

The Research on Temperature Variation Characteristic of Wood during High-intensity Microwave Pretreatment

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Abstract: High-intensity microwave pretreatment (HIMP) is a kind of wood modification technology with great potential. In this study, a microwave (MW) treatment of plantation poplar (*populus deltoids*) wood was investigated by applying MW treatments with varying conditions, such as radiation power, irradiation time, and initial moisture content of the wood. The effect of microwave pretreatment conditions on internal temperature of wood was studied systematically. Results show that the temperature of wood increased with the microwave radiation intensity and the irradiation time. Excessive moisture content would make the wood heated up slowly. The temperature of wood changed in three stages: rapid heating stage, constant temperature section and slow heating section.

Keywords: Microwave pretreatment; wood; temperature.

1. Introduction

High intensity microwave pretreatment (HIMP) is a new technology in the field of wood modification in recent years. Its principle is to use the dielectric loss characteristics of wood substances such as water molecules in wood to make water molecules quickly vaporize and generate steam expansion power, so as to effectively destroy the fine structures in wood, such as thin-walled cells and the porous membrane on the cell wall.

Scientists in international, especially in Australia, attach great importance to this work. Their research pointed out that high-intensity microwave treatment could change the microstructure of wood, increase the permeability of wood thousands of times, improve its impregnability, and even increase the volume of wood by about 10% [1-5]. This provided a very favorable prerequisite for the preparation of wood composite materials. Due to the low radiation power and low radiation density of microwave treatment equipment in China, the microwave pretreatment effect of wood was not good. Then scanning the research of the microwave pretreatment of wood home and abroad, the research focus was mainly on the influence of microwave pretreatment on wood drying characteristics [6-8] and permeability [4,9-10], while the research on wood microwave pretreatment process itself is rarely involved. Starting with the microwave pretreatment process itself, this study systematically studied the effects of microwave power, microwave time and initial water content of wood on the temperature change of wood, laying a

foundation for revealing the mechanism of high-intensity microwave pretreatment of wood.

2. Experimental

2.1. Materials and Equipment

Plantation poplar (*populus deltoids*) was obtained from Hunan province, China. Test specimens with dimensions of 2000 mm (longitudinal, L)×110 mm (tangential, T)× 25 mm (radial, R) were prepared from green wood. The high intensity MW pretreatment was carried by a equipment with four microwave sources, each microwave radiated power is 1200 w. Optical fiber thermometer (Opsun Photoelectric Technology Co., LTD., TempSens) temperature range -40-250°C.

2.2. Methods and Procedures

The wood was processed into a four-sided light standard specimen with a size of 100 mm (length) ×100 mm (width) ×60 mm (thickness). In order to prevent the water within wood evaporated rapidly from the end of the specimen, the end of the specimen was sealed with epoxy resin and tinfoil, and was cured in a sealed bag at room temperature for 24 h. After the resin was cured, a holes was drilled in the middle of the thickness of the specimen. The HIMP process was automatically collected by the computer automatic acquisition system, which collected once every 2.1 seconds. The experimental design of HIMP of wood was shown in table 1.

Table 1. The experimental design of HIMP of wood

experimental group	experimental factor	microwave intensity (A)	microwave time (s)	initial moisture content of wood (%)
Group 1		0.8-2.4	40	80
Group 2		2.4	20-60	80
Group 3		2.4	40	40-130

3. Results and Discussion

The effect of radiation intensity on temperature variation of wood was shown in figure 1, the temperature of poplar wood increases rapidly during HIMP of wood. When the microwave

power is 2.4 A, the internal temperature of wood reached 100°C within 25 s. The higher the microwave radiation intensity was, the higher the heating rate of poplar wood. When the microwave radiation intensity increased from 0.8 A to 2.4 A, the heating rate of the middle layer of wood increased from

1.30°C/s to 2.44°C/s.

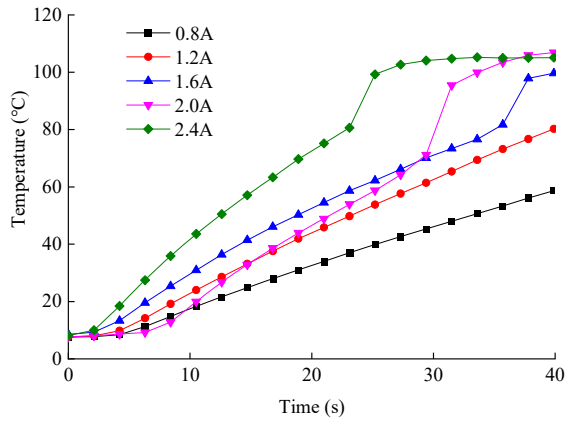


Figure 1. The effect of radiation intensity on temperature variation of wood

The effect of radiation time on temperature variation of wood was shown in figure 2. The longer the microwave radiation time was, the higher the terminal temperature of wood. This is because the longer the microwave radiation time, the more microwave energy was received by wood, which higher the terminal temperature of wood. When microwave radiation time in the first 5s, the temperature of wood rose slowly. Subsequently, wood entered the rapid heating section, and the temperature of wood increased rapidly. When the microwave radiation time was about 25 s, the temperature of wood above 100°C, and the temperature of wood were basically unchanged. The wood entered the constant temperature stage, and the microwave energy was mainly used for the evaporation of water inside the wood. When microwave radiation time continued to extend, most of the water in wood had been discharged, at this time, in addition to a small amount of microwave energy for wood water evaporation, most of the energy for wood temperature increase.

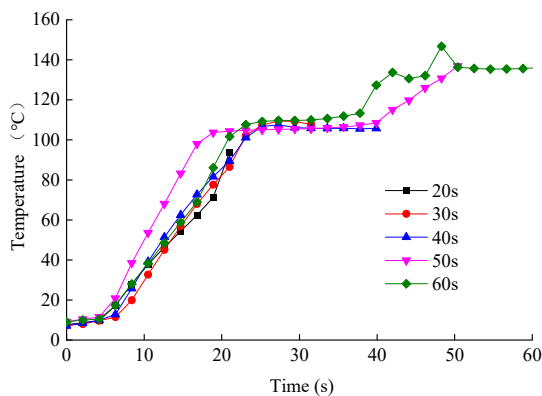


Figure 2. The effect of radiation time on temperature variation of wood

The effect of moisture content on temperature variation of wood was shown in figure 3. When the initial moisture content of wood was higher than 100%, the temperature was increased slowly. With the extension of radiation time, the wood with 43% moisture content showed an obvious temperature rise trend after the constant temperature stage. This is because after a long constant temperature period, most of the moisture had been removed from the wood with low initial moisture content. If the wood still received the same

intensity of microwave energy, most of the energy was used to increase the wood temperature, resulting in the internal temperature of the wood rising again.

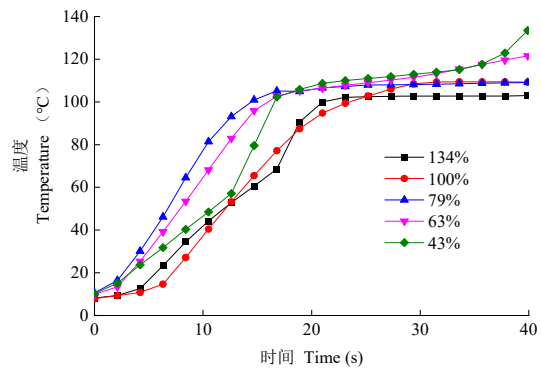


Figure 3. The effect of moisture content on temperature variation of wood

4. Conclusions

Microwave treatment could quickly increase the internal temperature of wood in a short time. The temperature of wood increased with the increasing microwave radiation intensity and radiation time. However, excessive moisture content would make the wood heated up slowly.

Acknowledgments

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