REGARDING THE QUESTION OF OBTAINING NATURAL TEXTILE FIBERS FROM PINE NEEDLES

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Abstract: *Pine needles can be a source of environmentally friendly natural textile fibers. The technology of producing natural textile fiber from pine needles has significant economic and environmental potential. The following stages of pine needle production were identified in the study: raw material collection and separation of clean pine needles; extraction of natural textile fibers from pine needles, technological processes of fiber processing for the production of finished products. A pneumatic-thermal method was proposed for separating clean pine needles and a schematic diagram of the installation for its implementation was developed. Using the method of multifactorial experiment, a technological regime for extracting textile fiber from pine needles was developed, which involves treating the needles at a temperature of 100°C for 40 hours in a solution of NaOH with a concentration of 70 g/l.*

Key words: *needles, natural fiber, pneumatic-thermal method, sodium hydroxide, technological regime.*

1. INTRODUCTION

The pine needles that we usually associate with winter holidays and Christmas trees are a valuable raw material. They are used to produce pine extract and essential oil, as animal feed, as organic fertilizer, for the production of wood pulp and chemical fibers, for energy production, and more [1].

Pine needles can also be a source of ecologically clean natural textile fibers. In the past, there was a technology for producing natural fibers from pine needles, known as "forest wool." These fibers were used to make warm knitted garments and were considered beneficial for health [2].

Today, this technology can be considered forgotten, but in our opinion, it has significant ecological and economic potential, can help improve production efficiency, reduce negative environmental impact, and create new opportunities for business and innovation.

2. BASIC STAGES OF PRODUCTION

Natural textile fiber from coniferous needles can be made from various types of coniferous trees, such as pine, fir, spruce, larch, and others. The process of obtaining natural textile fiber from needles may differ depending on the type of coniferous trees used. However, generally, the production of natural fiber can be divided into the following stages:

1. Collection of raw materials and separation of clean needles.
2. Extraction of natural textile fiber from needles.
3. Technological processes of fiber processing to make finished products.

3. COLLECTION OF RAW MATERIAL AND SEPARATION OF CLEAN NEEDLES

Typically, needles are collected during tree felling or from the waste of forest cultivation. Obtaining natural textile fiber from needles requires high-quality raw material - needles that are separated from other components of the crown (bark and branches), which are harmful impurities to each other [1]. There are available mechanical, pneumatic-mechanical, electro-hydraulic, cryogenic methods for obtaining clean needles, as well as methods using a high-frequency field. However, due to significant disadvantages of available methods and the possibility of further use of needles for the production of natural textile fibers, we propose a pneumo-thermal method, which is implemented on the installation (Fig. 1) [1].

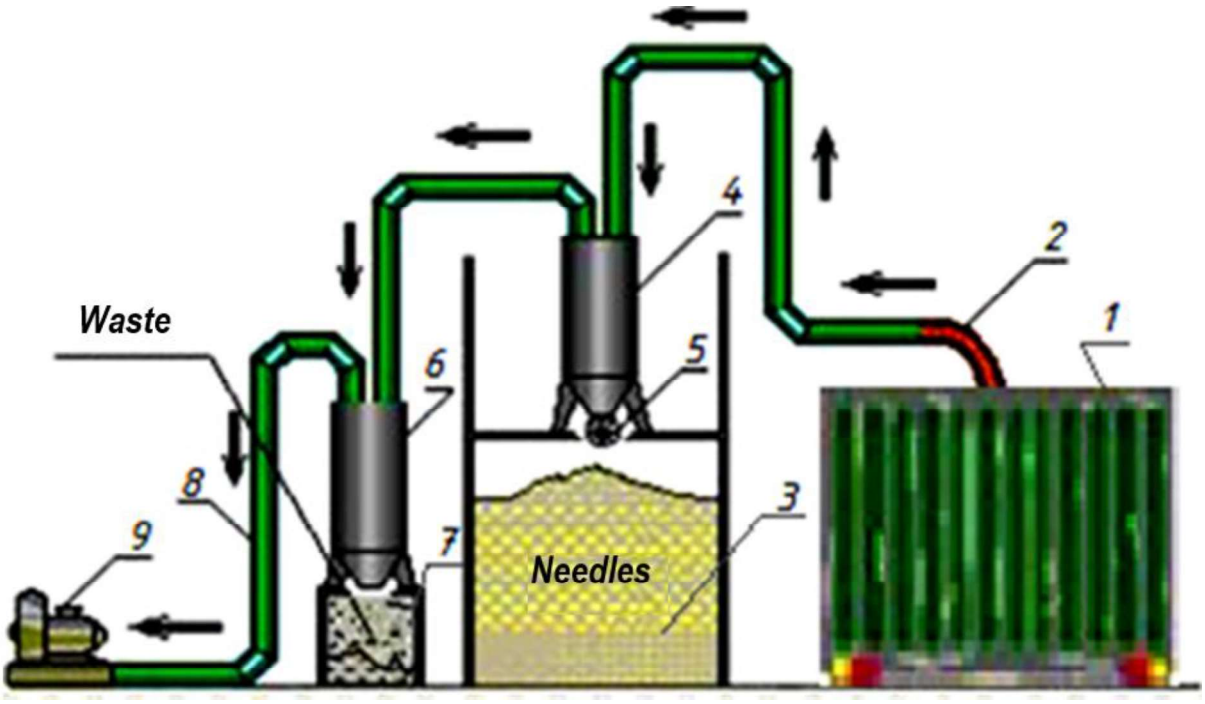

Figure 1: Schematic diagram of the installation for separation of needles by pneumo-thermal method: 1 - drying chamber; 2 - suction pipeline; 3 - needles collector; 4 - cyclone for separating needles; 5 - gate valve; 6 - cyclone for separating waste; 7 - waste collector; 8 - air duct

The separation of branches from needles is carried out in a drying chamber of a mobile plant for separating needles. During the drying process, the bond between the branches and needles weakens, making it easier to separate them with less force. The separation of needles from branches and their transportation to the needle collector is carried out by a vacuum pneumatic transportation system, which is a fundamental part of the design of the mobile plant for needle separation. The main components of the plant include an aerodynamic drying chamber, cyclones, a vacuum pump, and a needle collector.

Air, needles, and waste are sucked into the drying chamber 1. Since the branches have greater mass, they remain in the drying chamber. The mixture of air and needles is then transported through suction pipeline 2 to the needle separation cyclone 4,

where the separation of needles takes place under the action of centrifugal force. The separated needles pass through gate valve 5 into the needle collector 3. The air is cleaned of small waste particles in the waste separation cyclone 6, with the waste being collected in the waste collector 7. The vacuum in the air pipeline 8 is provided by the vacuum pump.

4. EXTRACTION OF NATURAL TEXTILE FIBER FROM NEEDLES

This stage is the most important step in the technology of producing natural textile fiber from coniferous trees. In the past, the fiber was extracted by soaking it for a long period of time (several months) in flowing river water. Various methods are now proposed to intensify the process of obtaining natural textile fiber from coniferous trees, but they are mostly complex and energy-intensive [3-6].

The following requirements were determined for the method of extracting natural textile fiber from coniferous trees:

1. Simplicity of the method. The method should contain as few operations as possible.
2. Ecological safety of the method. The use of chemical reagents to extract natural textile fiber from coniferous trees should be minimized.
3. Energy efficiency of the method. The duration of the processes and the energy costs involved should be minimized.

To intensify the process, the use of the chemical reagent NaOH (sodium hydroxide) and temperature was proposed. To determine the optimal conditions for obtaining fiber from conifer needles, a series of multifactor experiments were conducted, the planning matrices of which are presented in Table 1. The intensity of natural textile fiber extraction was evaluated by the residual mass of the raw material (%) after processing, as during the removal process, accompanying substances of cellulose, such as resin, lignite, and other substances, were dissolved.

The results of the experiment are presented in the form of response surfaces in Fig. 2, 3. According to the research results, the following technological regime is proposed for extracting textile fiber from coniferous trees:

1. Treatment duration - 40 min.
2. Treatment temperature - 100°C.
3. Concentration of NaOH in the solution - 70 g/L.

Table 1: Matrix of planning for a three-factor experiment

Experiment number	NaOH concentration, g/L	Time, min	Temperature, °C
1	20	10	80
2	70	10	80
3	20	30	80
4	70	30	80
5	20	10	100
6	70	10	100
7	20	30	100
8	70	30	100

Table 2: Matrix of planning for a two-factor experiment

Experiment number	NaOH concentration, g/L	Time, min
1	70	40
2	90	40
3	70	50
4	80	50

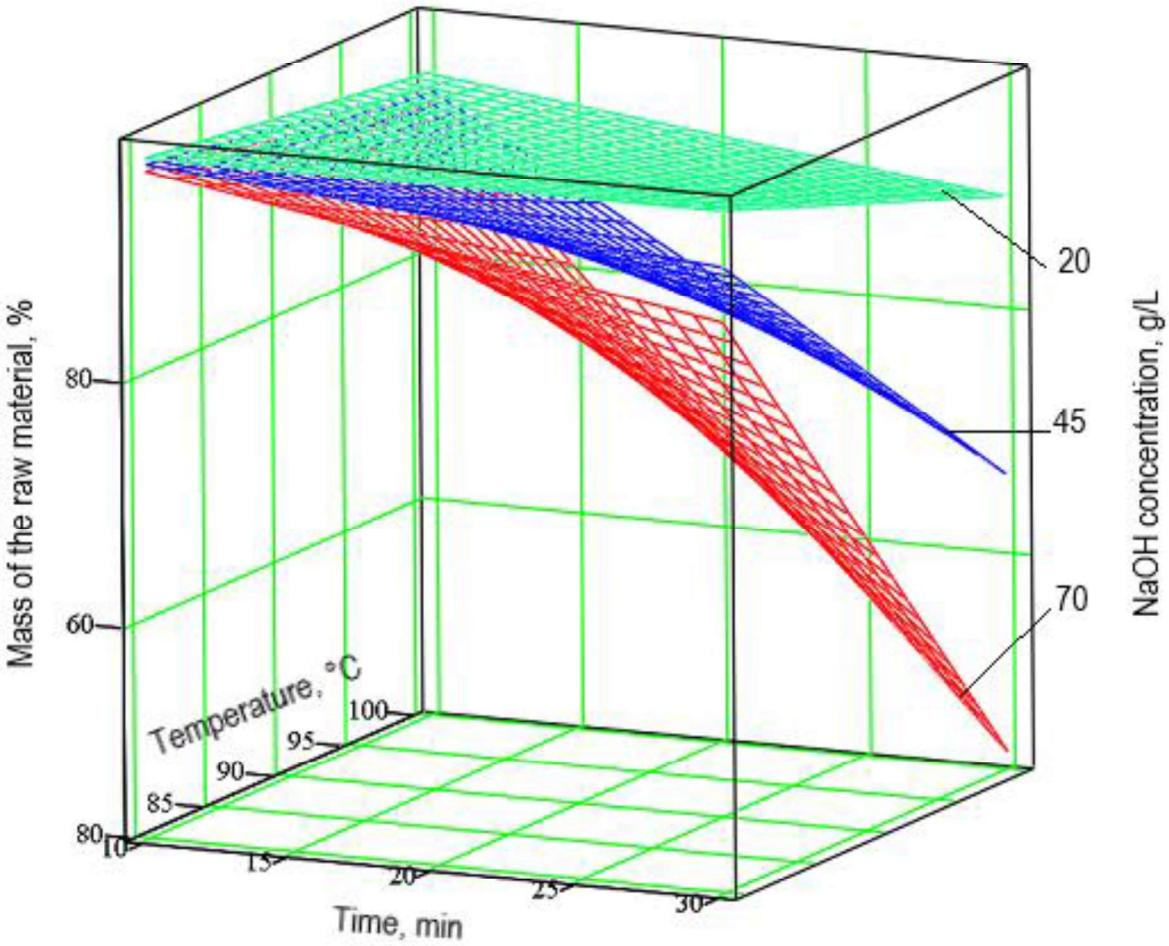

Figure 2: Dependence of residual mass of coniferous raw materials on NaOH concentration, time, and temperature

The appearance of the natural textile fiber obtained from the research is presented in Fig. 4.

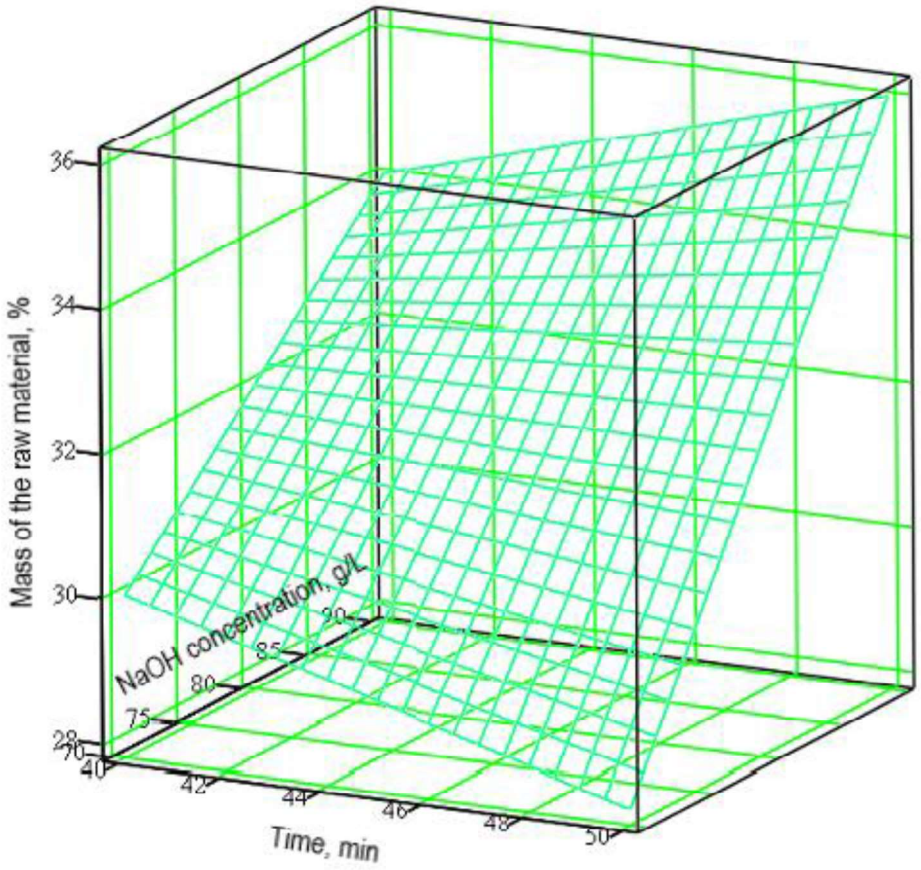

Figure 3: Dependence of residual mass of coniferous raw materials on NaOH concentration and time

Figure 4: The appearance of the natural textile fiber from needles

It should be noted that the intensity of the processing process is also influenced by the previous mechanical treatment of the needles (flattening). Studies with the use of mechanical action on the raw material before the process of boiling the needles are currently being conducted by us.

4. CONCLUSIONS

The technology of producing natural textile fiber from coniferous needles has significant economic and environmental potential. As a result of the conducted research, the main stages of needle production were identified. A pneumatic-thermal method was proposed for separating pure needles. A technological regime was developed for extracting textile fiber from needles, which involves treating the needles at a temperature of 100°C for 40 minutes in a solution of NaOH in a solvent (concentration of 70 g/L). Promising directions for further research were determined.

5. References

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