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Research Article

Design and Study on 20 kW Circular Microwave Drying Apparatus

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Abstract: 20 kW circular microwave drying apparatus is designed in order to dry the Shanghai Green Vegetable, the designed microwave drying apparatus contains microwave generator, dehumidification system, electrical cabinet, parabolic waveguide, control system, microwave leakage inhibited mechanism and other components. The parabolic waveguide can make microwave transmitted uniformly, combined power is used and reduce the cost. According to the working characteristics of a microwave device, PLC and infrared temperature control system are employed in control system and automated production can be realized. The drying experiment is carried by the designed apparatus, from the setting-to-work test, the design was success.

Keywords: Apparatus, circular, microwave drying, shanghai green vegetable

INTRODUCTION

Drying is one of the important agricultural product storage means, which aim is to extend the effective storage time (Li, 2013). Extensive use of coal which as fuel in the traditional drying method, not only caused air pollution, but emissions of dust particles on the dried object caused secondary pollution, seriously affected quality of the dried object. Microwave drying is an energy-efficient (Wang *et al*., 2014), uniform drying (Li *et al*., 2011), drying efficiency (Sebera *et al*., 2012), cleaner production, high product quality drying technology, not only to keep the flavor, the original appearance, the original color of the dried object and without losing the primary nutrients, meanwhile healthy and safety, therefore microwave drying have been widely used in agricultural products drying, such as spinach (Dadali *et al*., 2008), parsley (Soysal, 2004), mango (Villalpando-Guzman *et al*., 2011), kiwi (Maskan, 2001), carrot (Wang and Xiong, 2005), pumpkin (Alibas, 2007), pepper (Arslan and Ozcan, 2011), purple sweet potato (Liu *et al*., 2012), Apple (Huang *et al*., 2012), lettuce (Feng *et al*., 2012), mushrooms (Motevali *et al*., 2011), asparagus (Wang *et al*., 2013) and Honeysuckle (Geng and Ge, 2014) and other food and agricultural products drying.

At present, reports about microwave drying process is more, but the microwave equipment is a high-tech product integrated microwave, mechanics, materials science, thermodynamics, PLC control and other disciplinary, microwave drying is a new technology developed which based on physical changes of drying process, moisture migration process under conditions of internal and external heat exchange, so companies produced microwave drying device is still relatively small.

There are many domestic and foreign universities and research institutions studied microwave drying technology and developed microwave drying equipment. But these devices are too expensive and cumbersome to operate for the majority of the rural and are not conducive to the promotion. Therefore, the main content of this study is which research and develop a simple, inexpensive microwave drying apparatus.

MATERIALS AND METHODS

Design microwave drying apparatus:

Microwave drying principle: Microwave heating effects is used in microwave drying equipment; microwave heating principle is completely different from traditional methods (conduction, convection, radiation). When microwave irradiated to the aqueous materials, polar molecules become an orderly arrangement (Fig. 1) disorganized arrangement of the non-polar state (Fig. 2) because the water molecules are polar molecules. When the external electric field repeatedly changes, polar molecule repeatedly change direction followed by the external electric field and swing frequently, the corresponding conversion repeated frequently swinging in the swing process, resulting in a similar molecular friction generates a lot of heat, the material temperature also will increase. The microwave heating principle is the use of the dielectric loss of the microwave energy into heat energy conversion required for heating the material, is proportional to the loss factor of the material absorbing the heat and its dielectric material. As the water (or other solvent) in the dielectric loss factor is much larger than the other material, so the water (or other solvent) molecules preferentially absorb microwave energy, the water molecules move from the interior to the surface

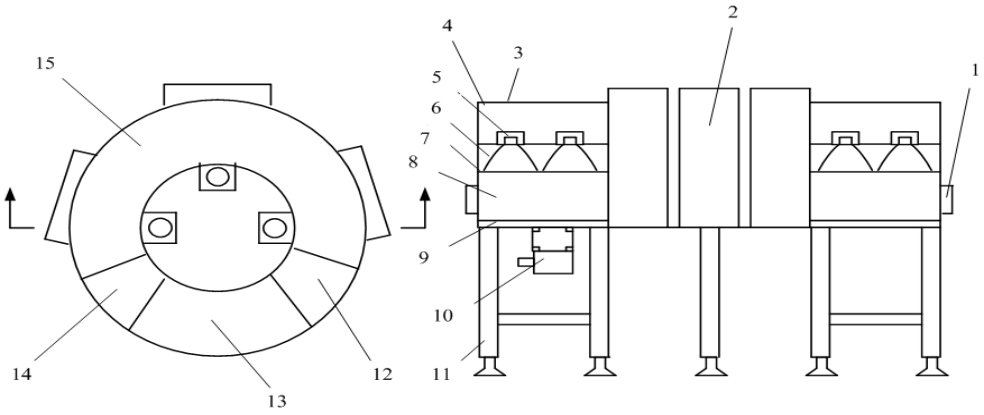

Fig. 1: Microwave drying apparatus structure; 1: Inlet; 2: Dehumidifying systems; 3: Framework; 4: Microwave generator mounting cavity; 5: Microwave generator; 6: Parabolic waveguide; 7: waveguide plate; 8: Microwave drying cavity linear motor; 9: Turntable guide rail; 10: Inverter motor; 11: Cover; 12: The right microwave leakage control mechanism; 13: Material handling area; 14: The left microwave leakage control mechanism; 15: Microwave drying zone

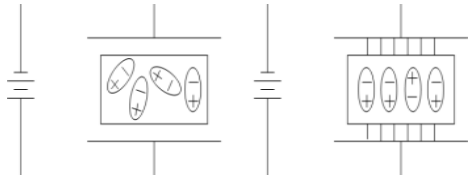

Fig. 2: Microwave drying principle

of the material to continue to absorb microwave energy, water vapor into water being discharged to quickly complete the drying purposes.

Microwave drying apparatus structure and work process: Circular structure is adopted in designing microwave drying apparatus, compact, small footprint, material handling easy and continuous production. Turntable is driven by variable frequency motor and the speed can be adjusted to meet the different dried materials. The microwave drying apparatus is assembled mainly by the microwave generator, dehumidification system, loading and unloading of materials area, electrical cabinet, control system, transmission system, microwave leakage control mechanism, parabolic-shaped waveguide and framework. The microwave apparatus structure is shown in Fig. 1.

Drying process: The material to be dried is loaded on turntable from handling materials area, turn on the power, the apparatus is in working condition; microwave generated by the microwave generator acted on water molecules in material to be dried and make the material to be dried dried rapidly. During the drying process, the temperature of the material to be dried is monitored by infrared temperature measurement system, the microwave generator state is controlled by PLC and to ensure the material is dried in a certain temperature. In addition, the speed of turntable can be adjusted by inverter motor according to drying process.

Table 1: Temperature measuring results

	Times of measuring	
Measuring point	1	2
The temperature on the 1st point	32.5	31.3
The temperature on the 2nd point	29.1	36.8
The temperature on the 3rd point	35.9	34.5
The temperature on the 4th point	29.6	33.4
The temperature on the 5th point	36.9	29.3
The temperature on the 6th point	29.9	34.9

Table 2: Mass measuring results

Times of drying	Sample mass/g	Total mass/g
0	535	2525
1		
2	382	1809

Water loss rate of unit mass sample: (535-382) /535 = 0.286; water loss rate of unit mass total materials: (2525-1809) /2525 = 0.284

After meeting drying requirement, turn off the power and then the dried material can be removed from the loading area.

EXPERIMENTAL RESULTS AND ANALYSIS

Materials to be dried are moving during drying process, in order to measure the dried material mass, a part is taken. Fresh, good color and no mechanical damage Shanghai Green Vegetable is chosen, washing and drained water, then drying Shanghai Green Vegetable leaves. Shanghai Green Vegetable surface temperature is measured by infrared thermometer after drying a while, 10 points temperature are measured and averaged. The mass of Shanghai Green Vegetable which moisture content is 95.3% is 2525 g (270 g is the sample), then turn on the microwave drying apparatus, heated 25 min, measured temperature, about 2 min and then heated 25 min. measured temperature and mass, data are shown in Table 1 and 2.

It can be seen from the above experiment that temperature deviations measured under the same conditions are within ±5°C; Water loss rate of unit mass

sample is basically the same to water loss rate of unit mass total materials, which shows that the drying is evenly in the designed microwave drying apparatus and meet the design requirements.

CONCLUSION

The circular microwave drying apparatus designed in this study can make drying more uniformly and better drying effect; PLC and infrared temperature control system are adopted which can make drying automated; and compact structure, small size, low cost and *et al* can meet agricultural products dry.

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