Journal of the Arkansas Academy of Science

Volume 44 Article 12

1990

Preliminary Study to Determine the Effect of Microwaves on Green Wood

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A PRELIMINARY STUDY TO DETERMINE THE EFFECT OF MICROWAVES ON GREEN WOOD

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ABSTRACT

A preliminary study was done to determine the moisture content of green wood by treating the wood with microwaves in an oven for various times between 1 and 4 minutes. The temperature of the wood was measured immediately following the radiation with a probe interfaced to a microcomputer and with a mercury-in-glass thermometer. Temperature probes were inserted into the wood samples. Actual moisture content of the wood was determined by weighing the samples before and after drying. Half of the samples exhibited a directly proportional relationship between moisture content and temperature after microwaving. The linear relationship was not generalizable to all green wood samples tested.

INTRODUCTION

The purpose of this experimental study was to determine the relationship between the percentage moisture content of green wood and the temperature produced in the sample after a specific time exposure to microwaves. A survey of literature was conducted but no studies of the same concept were found. Ryley (1969) reported the results of a series of tests using a microwave oven for the rapid determination of the moisture content of soils. Ryley's conclusion was that microwave drying can be used for most soils with comparable accuracy to drying in a conventional oven. However, the results were obtained in a microwave oven in 2 to 15 minutes compared to 16 to 24 hours in the conventional oven.

Fanslow and Saul (1971) reported on the use of microwaves in the drying of field corn. The data showed that a limit existed to the speed of microwave drying. Beyond the limit there was swelling of the corn kernels to lower the market grade.

Hamid (1972) reported successful drying of leather using microwaves.

MATERIALS AND METHODS

Green pine wood was irradiated with microwaves in a 1200 watt oven at a frequency of 2450 MHz. The temperature was measured in this experiment with a conventional mercury-in-glass thermometer and simultaneously with a thermistor probe interfaced to a microcomputer. The thermometers were placed in 0.64 cm diameter by 0.64 cm deep holes bored in the wood samples. The wood samples varied in diameter from 3.5 cm to 6.6 cm by 21 cm long. The microcomputer thermometer probe was calibrated in water to an accuracy of ± 1°C compared to a mercury-in-glass thermometer over the range of 0 to 100°C. The microcomputer used a BASIC program which was linearized between calibration points and reported the temperature every three seconds. The microcomputer temperature probe was observed to have a faster response time than the mercury-in-glass thermometer. The samples were weighed on a triple beam balance to the nearest 0.1 g before and after each microwave treatment. The samples were irradiated with microwaves for 1 minute and the temperature was measured by both thermometers as soon as the sample could be removed from the oven. The temperature of the samples was observed to increase for a period of time after the thermometers were placed in the sample, indicating the heating had occurred in the center of the sample and conducted outward to the surface. As soon as a maximum temperature was achieved and recorded on both thermometers, the sample was replaced in the microwave oven and again treated for one minute. The sample was again removed and the maximum temperature measured and recorded. The mass of the sample was again recorded and the sample was allowed to air dry in the laboratory. The samples were then dried in a conventional oven at 65.5°C for about 44 hours. This oven drying was continued until all samples remained the same mass within 1 g. This dry mass was used to calculate the relative percentage of moisture in the wood samples.

RESULTS

Sixteen samples were tested and all were cut from the green state and were tested at various stages of air drying. The samples varied from 0.8 percent moisture to 53.9%. From observed temperature measurements, the researcher concluded that heating occurred to a considerable depth as the temperature at the depth of 0.64 cm increased for up to several minutes before reaching a maximum indicating the heat was conducted outward from the center of the sample. More reliable data were obtained when the loose bark of the sample was removed and the thermometer placed in small holes bored in the wood. Data from the first 4 samples were unreliable because of the attached bark and were discarded for this study. No simple relationship could be determined between the percentage moisture and the temperature produced because of variation of individual samples.

A least squares fit program was run with the data listed in Table 1. The results found are listed in Table 2. Several unexpected results were noticed during the course of the study. Sample 7 caught fire as evidenced by smoke emission as a result of the microwaving for four minutes. Sample 14 has a negative slope which as believed to be a result of the small sample diameter allowing the change of phase of water as a result of the microwave heating for one minute. Water vapor was observed to be emitted from the sample at the early stages while the sample contained a high moisture content. The same effect was noted for larger diameter samples microwaved for a longer time.

DISCUSSION

A direct proportional relationship was found in half the samples between the percentage moisture content of the green wood and the temperature produced as a result of the microwave treatment as indicated by the high correlations. A general relationship was not found between percentage moisture and temperature of pine wood as shown by the variation in the slopes of various samples. The amount of time the samples were exposed to microwaves was important. Too long an exposure resulted in one sample burning. Small samples with high moisture content and long microwave exposure resulted in a change in phase of the water with no corresponding rise in the temperature of the samples. The amount of time needed to expose the sample to microwaves depends on the mass of the wood. Microwave drying of wood to find the percentage of moisture by weighing reduces the time to make the measurement. No cracking was observed in any of the samples as a result of microwave drying. A study of the drying of hardwoods with microwaves is needed, as well as a study of the relationship between temperature produced by microwaves and percentage of moisture in hardwood samples.

Table 1. Percentage of Moisture in Wood Sample and Temperature Produced by Microwaving.

Diameter(cm)	%Moisture	Temp(T1)	Diameter(cm)	%Moisture	Temp(C2)
5.0	51.9	74	4.1	53.9	85
5.0	22.8	75	4.1	9.8	64
5.0	5.2	67	4.1	5.3	62
5.0	4.8	63	4.1	2.0	59
5.0	1.7	68	4.1	1.5	57.3
5.0	1.4	55			
5.0	1.0	64			

Diameter (cm)	%Moisture	Temp(T1)	Diameter(cm)	%Moisture	Temp(C2)
5.1	11.2	61	5.3	36.9	66
5.1	6.2	59.5	5.3	7.8	60
5.1	2.1	64	5.3	3.2	57.3
5.1	1.2	65.5	5.3	1.2	57.3
			5.3	0.9	57.3
			5.3	0.9	57.3

Diameter(cm)	%Moisture	Temp(C1)	Diameter(cm)	%Moisture	Temp(C1)
4.2	21.9	91	3.5	53.3	44
4.2	11.0	64	3.5	41.1	46
4.2	5.5	58	3.5	36.5	68
4.2	1.9	57.3	3.5	27.5	94
4.2	0.8	47.3	3.5	18.9	88
4.2	0.8	50.7	3.5	5.9	85

T indicates mercury-in-glass thermometer (Celsius) after 1 (T1) min, or 2 (T2) min.

C indicates computer interfaced thermistor (Celsius) after 1 (C1) min, or 2 (C2) min.

Table 2. Least Squares Fit of Data from Table 1

Sample Diameter	Correlation	Slope	Temperature Axis Intercept
5.0	0.495	0.255	63.3
4.1	0.961	0.533	56.7
5.1	0.583	-0.458	64.9
5.3	0.977	0.243	57.2
4.2	0.948	1.839	48.5
3.5	0.676	-1.065	103.4

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