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FIRE SAFE STORAGE AND PRELIMINARY DEHYDRATION OF WOOD WASTE WITH DIAMETER <30 MM FROM FINAL FELLING AND FOREST CARE FELLING, AS A SEMI-FINISHED PRODUCT FOR THE PRODUCTION OF SOLID FUEL

Abstract: *The purpose of the work was to obtain fairly reliable initial data regarding the organization of fire-safe long-term storage of wet wood waste of a small diameter in the open air by various alternative methods. The subject of research was freshly felled hardwood with leaves in the form of a mixture of the following botanical composition: poplar, maple, cherry, mulberry. The average moisture content of freshly cut wood is 50%, i.e. 1 kg of moisture per 1 kg of completely dry wood. The three most common ways of storing of wet wood waste with diameter ≤ 30 mm were researched. In its natural form – in a pile and a fragment of a stack, and in its chopped form – in the form of wet "green" chips. During the storage period, the moisture content decreased on average: in the pile ~ by 5 times; in the stack fragment – 4.3 times; in a fragment of a stack of the "green" wood chips of trapezoidal section ~2.5 times [1, 2].*

Keywords: *storage, wood waste from felling, wet "green" wood chips, preliminary dehydration, semi-finished fuel.*

Introduction

Involvement in the fuel use of waste from felling for forest care and main use requires the organization of safe storage of large volumes of wet wood resources. The category of waste, in accordance with the regulatory documentation of Ukraine, includes tops of trunks and branches with a trunk diameter of <30 mm. According to the rules, these resources are subject to destruction by burning with using of liquid fuel in specially designated places. For fire safety reasons, this is done in the fall. In addition to the destruction of such waste by burning, it is allowed to grind it into wood chips and scatter it between trees for natural, gradual degradation. This method of destruction is considered undesirable due to wood chips disrupting natural biological processes in the forest floor, which plays an important role in the forest biocenosis. Currently, there is no established system of cooperation and coordination between forestry and energy in Ukraine. In our opinion, such a system is very necessary and must necessarily have a synergistic, mutually beneficial character – that is, promote the development of both forestry and energy. Wood fuel fully meets modern environmental requirements, is a promising renewable resource, but requires large volumes of raw material storage. For example, compared to coal, taking into account the difference in calorific value, bulk mass and humidity, the volume of wood in warehouse cubic meter exceeds the volume of coal by approximately 20 times, assuming the same thermal energy potential.

At the Institute of Engineering Thermophysics, within the framework of the topic "Research of heat and mass transfer processes and the development of new energy-efficient methods and technological equipment for the production of biofuel from forestry waste", the harvesting of small-diameter wood together with green leaves was carried out, as well as the storage of this wood for 16 months.

So, the storage of small-diameter wood in the three most common ways was researched, namely: in its natural form – in a pile and a fragment of a stack, and also after chopping wood – in the form of wet "green" chips (Fig. 1). The first and second methods are considered safe in terms of self-ignition, so the main task of researching these methods was the effect of long-term storage on the moisture content of wood. The third method – in the form of wet wood chips is considered dangerous in terms of self-ignition, and this especially applies to "green" chips obtained by the method of chopping wood together with leaves.

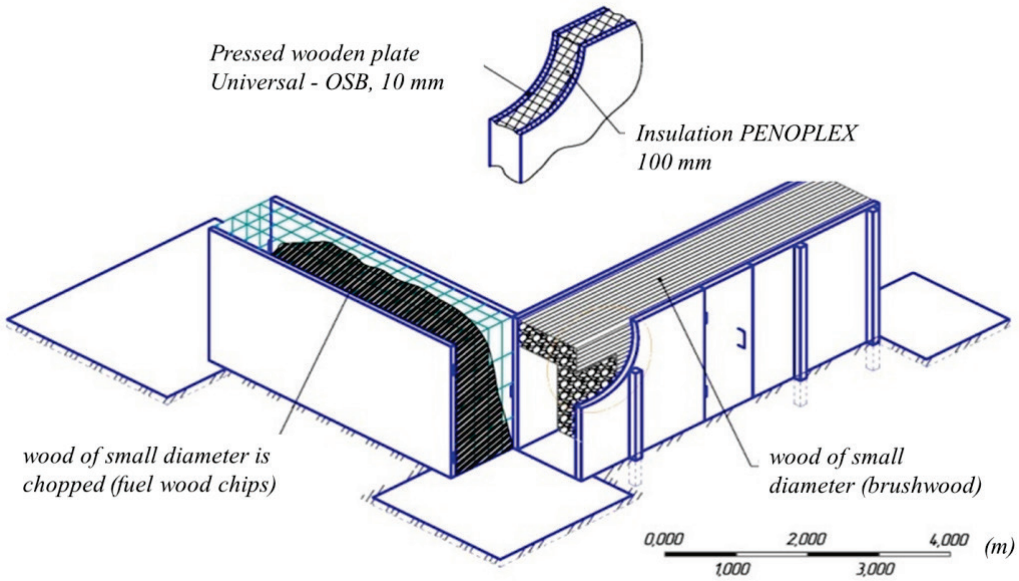

FIGURE 1. *Structural scheme of the building for experimental research long-term storage and preliminary drying wood*

Characteristics of alternative methods of outdoor storage for 16 months

1. In a separate pile, in the form of whole trees with leaves: width – 1.7 m; length – 3.4 m; height – 1.5 m; bulk volume ~9 m^3.
2. In a fragment of an industrial stack: width – 5 m; height – 2 m; length – 1 m (in practice, the length is not limited, has no technological significance and is determined for organizational reasons, taking into account the size and shape of the storage area); bulk volume ~10 m^3.
3. A fragment of the stack of crushed wood together with "green" leaves (of the "green" chips). Stack dimensions: height – 2 m; width: at the mark "0" – 5 m, at the mark "2" – 3 m; length – 1 m; bulk volume ~5.5 m^3.

The conception (idea) of the research was based on the following:

- Pile storage was organized on a 1:1 scale and is a full-scale experimental and industrial test.
- Storage of freshly cut "green" wood in a stack is organized in the form of a 1 m long fragment with a cross-section on a scale of 1:1, which had the shape of a rectangle, 5 m wide and 2 m high. The fragment of the stack was formed between two parallel heat-insulated flat fences.
- The research of wet "green" chips was aimed, first of all, at determining the technical conditions that prevent spontaneous combustion, which has repeatedly occurred in practice and was confirmed by researchers from different countries.

When choosing the shape and cross-sectional dimensions of the stack for storing wood chips, we took the following into account:

- Self-ignition requires a temperature level that cannot be achieved only through purely biochemical processes. Reaching the temperature necessary for self-ignition indicates the participation of exothermic chemical reactions (probably hydrocarbon oxidation reactions in the presence of flammable gases).
- Flammable gases can be formed during the activity of facultative microflora, which operates at an oxygen concentration insufficient for aerobic microflora, which produces only non-flammable gases – water vapor and carbon dioxide.

The above considerations indicate a huge unevenness of conditions in the massif of "green" wet cod. Similar problems associated with insufficient aeration occur during composting of biomass – its biological conversion by fermentation under the influence of aerobic microflora. In field composting technology, this problem is solved by mixing and aerating biomass with specialized mechanisms. Therefore, we decided to organize the storage of wet "green" wood chips in a fragment of an elongated stack with cross-sectional dimensions that would allow, if necessary, processing of the stack with commercially available mixer-aerators.

A 1 m long stack fragment was arranged between two parallel heat-insulated flat fence walls with a cross-section in the form of a trapezoid. Section dimensions: height – 2 m; width: at the "0m" mark – 5 m, at the "2m" mark – 3 m; length – 1 m.

During the entire period of storage, the temperature was measured at different points of the internal volume of the wood using a specially designed probe (Fig. 2).

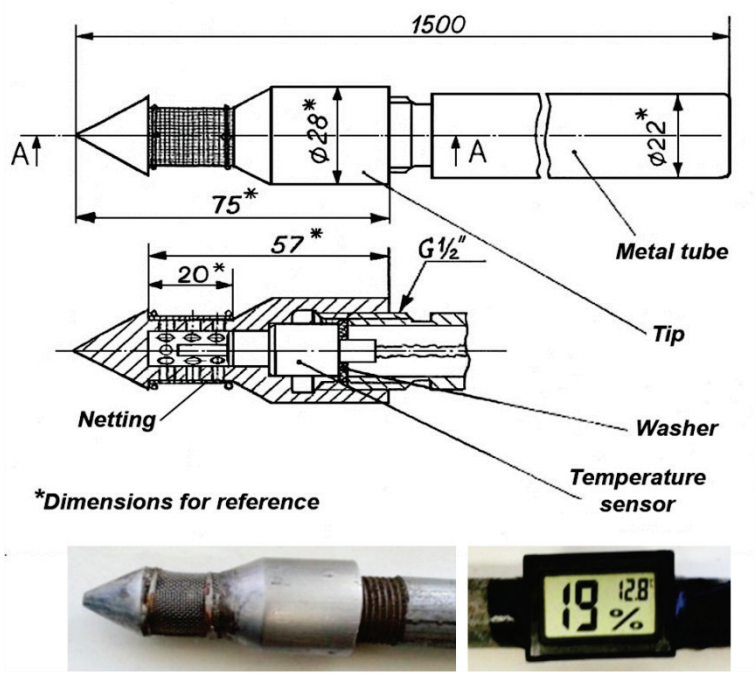

Figure 2. *Immersion temperature measuring device – "probe" 1500 mm long*

The probe provides measurement of the air temperature in the location area of the mechanically protected sensor. Air is a continuous gaseous phase in the inner volume of a two-phase material. The solid phase of the material is represented: in the pile and stack by whole brushwood with leaves, and in the chip stack by polydisperse fragments of wood (chips) and leaves.

It was established that the temperature in the massif of the heap was almost no different from the ambient temperature; in the stack fragment it reached 40°C; the maximum temperature in the chips massif reached 62°C, after which it gradually decreased to the ambient temperature over the course of 2 months.

During the storage period of the raw material, its moisture content decreased on average:

- In a pile ~5 times (from 1 kg of moisture per 1 kg of completely dry wood to 0.2 kg of moisture per 1 kg of completely dry wood) (Figs. 3, 4).

FIGURE 3. *Storage in a separate pile*

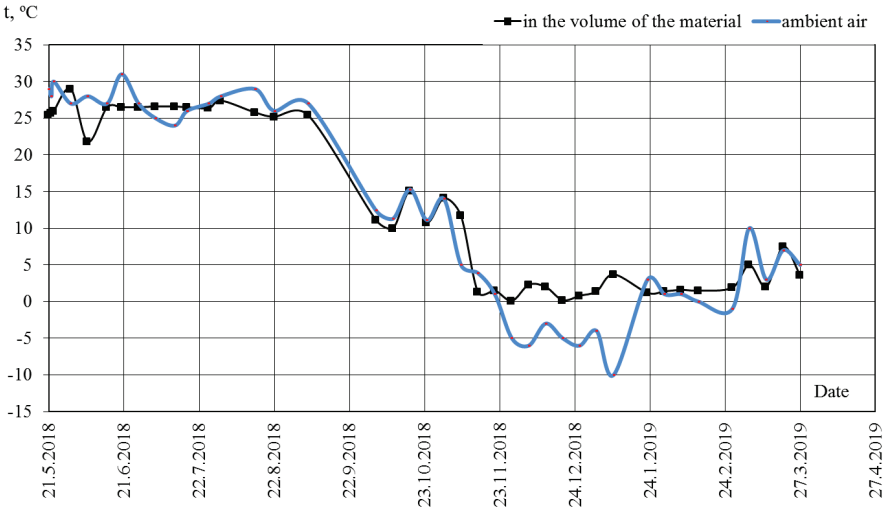

FIGURE 4. *Temperature in the material pile and the environment*

- In a stack fragment – 4.3 times (from 1 kg of moisture per 1 kg of completely dry wood to 0.23 kg of moisture per 1 kg of completely dry wood) (Figs. 5, 6).

FIGURE 5. *Experimental fragment of the stack*

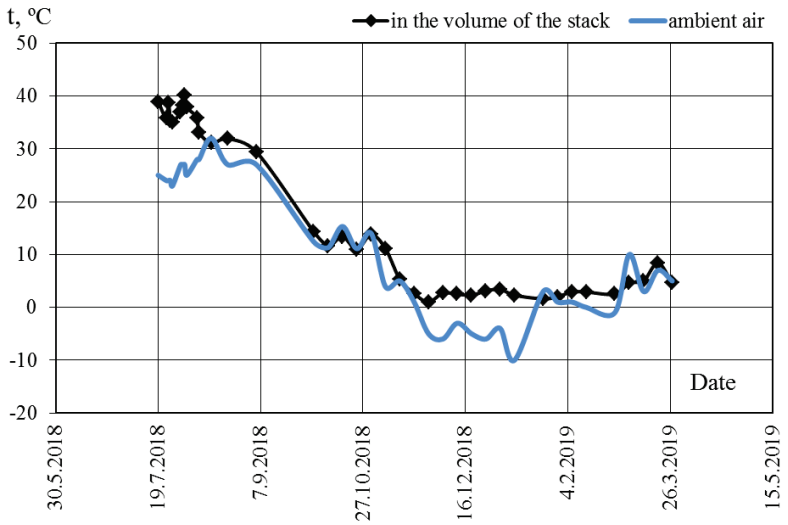

FIGURE 6. *Temperature in the volume of the stack fragment and the environment*

- In a fragment of a stack of "green" wood chips ~2.5 times (from 1 kg of moisture per 1 kg of completely dry wood to 0.4 kg of moisture per 1 kg of completely dry wood) (Figs. 7, 8).

FIGURE 7. *Fragment of a stack of "green" wood chips*

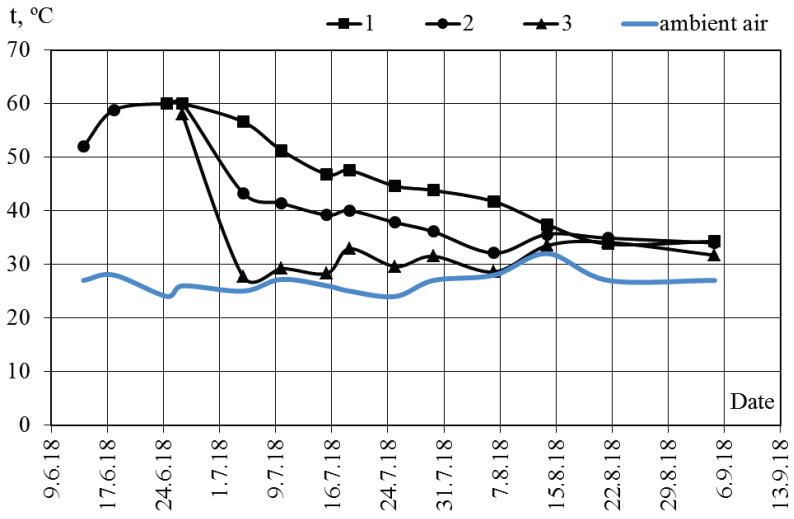

FIGURE 8. *Temperature in the environment and in the volume of the wood chips (points 1, 2, 3)*

Discussion

In our opinion, some advantage in the dewatering of whole wet wood waste ≤30 mm in diameter when stored in a pile, compared to stored in a stack, is explained by the following factors:

- a larger specific external surface in relation to the environment;
- better air exchange conditions.

When storing whole wet wood waste with a diameter ≤30 mm in a pile, the effect of biological conversion is not noticeable, as evidenced by the practical temperature equilibrium with the environment.

When storing whole wet wood waste with a diameter of ≤30 mm in a stack, there is some influence on the dehydration of the biological conversion process, which is evidenced by reaching a temperature of 40°C.

The study of long-term storage of "green" wood chips proves that a very active process of biological conversion takes place in its volume. This is evidenced by reaching a temperature of 62°C. Such an increase in temperature is characteristic of the so-called succession process. With it, there is a gradual change in microflora generations (cryophilic generation – 10-20°C, mesophilic – 20-40°C, thermophilic – 40-65°C).

Such a scheme of gradual change of generations of microflora is characteristic of composting (solid-state microbial fermentation). At each stage, the next generation of microflora utilizes the previous microflora as an edible medium. Reaching a temperature ≥60°C practically stops the processes of biological conversion.

Conclusions

1. All researched storage methods are safe with respect to spontaneous combustion.
2. Long-term storage (≥16 months) provides significant dehydration; when stored whole wet wood waste with a diameter of ≤30 mm in a pile and stack, it is practically provide that the air-dry state is reached, and the fuel semi-finished product does not require further dehydration. Storage in the form of fuel chips requires further drying of the semi-finished product.
3. Dehydration during storage in the form of wet "green" wood chips is ensured mainly due to the process of biological conversion of shredded leaves and small wood particles. We formulated and received a patent for a useful model for stacking wet wood chips in elongated stackes of a defined cross-section, which is sufficient for fire-safe storage and significant preliminary drying without stirring [3]. In addition, acceleration (if necessary) of conversion and drying by mixing and aeration was proposed.

References

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