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Application of Cold Drying Technology to Increase the Germination Rate of Rice Seeds in Vietnam

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---***ABSTRACT***---

Vietnam is an agricultural country with a large area of rice cultivation throughout the country. However, the post-harvest handling still has some limitations, resulting in low product costs. Currently, the rice seed dryers in Vietnam are mostly using coal, gas or oil for operation in direct heat transfer method. Direct heat transfer will increase the risk of localized heat, which reduces the germination capacity of the seed, reducing energy efficiency, bulky equipment, large factory area and space. For modern drying methods such as vacuum drying, sublimation drying, fluidized bed drying that are high cost huge investment and complicated operation, they are less suitable for drying the seeds. Through the results of research and application of heat pump drying technology (cold-drying) show that this drying method has many outstanding advantages compared to the hot-drying technology: materials after drying are products keep natural color, good quality, no environment pollution and energy saving.

KEYWORDS: *Drying technology, cold drying, rice-seed drying, heating pump.*

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I. INTRODUCTION

Cold-drying (also called heat-pump drying) is a drying process conducted at atmospheric pressure using drying agent is moist air which is fed into the evaporator of the heat pump system to lower the temperature below the dew point temperature, then the water vapor is condensed and separated from the air to decrease the humidity ratio, partial pressure of the water vapor in the moist air are decreased, then the air is led into the condenser of the heat pump to be heated to rise the temperature of the air up to the refrigerant condensing temperature and become the moist air having the relative humidity is less than 10%. Then, the drying agent is led into the drying chamber containing materials needing to be dried. By difference of partial pressure between water vapor on the material surface and water vapor in the drying agent, the water vapor of the materials enters the drying agent, and then becoming dry. Due to the low drying environment temperature, the product quality is less affected compared to the original to ensure high economic value [3] & [4]. When cooling the moist air in the heat exchanger to a temperature lower than the dew point temperature, the air becomes a saturated air and water vapor will condense and separate from the air; the humidity ratio will be lower than the initial humidity ratio, then the air will pass through the condenser of the head pump to increase drying potential in drying the materials.

II. MATERIAL AND TECHNOLOGY

1. Material

Rice seeds while preserving still a certain amount of water from 12% to 14% of dry weight. When soaked in water, the seeds absorb water becoming bloated, the moisture in the seeds increase to 25% to be able to germinate. At that time, the starch in the albumen is decomposed into simple substances to provide nutrition for the growth of the germ. Water absorption time is fast or slow depending on old or new seeds, the husk is thick or thin, water temperature for soaking the seeds is high or low. In general, high temperature of air, warm water, old seeds or thin skin which is pervious will result in strong water-absorbing of the seed, thus the seed will reach the required humidity quickly. Soaking the seeds for too long time will result the seeds absorb water excessively, the nutrients dissolve and diffuse into the environment, so that decreasing the nutrients stored in the embryo, the seeds will be rotted and germinate weakly. Water content in the seed suitable for germination process varies from 30% to 40% depending on temperature conditions. The suitable temperature for germination is from 27 ÷ 37^{0}C. Temperatures lower or higher than this temperature will cause the germination of the seeds is weak and the time for germination is prolonged. Under the right temperature and humidity conditions, the germ will grow and puncture the husk and appear outside. Compared to many other seeds, the rice germ requires less O_2.

- When seeds have gone through physiological ripening stage, they can all germinate if they are under favorable conditions. If the storage conditions are not good, it will reduce the quality of the rice seeds.

- Change in hormone balance: The hormone balance that regulates germination or dormancy is the ratio between gibberellin (GA) and abxixic acid (ABA). When the seed is in a dormant state, the ABA content is very high and GA is negligible. Conversely, when the seed absorbs water, the embryo will activate the growth to promote and enhance the synthesis of GA transported out of the embryo and stimulates the synthesis of α-amilase from the aleuron layer. This is an important enzyme that performs the process of decomposition and lysis of starches into sugars used as respiratory materials. Simultaneously, a part of the formed sugar is transported into the embryo as a material for promoting the growth and development of the germ.

In actual production, to break down dormant state, stimulate germination of the seed, there is need to break the dormant state by creating all favorable conditions for respiration such as adequate supply of H_2O, temperature, O_2 or regulate the balance between these two hormones by treating GA_3 to help the seed germinates quickly and evenly.

Type of rice seed for research is BacThom, a product of Hai Duong Seeds Joint Stock Company. Rice corn after harvesting, doing remove impurities, branches and leaves and poor rice seeds by aerodynamic method. Take samples to determine the initial moisture and dry the seeds on rotary drum drying equipment. The input materials are rice seeds without poor rice seed, rot, spoilage or impurities, and having uniform quality.

II. Technology

In 2015, Sao Do University did study, design and successfully manufacture cool-drying equipment to dry agricultural products and rice seeds. In 2017, did the improvement of the cool-drying equipment for drying 3 types of rice seeds. Structure of the rotary drum heat pump drying equipment is shown in Figure 2.1

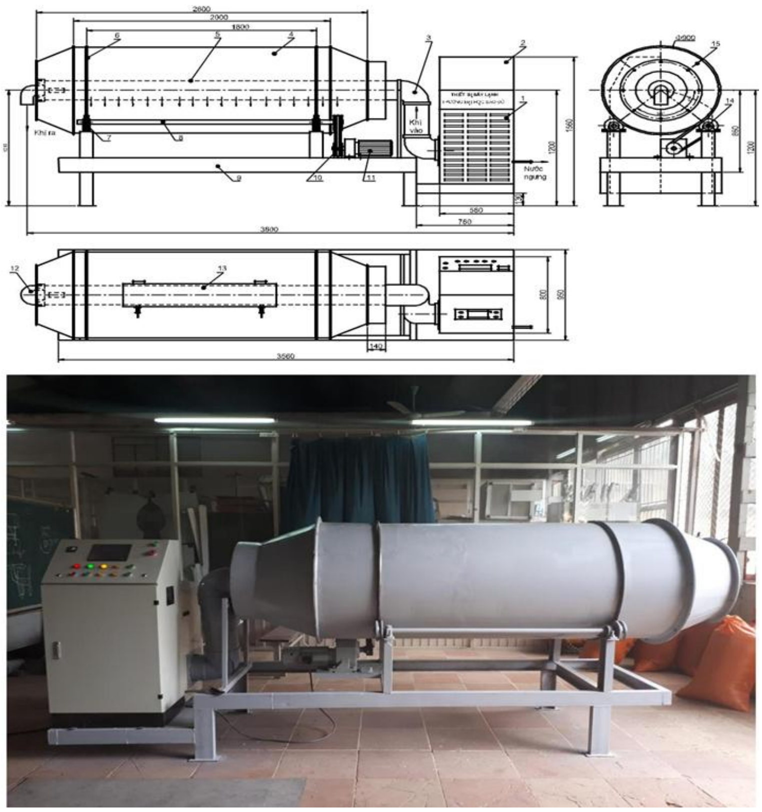

Figure2.1. The rotary drum heat pump drying equipment of Sao Do University

By Figure 2.1: Explanations of notation as below:

1. Head pump
2. Control cabinet
3. Inlet air pipe
4. Drying barrel
5. Air distribution pipe

9. Support bracket
10. Belt transmission mechanism
11. Reduction gear motor
12. Outlet air pipe
13. Supply and escape door

6. Navigation ray
7. Pulley
8. Shaft
14. Shaft bearing
15. Reversing wing

Equipment structure includes: 1 heat pump to dehumidify with capacity of 1.5 kW; 01 motor supplies rotational movement for rotating the barrel with capacity of 1.5kW; power control system with capacity of 0.05kW, lighting of 0.075kW.

Operation principle: Materials are fed by inlet door 5. Fresh air is cooled when passing through the evaporator 1 for the purpose of dehumidification. After the evaporator, the air passed through the condenser to be raised the temperature up to the requirement. After heated, the air is pushed into the drying barrel by the fan. Motor 6 operates and provides the movement to rotate barrel, the material is churned to increase the evaporation of moisture. Temperature and wind speed are controlled according to user requirements. After drying, the material is taken out from outlet door 5.

* Heat pump

Diagram of the construction principle of a heat pump is shown in Figure 2.2

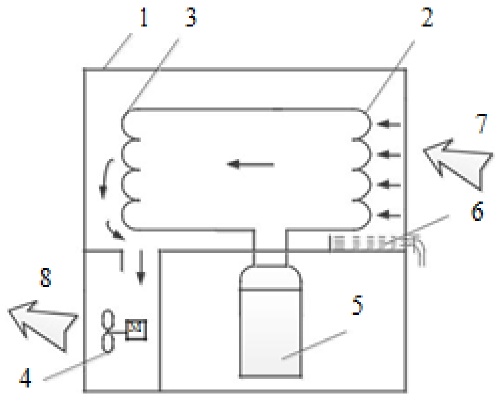

Figure2.2. Diagram of the construction principle of a heat pump

By Figure 2.2, explanations of notation as below:

1. Cover
2. Evaporator
3. Condenser
4. Fan
5. Compressor
6. Condensate
7. Input of moist air
8. Output of dry air

The air in state 7 (input) is high humidity, when going out of the heat pump in state 8 will be dry air with low humidity. The humidity in state 8 can be adjusted depending on technology requirements.

* Control system

The control system is installed to ensure high automation.Advanced and modern equipment include: PLC Omron CP1L 20CDR; Monitor, Omron HMI; Yaskawa inverter; temperature, humidity, wind speed sensor.

* Dry barrel

- Determine the volume of the barrel: $V = V_h + \Delta V$

In there:

V: Barrel volume (m^3)

V_h: Effective volume (m^3)

ΔV: Void volume ($\Delta V = (30 \div 40)\%V$)

III. RESULTS

Drying time is short or long depends on technological conditions such as drying temperature, velocity of drying agent, relatively humidity of drying agent. The higher the drying temperature, the shorter the drying time; if the drying agent humidity is greater will result the slow rate of moisture escape, then leading to a long drying time. In the condition of higher drying agent velocity, the process of moisture exchange takes place strongly, water at the surface of the materials escapes quickly, to make increasing the difference in humidity between the layers of the materials. After conducting experiments according to experimental matrix, the results are shown as in Table 3.1.

Table3.1. Results of doing experiment of Bac Thom rice seeds according to experimental planning matrix.

Experimental order (TN)	Drying agent humidity (%) Z1	Drying agent velocity (m/s) Z2	Drying temperature (^{0}C) Z3	Drying time (hour) Y1	Humidity of input materials (%) Y2	Germination rate (%) Y3
1	30	3.5	30	25.5	13.0	88.3
2	50	3.5	30	27.5	13.5	87.3
3	30	8.5	30	20.5	13.1	86.3
4	50	8.5	30	25.5	13.4	88.3
5	30	3.5	40	20.0	13.3	87.3
6	50	3.5	40	26.5	13.4	86.7
7	30	8.5	40	18.5	13.2	87.0
8	50	8.5	40	23.5	13.3	87.3
9	40	6.0	35	21.5	13.5	87.7
10	40	6.0	35	22.5	13.2	88.0
11	40	6.0	35	23.5	13.4	87.7

After processing the statistics in Annex 2, removing coefficients that do not have high significance will get the following regression equation as below:

$$Y1 = 23.182 + 2.321\, x1 - 1.437\, x2 - 1.313 x3 \quad (3.1)$$

By the equation (3.1) showing the humidity of the air entering the drying barrel is proportional to the drying time, whereas the drying agent velocity and drying temperature are inversely proportional to the drying time. This means that when the drying agent humidity is increased, the drying time is increased, when the drying agent velocity and drying temperature are increased, the drying time is increased. Among the above three factors, drying agent humidity is the most influential factor on the drying time (b1 = 2.321), followed by drying agent velocity (b2 = - 1.437) and drying temperature (b3 = - 1.313).

Changes in moisture content of Bac Thom rice seeds are shown in Figure 3.3, Figure 3.4 and Figure 3.5.

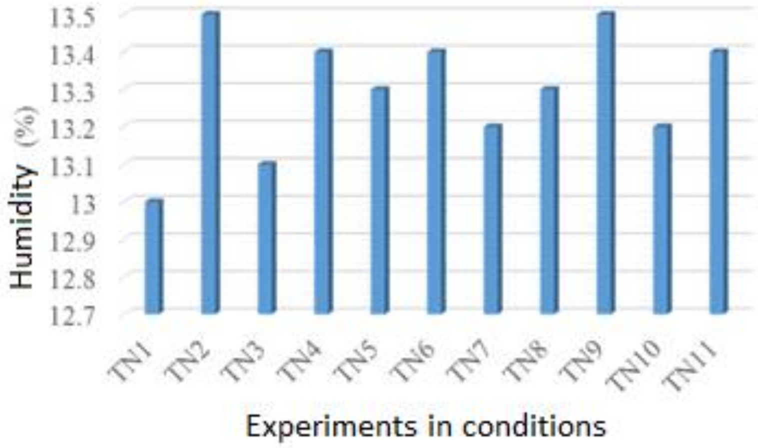

Figure3.3. The humidity of Bac Thom rice seeds in the experiments.

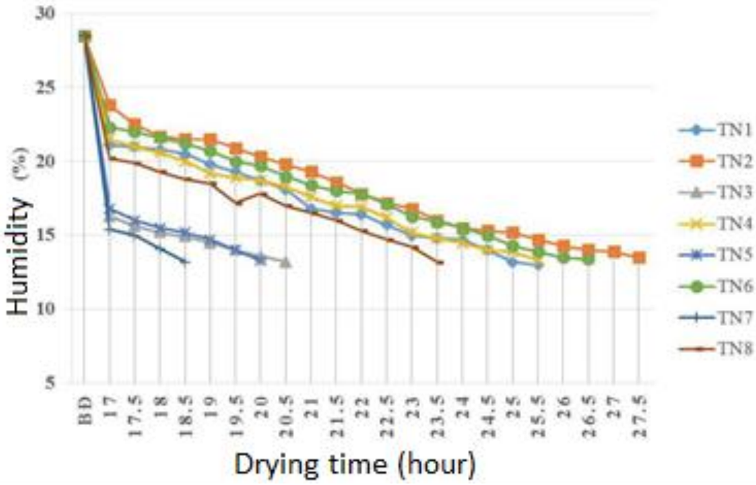

Figure3.4. Changes of the humidity of Bac Thom rice seeds in conditions according to experimental planning matrix

The moisture content of the rice seeds is significant meaning to preservation process and germination rate of the seeds in the future. When the moisture content the seeds is too high, it will lead to biochemical and microbiological changes inside the seeds. The respiratory process is taking place strongly, consuming nutrients and simultaneously generating heat, CO_2, H_2O are causing the humidity inside the seeds increased – resulting in the phenomenon of condensation can appear. The high of temperatures and humidity are motive power for microbial growth and enzyme activity causing damage to the seeds. Therefore, before storage, the seeds must be turned to the safe moisture content of the rice seeds by requirement φ = 13.5%.

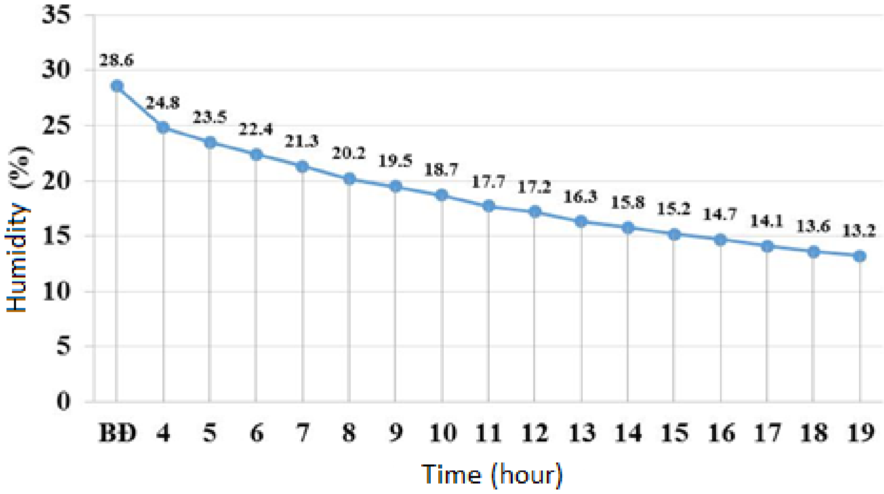

Figure3.5. The drying curve of BacThom rice seeds in the optimal mode (according to the method of Box-Willson)

In Figure 3.5 shows the changes in moisture content and drying speed of Bac Thom rice seedsaccording to drying time at drying agent velocity of 6.6m/s, the relative humidity of drying agent by 36%, and drying temperature of 37 0C, the results show: By the drying timeline, the humidity of Bac Thom rice seed decreases, in the first stage, in a very short period, the drying speed increases rapidly, followed by a constant drying speed and then the drying speed decreases gradually. In the early stages, the temperature of the seed surface increases, which increases the water vapor pressure on the surface resulting in increase of the differential pressure and partial pressure of water vapor in the humid air, causing an increase in external diffusion intensity and gradual increase of the amount of escape moisture. Therefore, the drying speed increases gradually until the temperature at the seeds surface is equal to the wet temperature of the humid air. In the first 5 hours, the rate of humidity reduction was 5.1%, in the next 10 hours the moisture content decreased from 18.7% to 13.2% (down 5.5%). In the cold-drying mode, Bac Thom rice seeds met the requirements after 19 hours of drying (humidity <13.5%).

IV. CONCLUSION

Cold-drying is a drying process in which the drying agent is dehumidified and lowered the temperature before being brought into the drying chamber, after which the drying agent will pass through the heating unit and go into the drying chamber. The drying temperature can be adjusted lower, equal or higher than the ambient temperature depending on the materials. By the research and application results of heat pump drying technology (cold-drying) show that this drying method has many outstanding advantages compared to the hot-drying technology are: after drying process, keeping natural colors, good quality, not polluting the environment, saving energy... Heat pump drying technology is not only suitable for temperature-sensitive materials but also It is widely applicable in hot and humid climates like Vietnam, bringing high economic and technical efficiency. Application of cold-drying technology of Sao Do University in drying Bac Thom rice seeds of Vietnam, the seeds after drying in the appropriate mode was sampled and determined the germination rate in the sowing time showed the rate is very high reaching 93%. Besides, the use of electric power will not pollute the environment; not affect the health of employees directly; not generate dust to pollute the environment; No greenhouse effect. he graph databases and relational database both performed well. In general, graph databases performed better when objective tests were performed. The Implementation shows that graph databases retrieve the results of the set of predefines query faster than relational databases.Alsograph databases are more flexible than relational databases as we can add new relationships to graph databases without the need to restructure the schema again.

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