WATER TRANSPORT IN WOOD PARTICLE MATERIAL

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ABSTRACT  An analogy between water flux and the field of temperature gradient in a column of wood fuel chips was discovered by these experiments. The heat–mass transfer coefficient was determined by least squares method. An equation relating water flux and temperature gradient was developed and it was demonstrated that the temperature gradient was the main driving force for water transport. The mechanism was evaporation–condensation of water vapor through natural convection in air phase. The study gives a theoretical explanation for analyzing the problem of water transport in wood particle material.

Key words: Wood fuel chips, Water flux, Temperature gradient, Analogy

Woodchips are raw materials for shaving board, fibreboard, pulp, active carbon and wood fuel. Reasonable and effective utilization of this resource is of great importance for economic exploitation of forests.

During the storage of wood chips, physical changes, biological activity and chemical reactions often take place. These processes interact and have great effects on the physical properties and quality of the material.

When wood is chipped, the mechanical energy (strain and friction energy) transforms into heat and is released through stress relaxation, increasing the temperature of the material. Under proper temperature and moisture conditions, white–rot fungi and brown–rot fungi decompose cellulose, hemicellulose and lignin (white–rot fungi only) and simultaneously produce heat. Consequently, the temperature in the pile of wood chips can rise to above 65°C within 2 weeks. At elevated temperatures, chemical reactions take place between organic material and oxygen, leading to decay of the material and the production of carbon dioxide and water. Decomposition reduces the quality of wood and causes allergic reactions in workers.
Temperature gradients will be formed in the piles of wood chips because heat diffuses from piles to surroundings. Water in chips will evaporate to the outside and moves from high to low temperature regions through natural convection (3). Due to condensation of water vapor in cold regions, water is transported, so, usually a dry layer around the center and a wet layer in the outer part of the pile are formed. The moisture content of the wet layer can be twice as high as that of the dry part (3).

If wood chips are stored at low temperatures (<0°C), the wet part often freezes into blocks or on the surfaces of transport or storage facilities. This physical change can cause difficulties in handling processes of the materials (3).

The above-mentioned problems directly relate to moisture content and its dynamic redistribution. Therefore, the process of water transport in fuel wood chips was investigated.

THE PROCESS OF WATER TRANSPORT IN WOOD CHIPS

The Properties of Fuel Wood Chips
Wood is a biological material that is anisotropic with regard to heat and moisture transport. Wood chips are often regarded as a double-porous bulk material, having pores within the wood and between the wood chips. The piles of wood chips consist of multiple components, namely, wood solids, water and air. When wood decomposes, its mass will change. This makes study of the properties of wood chips very complicated. Experiments have shown that the following factors influence the process of water transport in wood chip piles (3):
- components, such as tree species, branch and bark contents, etc.
- particle size distribution, density and geometry of the pile;
- temperature and moisture content of the pile;
- surroundings, such as ventilation, temperature, etc.;
- storage duration.

Experimental Materials and Methods
A cylindrical column was taken from the middle of a pile of fuel wood chips. Since the column was located at the natural axis of the pile, only water transport in the vertical direction was considered, i.e. a problem of one-dimensional heat transfer. The pile of wood chips consisted of skeleton wood chips, water and air in the pores. Because of the random orientation and contacts of wood chips, the material was regarded as anisotropic material. The pile of wood chips was in an unsaturated condition, which means that water was absorbed in wood chips and no water existed in the pores between chips.

The experimental apparatus is shown in Figure 1. As a one-dimensional problem, the long column, "c", was insulated.

To simulate the common case of high temperature in the center of a pile of wood chips, a heat plate was set at the bottom and kept at 65°C when the stable state of temperature was reached. To generate the cold environment, a cold plate connected to a cooler was set on the top of the column. The cold plate was kept at −25°C upon reaching the stable state. The effects of biological activity...