	15.5	2.3	

Fig. 6 shows temperature distributions of drying section. The drying air temperature was highest in the fifth layer and it was the seventh layer, the third layer in descending order. Therefore a heating distributor should be install in front of the fifth layer to minimize the temperature deviation. Fig. 7 and 8 show the temperature distribution of the cooling and drying module on the plate, respectively. In the drying test, when the air was heated by air heating system, the air temperature of inlet duct was higher than the exhaust duct. We measured the air temperature of inlet duct, center and exhaust duct in the drying room. The distribution curve of the drying air temperature in cooling module showed the shape as one in drying module, and the temperature difference of drying air between inlet and exhaust duct was 2℃.

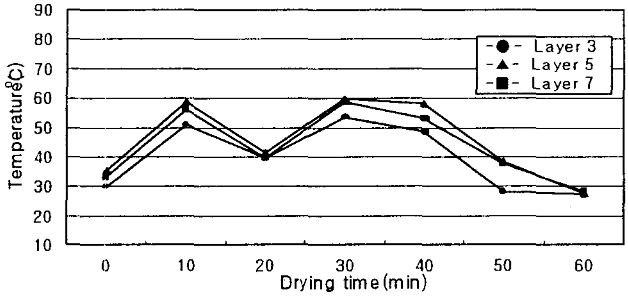

Fig. 6. Distribution temperature of drying section

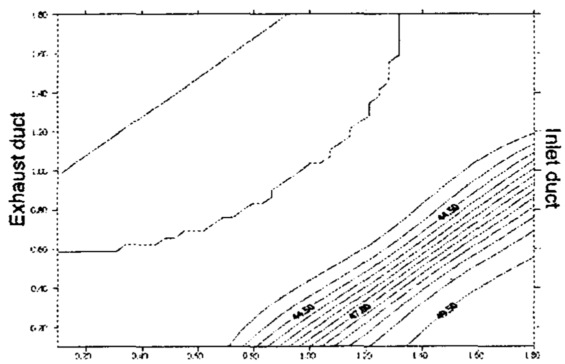

Fig. 7. Distribution of temperature in the drying module on the same plate.

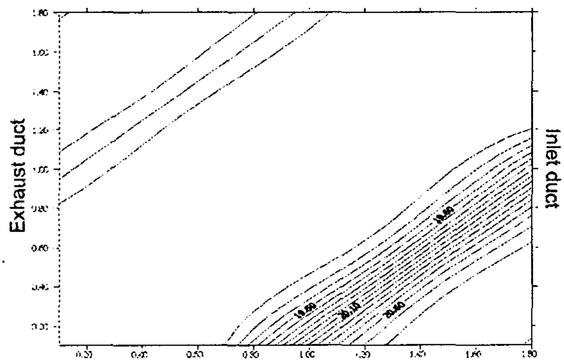

Fig. 8. Distribution of temperature in the Cooling module on the plate.

d. Crack ratio

Table 3 shows the quality of rough rice before and after the drying. In the first test though, the initial crack ratio showed higher value than other tests, the crack ratio after drying increased by 0.7%, But the increased crack ratio has no effect on the drying performance.

Table 3. Crack rate of rough rice.

Drying time / Items	First drying	Second drying	Third drying
Before drying	4.6	3.5	3.5
After drying	5.3	3.7	4.3
Variation	0.7	0.2	0.8

e. Performance of turbo cleaner

Table 4 shows the performance of turbo cleaner. And it was described as the air flow rate. The performance test of the turbo cleaner shows that airflow rate was 565cmm, static pressure was 87mmAq. The results were in accordance with the theoretical values for dryer design. Table 5 shows static pressure of inlet and exhaust duct. The static pressure of exhaust duct was about 30mmAq higher than the inlet duct independent of opening dampers. And the static pressure of the empty state was higher than one of the grain full state in the drying module.

Table 4. The performance inspection of turbo cleaner.

Items	Discharge Rough rice	Charge Rough rice	Theoretical
Air flow(cmm)	4.6	3.5	3.5
Static Pressure (mmAq)	5.3	3.7	4.3

Table 5. Static pressure of heated inlet and exhaust duct part.

Items	No rough rice in the chamber			Charge & no drain rough rice	Charge & drain rough rice
	Damp closed	Damper of one open	Damper two Open		
Inlet duct	42.8	37.6	33.1	34.1	33.6
Exhaust duct	77.8	68.0	59.2	76.9	70.9

CONCLUSIONS

In this research was developed a continuous grain dryer and drying performance test was undertaker. and the result are shown as follow:

a. The drying air temperature showed the highest value in the fifth layer fallen by the seventh layer, and the third layer in that order. It is recommended that a heating distributor should be installed in front of the fifth layer to minimize the temperature deviation. The air temperature of inlet duct, center and exhaust duct were measured in the drying room. The distribution curve of the drying air temperature in cooling module showed the shape as one in drying module, and the temperature difference of drying air between inlet and exhaust duct was 2℃.

b. The performance test of turbo cleaner shows that airflow rate was 565cmm, static pressure was 87mmAq. The results were in accordance with the theoretical values for dryer design. The static pressure of exhaust duct was about 30mmAq higher than inlet duct and independent of opening dampers.

c. In the first and second experiment, the drying air and discharge grain temperature were 55℃, 22℃ and in the third experiment, 60, 25℃ respectively. In the first experiment, the initial MC of rough rice was 21.3%,wb. When it passed through the dryer once, the MC was 18.6%,wb, and then it poured into the tempering bin. The initial moisture content in the third experiment was 17.8%,wb, the first half of drying curve shows the constant-ratio period of drying and the second half shows the falling-rate period.

d. In the first test though the initial crack ratio showed higher value than other tests, the crack ratio after drying increased by 0.7%, But the increased crack ratio has no effect on the drying performance.

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