STUDY AND ANALYSIS OF THE DIFFERENT MICROWAVE DRYING POWER EFFECTS ON THE MICROSTRUCTURE OF AIR DRIED SHEET (ADS) RUBBER

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ABSTRACT

The aim of this research was to study and analysis of the different microwave drying power effects on the microstructure of air dried sheet (ADS) rubber. Based on the comparative study and analyze the result from different microwave power with initial moisture content ranging of 25-40% dry-basis, ADS rubber temperature of 40-100°C and final moisture content of 0.5% drying-basis, the result showed that microwave drying power about the temperature less than 40°C will not damage to the microstructure of ADS rubber, and then take a picture of different microwave power on the microstructure from motorized fluorescence microscope (MFM) that we found it can be used effectively without affect to the microstructure.

1. INTRODUCTION

Rubber is an important crop in Thailand because the rubber exports ranked one of the world. The information from office of agricultural economics we found that natural rubber was roughly harvested about of 15.13 million raises and raw production of rubber sheet was about of 3.78 million tons. In the current, the products that come from natural rubber has a greater role in daily life such as the medical, the vehicle, the automobile spare parts, basic health and use as a raw material source in product of food and chemical industry. From the mentioned above, need to latex processing first such as ribbed smoke sheet (RSS),air dried sheet (ADS) rubber, block rubber, crepe rubber and concentrated latex, etc.

Beside, (W. Suchonpanit et al, 2011) reported the study effect drying conditions on kinetics and quality of ADS rubber, the comparative of five different strategies were carried on by green house drying (GH), green house and natural convention (GH-NC) drying, open sun and natural convention (OS-NC) drying, infrared radiation (IR) drying and hot air (HA) drying. They found that the ADS rubber was dried by GH-NC drying longer period than those of OS-NC drying, GH drying, HA drying and IR drying, respectively. The result showed that quality of samples was acceptable in market level. In research of (P. Rattanadecho et al, 2006) reported the study drying of dielectric materials by a continuous microwave belt drier has been investigated experimentally, it focuses on the investigation of drying phenomena under microwave environment. They found that using the continuous microwave applicators technique has effectively than the conventional method such as shorter processing times, the dissipation of energy throughout a product and high energy efficiency compared with other process. However, in research of (C. Mei et al, 2012) reported the effects of different drying methods on the microstructure of natural rubber. They found that the microwave drying damage to the microstructure of natural rubber. From the mentioned above, the reported of different drying methods we found that the microwave drying technology as one of the most interesting.

This paper presents a study and analysis of the different microwave drying power effects on the microstructure of ADS rubber. Base on the comparative study and analyze the result from different microwave power to find a suitable power, which does not damage to the microstructure of the ADS rubber and can use this method to be applied in the combination with the other methods to increase the efficiency of drying technology in the future.

2. EXPERIMENT

2.1 Materials

2.1.1 Drying equipment. The microwave dryer showed in Fig. 1 which the dimension of dryer room diameter was about 80 cm and high 60 cm, inside the dryer will have axes hanging rubber spinning. The dryer has a three point

microwave signal input which frequency 2.45 GHz, each point put away the angle of 120 degree, high, medium and low respectively.

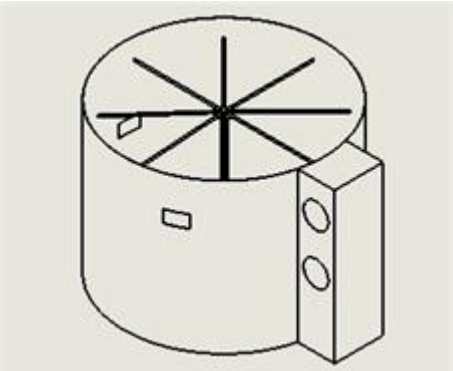

Fig. 1 Microwave drying system.

2.1.2 ADS rubber. The dimension of sample ADS rubber sheet was about of 60×120 cm and weight of 1.6-3.0 kg. We divided into four equal parts approximately, in each parts have the moisture content ranging about 25-40% dry-basis.

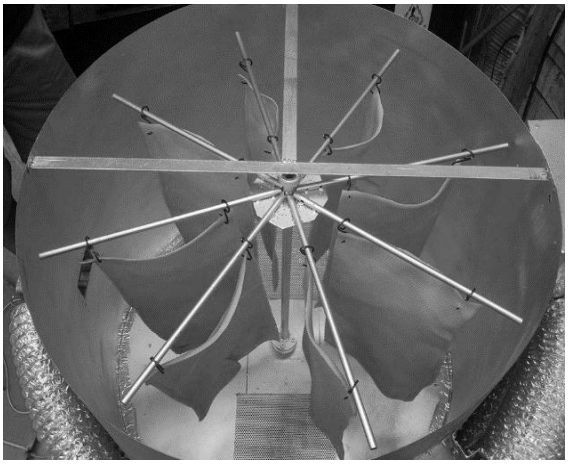

Fig. 2 The ADS rubber in the dryer.

2.2 Methods

2.2.1 Preparation of the samples. The preparation of ADS rubber dried by microwave heating is as follows: the fresh ADS rubber must be suspended on rail to drain the residue out of rubber sheet first after that before put the ADS rubber into the dryer will be divided them to four equal parts approximately.

2.2.2 Testing. Preparation of the ADS rubber after pass procedures of the drain residue of rubber sheet. After that put them into the dryer and run the microwave heating in the following order. The increase in temperature of the ADS rubber as a result of the absorbed electromagnetic energy from microwave heating can be expressed by (Nelson, 1996).

$$\rho C_p \frac{\Delta T}{\Delta t} = 5.563 \times 10^{-11} f E^2 \varepsilon'' \quad (1)$$

Where C_p is the specific heat of the material ($J \times kg^{-1} \times °C^{-1}$), ρ is the density of the material ($kg \times m^{-3}$), E is the electric field intensity ($V \times m^{-1}$), f is the frequency (Hz), ε'' is the dielectric loss factor of the material, Δt is the time duration (s) and ΔT is the temperature rise in the material (°C). The decrease in moisture content of the ADS rubber as a result of the weight loss from the microwave drying can be expressed by (ASAE standard, 1982) method.

$$\text{Moisture ratio, MR} = \left[\frac{M_t - M_{eq}}{M_i - M_{eq}}\right] \quad (2)$$

Where MR is moisture ratio (no unit), M_t moisture at any time (% dry-basis), M_{in} is initial moisture (% dry-basis), M_{eq} is moisture balance (% dry-basis) which can find it will be use Halsey model equation (Y. Tirawanichakul et al, 2011) expressed in equation 3.

$$M_{eq} = \left[\frac{-0.377}{(-33174.961T + 107.421T^2)\ln RH}\right]^{\frac{1}{2.264}} \quad (3)$$

Where T is temperature (K) and RH is relative humidity (decimal).

3. RESULTS AND DISCUSSION

Fig. 3 showed the relationship between the moisture ratio with the drying time of ADS rubber drying process from the difference microwave drying power which affects to difference temperature in each result.

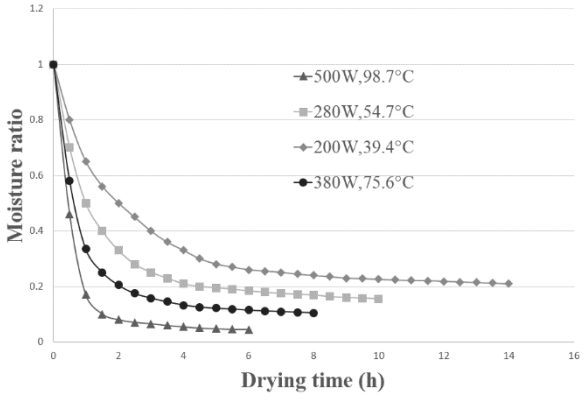

Fig. 3 The relationship between the moisture ratio with the drying time of the ADS rubber drying process.

The four of difference microwave drying power was reported, the 500W microwave power affects to ADS rubber have temperature about 98.7°C, the 380W microwave power affects to ADS rubber have temperature about 75.6°C, the 280W microwave power affects to ADS

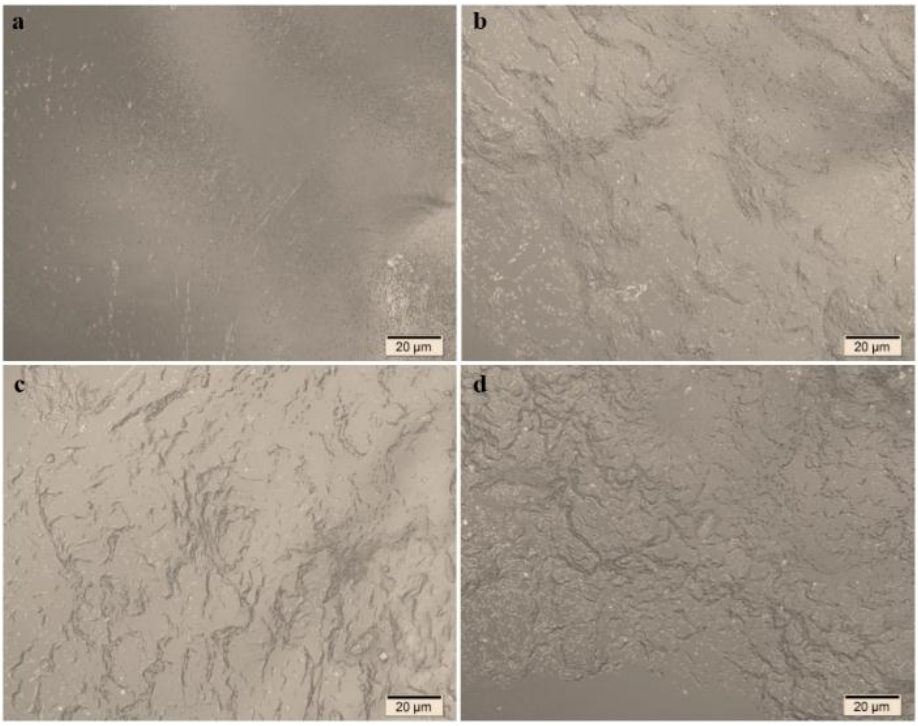

Fig. 4 MFM micrographs of ADS rubber sample obtained by different microwave drying power.

rubber have temperature about 54.7°C and the 200W microwave power affects to ADS rubber have temperature about 39.4°C.

Fig. 4 showed the difference microwave drying power which effects on the microstructure of ADS rubber at the same expansion rate of each sample. The result in fig. 4(b-d) are effect from 500W, 380W, 280W and 200W microwave drying power respectively as a result showed that damage to the microstructure of ADS rubber. The result in fig. 4(a) is effect from 200W microwave drying power as a result showed that not damage to the microstructure of ADS rubber.

Consider follow the equation 1 will see that the temperature occurred in each sample depended on the electric field intensity ($V \times m^{-1}$). In the drying industry which regarded quality first so in the drying process with the microwave heating must be adjust power to appropriate.

CONCLUSION

The microwave drying technology is another interesting option that can be apply in drying industry. Because it has effectively than the conventional methods such as shorter processing times, the dissipation of energy throughout a product and high energy efficiency compared with other process. The microwave drying can be adjust for the drying process of the other product which can be maintain the quality of product in the drying industry and this principle can be application with the other drying methods to enhance the efficiency of drying process in the future.

ACKNOWLEDGMENT

This work was supported by Suranaree University of Technology (SUT) and by the Office of the Higher Education under NRU project of Thailand.

REFERENCES

Suchonpanit, W., Tirawanichakul, Y., and Tirawanichakul, S., Experimental study of the effects of different drying methods on the kinetics and quality of air dried sheet (ADS) rubber, in Humanities, Science and Engineering (CHUSER), IEEE Colloquium on, 2011.

Rattanadecho, P., Suwannapum, N., Watanasungsuit, A., Duanduen, A., Drying of Dielectric Materials Using a Continuous Microwave Belt Drier (Case Study: Ceramics and Natural Rubber), J. of Manufacturing Science and Engineering vol. 1, no. 129, pp. 157-163, 2006.

Mei, C., Yong-Zhou, W., Guang, L., and Xiao-Ping, W., Effects of different drying methods on the microstructure and thermal oxidative aging resistance of natural rubber, J. of Applied Polymer Science, vol. 6, no. 126, pp. 1808-1813, 2012.

ASAE standard, Moisture Measurement, the 29th ed., St. Joseph, Miami, USA, 1982.

Nelson, S. O. Review and assessment of radio-frequency and microwave energy for stored-grain insect control. Transactions of the ASAE, 39, pp. 1475–1484, 1996.

Tirawanichakul, Y., Suchonpanit, W., and Tirawanichakul, S., Sorption Isotherm and Liquid Diffusion Model for Unsmoked Sheet Rubber Drying, international conference on alternative energy, pp. 167-173, 2011.

NOMENCLATURE

a : Microstructure
b : Microwave
c : Drying

Subscripts

ADS : air dried sheet
MFM : motorized fluorescence microscope

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