Effects of Loading Conditions on the Power-Reflecting Characteristics of Microwave Drying Chamber

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1. Introduction

Power reflecting characteristics of microwave drying chambers under different loading conditions are important basic data for designing and operating microwave drying equipment. Although the microwave power reflecting characteristics of a variety of materials have been used for measuring their moisture contents and other properties, study concerning with the power reflecting characteristics of microwave drying chambers has not been found. The objectives of this study are to find the relationship between the power reflecting characteristics and the loading conditions of a typical microwave drying chamber and to deliver basic data for designing and operating microwave drying equipment.

2. Materials and Methods

In this study, distilled water and Japonica-type Koshihikari rice was used as the test materials. A typically structured microwave drying experimental apparatus (Fig. 1) was used for this study. The microwave power output of the apparatus can be changed within a range of 0.0 ~ 1.2kW continuously with a working frequency of 2.45 ± 0.03GHz. By using a set of measuring equipment shown in Fig. 1, which was mainly consisted of a directional coupler and a microwave power meter, the incident microwave power $P_{inc}$ to the microwave drying chamber and the reflected microwave power $P_{ref}$ from the microwave drying chamber can be measured directly. So, the power-reflection coefficient of microwaves drying chamber is expressed as the following equation.

$$ f_{ref} = \frac{P_{ref}}{P_{inc}} \quad (1) $$

Loading conditions of the drying chamber are that distilled water, brown rice or rough rice were uniformly spread all over the drying bed respectively (Fig. 1).

3. Results and Discussion

With the increase of the thickness of the material being loaded (Fig. 2), i.e. with increase of the amount of loaded materials (Fig. 3), the power-reflecting coefficient $f_{ref}$ of the microwave drying chamber decreased. This is because the amount of absorbed microwave energy increases with the increasing of the amount of material loaded. When the thickness of the distilled water loaded is over 0.007 m, $f_{ref}$ was steadily as low as 0.09 ~ 0.13. When the thickness of the rough rice loaded is smaller than 0.017 m, $f_{ref}$ was as large as 0.39 ~ 0.57. If the thickness of the rough rice or brown rice loaded is larger than 0.017 m,
$f_{ref}$ can be smaller than 0.20. As the dielectric properties of water, rough rice and brown rice are different, the power reflecting characteristics of microwave drying chambers are different when these materials are loaded respectively in it. Under the same loading condition, i.e. with the same amount of loaded material being spread uniformly all over the drying bed, the $f_{ref}$ of distilled water was the lowest, and that of rough rice was the highest. The $f_{ref}$ of brown rice was near the same as or a little smaller than that of rough rice (Fig. 3).

4. Conclusions

With the increase of the amount of loaded materials, the power-reflecting coefficient $f_{ref}$ of the microwave drying chamber decreased. With the material being spread uniformly over the drying bed, if the load thickness for rough rice or brown rice is larger than 0.017 m, and for distilled water is over 0.007 m, the $f_{ref}$ can be smaller than 0.20, 0.09–0.13 respectively. Under the same loading condition, $f_{ref}$ of distilled water was the lowest, and that of rough rice was the highest. These basic data will be useful for designing and operating microwave drying equipment.

Fig. 1 Schematic diagram of the experimental apparatus for measuring incident and reflected microwave power

Fig. 2 Effect of material thickness on drying bed on microwave power reflecting coefficient

Fig. 3 Effect of material mass amount on drying bed on microwave power reflecting coefficient

References