Official Test of Rice Dryer in Japan

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There are several types of rice dryer on farm drying in Japan. They are the flat bed type forced air dryer, the upright type forced air dryer and the grain circulation type heated air dryer. For further details of them the reader should refer to "Rice Drying and Rice Dryers in Japan" in JARQ, Vol. 4, No. 3, 1969.

We have three test codes for each type of rice dryer[1),2),3)]. However, tests of the flat bed type forced air dryer and the upright type forced air dryer have not been undertaken during the last few years. Hence, the outline of the test code for the grain circulation type heated air dryer will be described hereunder.

Test procedures for the dryer

The test shall be conducted by the following items: (1) Check of construction, (2) Drying performance test, (3) Fan performance test, (4) Controlling performance test, (5) Dryer handling test and (6) Investigation after disassembling.

The main dimension, weights, materials, equipment and so forth are ascertained on the check of construction. Handling of dryers, safety in operation, fireproof character, cleaning of each part and the minimum volume requirement for drying, etc. are evaluated in the dryer handling test. For investigation after disassembling, the dryer disassembled completely after the test is examined and abnormalities or troubles are detected if any.

Further explanation for the check of construction, the dryer handling test and investigation after disassembling are omitted here as these check procedures are well known.

Drying performance test

The object of this test is to find out the drying performance and operating condition of the dryer for paddy.

The dryer is set in the balance (truck scale) without fuel tank and the drying chamber is fed with paddy up to the maximum holding capacity specified by the applicant. As a rule, the moisture content of the paddy used for drying shall be 20 to 25 per cent.

For the measurement of temperatures in ventilating and intake air, a thermocouple type thermometer is used, and the thermocouple elements are hung on the screen of the air chamber in the drying chamber. A wattage meter for measurement of the required electricity and a scale for the fuel consumption are used.

An air oven and a pression balance for the moisture content of the paddy are used but for the estimate of initial moisture content of the paddy, an infrared drying type or an electric resistance type rapid measurement moisture meter is used.

Drying operation is continued until the moisture content of the paddy shall be reduced to 14 per cent. Weight of the paddy with the dryer is measured every one hour. Drying process shall be discontinued when the weight of the paddy is reduced to the estimate of the paddy weight which is to be calculated by the following formula:

$$W=\frac{(100-m)}{(100-14)}(W_1-w)$$

W: Estimate of the paddy weight (kg) at the termination of drying.

W_1: Total weight (kg) of the loaded paddy.

w: Weight (kg) of loss or dispersed paddy during drying.

m: Mean moisture content in the sample grain at the initiation of drying.

The weight of the total loaded paddy and the time required for loading are measured to calculate the hourly loading capacity, and the total weight of paddy before unloading and the time required for unloading are measured to calculate the hourly unloading capacity.

During loading and unloading about 500 g of sample paddy are taken out, and 1,000 kernels are husked to count cracked kernels and the increasing rate of cracked kernels is determined.

Each remainder of the sample paddy are investigated damaged grain (hulled grain, half hulled grain and broken grain). The increasing rate of damaged grain is calculated.

Twenty pieces of sample paddy (about 10 g each) are collected before they are loaded to the dryer to calculate the mean moisture content of paddy at the initiation of drying.

When the drying process is over, 20 pieces of sample paddy (about 10 g each) are collected at the fixed interval to calculate the mean and unevenness of moisture content in the drying. The unevenness of moisture content is expressed by the coefficient of variation. The formula for it is as follow:

$$U=\frac{1}{\bar{m}}\sqrt{\sum_{i=1}^{n}\frac{(m_i-\bar{m})^2}{(n-1)}}$$

U: Coefficient of variation for moisture content at the termination of drying (—)

$\bar{m}$: Mean moisture content in the sample paddy (%).

m_i: Moisture content in each sample paddy (%).

n: Number of samples.

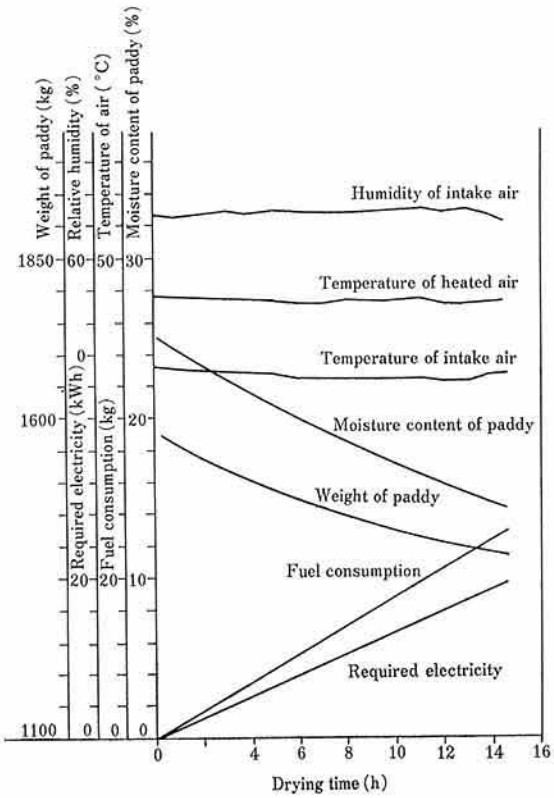

Fig. 1. An example datum on the drying performance test

Table 1. Test results of the official tests of the grain circulating type heated air dryers

Items	Range of results	Mean of results
Maximum holding capacity of paddy (kg)	1,070～2,590	1,850
Time for loading paddy (min)	22～ 47	31
Time for unloading paddy (min)	17～ 36	28
Coefficient of variation for moisture content at the termination of drying (—)	0.007～0.021	0.013
Increasing rate of damaged grains (%)	0～1.0	0.11
Increasing rate of cracked kernels (%)	0～1.8	0.4
Mean drying rate (%/h)	0.63～0.89	0.75
Static pressure efficiency (%)	40～ 50	43
Variation in the temperature on the screen of flow passage (%)	1.2～20.3	9.3

Then, the quality of paddy is investigated on germination percentage, milling ratio, staining, odor production, etc.

An example of the data during the test is shown in Fig. 1. Test results of many dryers are shown in Table 1.

Fan performance test

The object of this test to find out the fan performance inclusive of heater and to obtain the data for estimation of the air flow rate for drying.

Test equipment shall be arranged as is illustrated in Fig. 2.

An electric dynamometer shall be used for measurement of the input power. A pilot tube shall be used to measure the air flow rate. A Gottingen type manometer or a micro pressure difference indicator of the same accuracy shall be used to measure the pressure.

Air flow rate shall be calculated based on the velocity of flow that is deduced from the mean of dynamic pressure at the 20 points placed on the cross sectional plane of the test duct for the measurement. Static pressure shall be calculated based on the mean static pressure sampled at two holes bored on the test duct for measurement.

The formulas for calculation[4] are as follows:

$$Q=A\sqrt{\frac{2g\cdot hd}{r}}$$

Q: Air flow rate (m^3/s).
A: Sectional area of test duct (m^2).
g: Acceleration of gravity (9.8 m/s^2).
hd: Mean dynamic pressure (mm Aq or kg/m^2).
r: Weight of air at the testing (kg/m^3).

$$r=\frac{0.034\cdot P}{(273.2+t)}$$

P: Absolute pressure of air in the test duct (mm Aq).
t: Dry bulb temperature (°C).

$$Pt=hs+hd+\Delta p$$

Pt: Total pressure of the fan (mm Aq).
hs: Static pressure of the test duct (mm Aq).
Δp: Pressure loss of the test duct (mm Aq).

$$\Delta p=\frac{0.025\cdot L\cdot hd}{D}$$

L: Length of the test duct between the static pressure measuring position and the fan outlet (m).
D: Internal diameter of the test duct (m).

$$Ps=Pt-hd(D/D_f)^4$$

Ps: Static pressure of the fan (mm Aq).
D_f: Internal diameter of the fan (m).

$$Ys=\frac{Q\cdot Ps}{75\cdot B}\times 100$$

Ys: Static pressure efficiency (%).
B: Input power (PS).

Otherwise, the pressure at the center surface of the boss of the fan is measured and used for estimation of the air flow rate of drying.

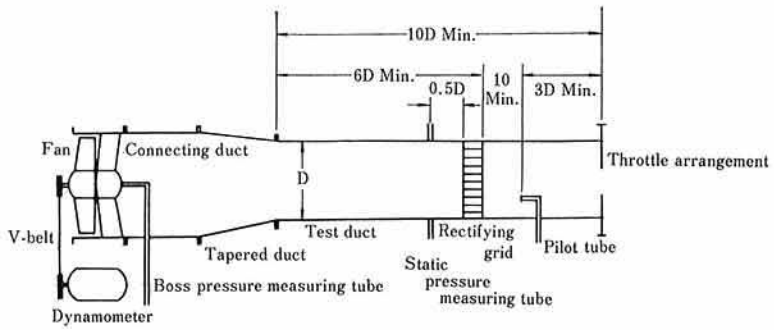

Fig. 2. Test equipment for the fan performance test

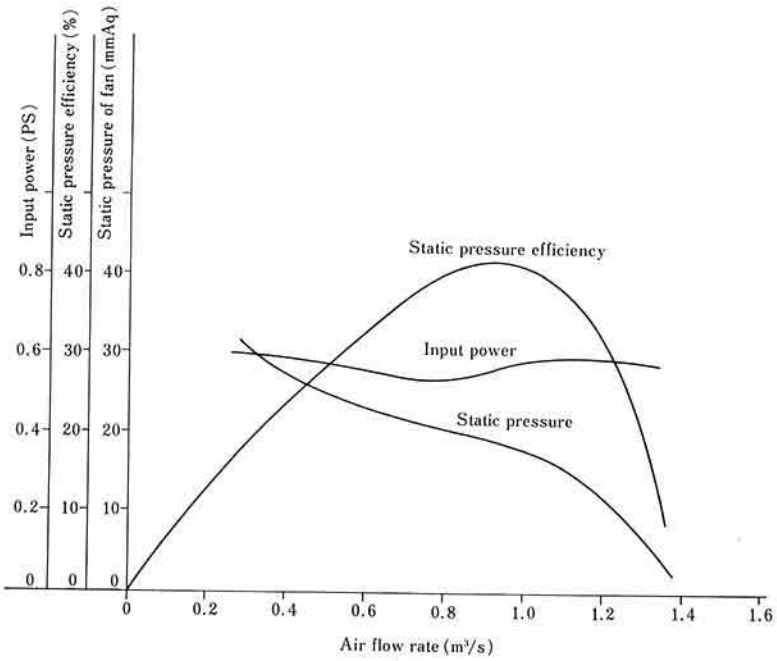

Fig. 3. An example of the results of the fan performance test

An example of the results of the fan performance test is shown in Fig. 3.

Controlling performance test

The object of this test is to find out the controllability of temperature of the heater.

A thermocouple type thermometer shall be used to measure the variation in the temperature of the drying air. The screen of the air chamber in the drying chamber shall be equally divided in each area and 12 pieces of thermocouple elements shall be hung around the center of the divided areas.

Grains shall be loaded to the dryer up to the maximum loading capacity of the drying chamber.

Temperature shall be measured in regard to the following two kinds of controlling methods:

1) The dryer shall be driven in the maximum temperature where stabilized operation of the machine is provided. The variation in the built-up temperature (raise) shall be measured for 30 min and temperature fluctuation shall be calculated on the basis of the following formula:

$$H=\frac{Th-Te}{Tm}\times 100$$

H: Variation in the temperature on the screen of flow passage (%).

Th: The maximum value in the mean of the measured temperature at each measuring spot (°C).

Tl: The minimum value in the temperature mentioned above (°C).

Tm: Total mean value of the rising temperature of the air (°C).

2) The dryer shall be driven in the minimum temperature where stabilized operation of dryer is available, and the variation in the rising temperature shall be measured for 30 min.

Standard for passing the test

The standard to pass the test of the grain circulating type heated air dryer is as follows:

1) The drying rate per hour shall be more than 0.6 per cent/h.

2) The coefficient of variation of the mois-

ture content at the termination of drying process shall be below 0.05.

3) The increasing rate of cracked grain shall be below 2 per cent.

4) The increasing rate of damaged grain shall be below 3 per cent.

5) Hourly capacity in loading and unloading grain shall be over 2,000 kg/h.

6) The quality of grain shall not be remarkably downgrade either by staining or odor production.

7) The maximum static pressure efficiency shall be over 35 per cent.

8) The condition of burning shall not be abnormally unbalanced.

9) The temperature of drying air shall not be varied to a considerable large extent.

10) Every part shall be free from the abnormal and outstanding choking conditions.

11) Floating dust and foreign particles shall not be large in volume.

12) The grain parts or such accompanied with difficulty in renewal shall be trouble-free and perform the normal working at any specific time.

13) Each part shall be free from seizing, sticking or jamming.

14) No leak shall be observed in the fuel line of the dryer.

15) Bearing shall be dust-proof.

16) No defect which may endanger the operator during the operation of the dryer on the test.

17) No defect which may be the cause of difficulty to replace or adjust the parts or tune them up or to clean during the operation of the dryer.

18) The dryer shall be free from the threat of the outbreak of fire.

References

1) The test code of the flat bed type forced air dryer: Official Gazette issued on November 6, 1964.

2) The test code of the upright type forced air dryer: Official Gazette issued on October 2, 1968.

3) The test code of the grain circulation type heated air dryer: Official Gazette issued on September 26, 1970.

4) Testing methods for fans and blowers: Japanese industrial standard B 8330.