PALLET PHYTOSANITARY PROJECT BULLETIN

A Cooperative Effort of the
Limestone Bluffs Resource Conservation and Development Area
And
The Wood Education and Resource Center
USDA Forest Service

Number 9 November 2004

FEASIBILITY OF ERADICATING CERAMBYCID LARVAE AND PINEWOOD NEMATODES INFESTING LUMBER WITH COMMERCIAL 2.45 GHz MICROWAVE EQUIPMENT[1]

This bulletin summarizes the results of the above titled research project funded under the Competitive Grants Program of the Pallet Phytosanitary Project.

INTRODUCTION

Commercialization of microwave processes to eradicate pest infestations in Wood Packaging Material (WPM) may offer an effective alternative to the currently acceptable treatment methods: heat and methyl bromide. Microwave energy is currently used commercially for cereal and granola baking, drying of coatings, snack food processing, foundry core drying, pharmaceutical processing, ceramic filter drying, ceramic sintering, rubber vulcanization, chemical vapor deposition, and chemical waste processing. In the wood products industry, TrusJoist (A Weyerhaeuser Company) consolidates veneer cut strands into processed composite lumber by applying microwave energy. Also, a number of researchers have studied mortality of termites, powder post beetles, and woodworm larvae in wood. Results indicate that microwave irradiation is lethal and that moisture content can have an effect on the amount of microwave energy required to ensure mortality.

The objectives of this research were to:

- Test a system of separating nematode- or cerambycid-infested wood material into moisture ranges by green weight.

[1] The researchers were Mary R. Fleming (Pennsylvania State University), John J. Janowiak (Pennsylvania State University), John M. Halbrendt (Pennsylvania State University), Leah S. Bauer (USDA Forest Service, North Central Research Station), Deborah L. Miller (Michigan State University), and Kelli Hoover (Pennsylvania State University).

- Determine the feasibility of killing nematodes and cerambycids (such as the Asian Longhorned Beetle) with commercially available microwave equipment using temperature as the critical parameter.

METHODOLOGY

Freshly felled red pine logs (Pinus resinosa), 8 to 10 feet in length were selected based on red pine's preferred host status for the pinewood nematode. The logs were sawn into 4"x4"x20" cants and dressed 1"x4"x20" boards. Holes were drilled for insertion of either nematodes or cerambycid larvae.

Batch Microwave Experiments

One series of tests was conducted in a batch system configuration. That is, test samples were placed in a microwave chamber, the test samples irradiated and then removed to determine results.

The red pine sample pieces were placed into one of four moisture content categories: Very high (greater than 150% MC), high (greater than 110% MC but less than 145% MC), medium (greater than 65% MC but less than 105% MC), and low (less than 60% MC). Prior research has indicated that moisture content of test samples affects the microwave dose required to obtain 100% mortality.

Following a series of preliminary testing, the best batch testing configuration was determined to be a single row of 4 boards. Fiber optic probes were used to monitor temperature. Cerambycid larvae and a solution containing pinewood nematodes were inserted into pre-drilled holes in the red pine samples and capped with a wood plug. Several insertions were made at varying distances from the end of each piece.

Four to six loads of larva infested samples for each moisture content range were irradiated at 5000 W until all fiber optic probes registered at least 62°C. After reaching the critical temperature, the wood plug was removed from each sample. Each larva was extracted and its status, live or dead, was determined.

For the nematode infested samples, (5 loads of very high, medium, and low moisture content ranges, and 10 loads of high moisture content) were also irradiated at 5000 W until probes reached 62°C. Once removed, the nematode plugs were shipped overnight to a facility for the purposes of recovering and counting any live nematodes.

Continuous Microwave Experiments

A second series of tests were conducted in a continuous microwave system. Red pine samples were separated into three green weight groupings (medium, high, and very high) to approximate moisture content groupings for testing purposes. One run of 10 boards from each weight grouping was conducted for nematodes and a separate run for cerambycid larvae. The boards were placed on the moving conveyor belt (end-to-end in order to have a consistent load in the chamber at all times). The high and very high weight groupings were irradiated at 7kW, while the medium weight samples were irradiated at 6 kW and 5kW. After a sample came off the belt, a thermocouple was immediately placed inside the predrilled hole and a fiber optic probe was placed on the surface to determine internal and surface temperatures. Nematode and larvae survival were determined in the same manner as the batch testing.

RESULTS

Batch Microwave Experiments

Regardless of moisture content, there was 100% mortality of cerambycid larvae in red pine samples that reached 62°C. At this same temperature, some nematodes in the red pine samples survived. In all cases where temperatures were above 63°C, 100% nematode mortality occurred.

Statistical analyses indicated that a significant relationship between temperature and mortality for the nematodes, with higher temperatures resulting in higher mortality. A statistically significant relationship also existed between moisture content and the time required to reach 62°C. A minor effect was also noted for the time to reach 62°C along the length of the sample boards. The probes near the ends of the boards were slower to reach 62°C than those farther from the ends of the boards. Since the samples were stationary in the batch system, the microwave field intensity varied within the chamber and distribution of microwaves within each board likely varied, contributing to the slight differences in time to reach 62°C along the length of the boards.

Continuous Microwave Experiments

Not all of the red pine samples reached the target internal temperature of 62°C in any of the test groups. However, mortality in the continuous system killed all nematode and larval samples. Interestingly, core wood temperatures as low as 46°C and 53°C were still lethal to larvae and nematodes, respectively. These lower lethal temperatures may be due to the movement of the sample through the chamber, exposing the sample to a more uniform microwave field. Some additional trials conducted on wood cubes tended to verify a near 100% mortality of cerambycid larvae was possible at lower temperatures when the samples were rotated compared to samples that remain stationary during microwave treatment.

The researchers hypothesize that the lower temperatures recorded for some samples occurred because the total moisture content load in the chamber was influenced by the total moisture content load from all the boards combined, not just by the moisture content of each individual board.

DISCUSSION

In the batch experiments, where moisture content load and the microwave input power were fixed, increased wood moisture content increased the microwave exposure time required to reach 62°C. Therefore, separation of lumber by moisture content will likely be an important consideration in order to reduce the microwave energy input required for 100% mortality in a batch. Wood temperatures in excess of 62°C are lethal to pinewood nematodes and cerambycid larvae infesting red pine in a chamber where the wood samples remain stationary.

Results also indicate that nematodes or larvae in lumber, where the microwave field is continuously moving, either by rotation or on a conveyor belt, experience mortality at lower temperatures than in a stationary batch system. The researchers recommend additional experiments with non-stationary, commercial microwave equipment to further investigate this phenomenon.

Based on their results, the researchers believe that commercial microwave treatment is a feasible alternative to conventional heat treatment and methyl bromide fumigation of WPM.