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MILLED LUMBER STEAMING CHAMBERS

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ABSTRACT

This paper describers the steaming chambers used for thermal treatment of milled lumber. The steaming process is a principal operation, as part of the primary wood processing. This technological process is a relevant prerequisite for obtaining quality lumber for final manufacturing. Steaming processes take place in constructed facilities called steaming chambers, under normal range of barometric pressure. This paper presents the two methods used for milled lumber steaming, direct vaporization and indirect vaporization. The two methods are characterized by different functional principles and different installation of the steaming chambers. An important aspect for obtaining quality lumber is the level of automatization of the steaming process. Automatization is composed by technical equipment for process monitoring and allows precise insight into the steaming process. The traditional manual steaming chambers monitor the color of the condensate as an indicator of the phase of the steaming process. Alongside automatization, this paper describes the industrial energetic and water supply installation of the steaming chambers.

Key words: steaming chamber, lumber, water vapor, temperature, relative humidity, automatization.

1. INTRODUCTION

The data regarding treatment of milled lumber with water vapor in constructed facilities and under normal range of barometric pressure dates back in the 1930s.

With the development of science and technology, the heat loss in the chambers is significantly decreased, as well as the thermal efficiency of this process. This was achieved by: new methods for construction of the chambers, rationalization of the steaming modes, variety of new appliances, probes connected to computer software for the purpose of monitoring the steaming process.

This research is oriented towards the requirements for new data regarding the process of streaming milled lumber.

2. RESEARCH METHOD

The information presented in this paper is obtained by analyzing literature and publications from domestic and international authors. The literature and publications analyzed were from the field of milled lumber steaming and primary wood processing. This paper presents data from monitoring the steaming process in manufacturing conditions. An analysis was conducted regarding the steaming equipment used in the industrial capacities. The presented results are applicable and relevant in manufacturing conditions.

The steaming process is a technological and thermal process, in which milled lumber is exposed to the influence of saturated water vapor. This process takes place in closed space called chamber and is followed by temperature and pressure. The purpose of the steaming process is change in lumber color, improvement of its properties, sterilization. Steaming of milled lumber also removes some defects that had occurred during the drying process.

3. RESULTS AND DISCUSSION

The results are directed towards: the methods of milled lumber steaming,
– the steaming chambers,
– the chamber automatization and
– the industrial installation in the steaming chambers.

3.1. Methods of milled lumber steaming

The steaming process takes place in constructed facilities, under the influence of water vapor. The process is executed by the following methods:
– direct vaporization of the milled lumber and
– indirect vaporization of the milled lumber.

In the method of direct vaporization, the steaming medium is saturated water vapor. This saturated vapor is carried by pipelines from the boiler. The boiler is located next to the steaming chamber.

The pipes through which water vapor is sprayed into the steaming chamber can have varying positions. The position can be central, along the length of the chamber, or the pipes may be slightly raised above the floor or laterally attached along the walls of the chamber. Their diameter is d = 60 ÷ 70 mm. The pipes are perforated with spirally arranged openings with a diameter d = 5 mm, at a distance r = 14 ÷ 15 cm. They are made of non-rusting materials, usually copper or aluminum. A chamber for direct vaporization of milled lumber is shown in Figure 1.

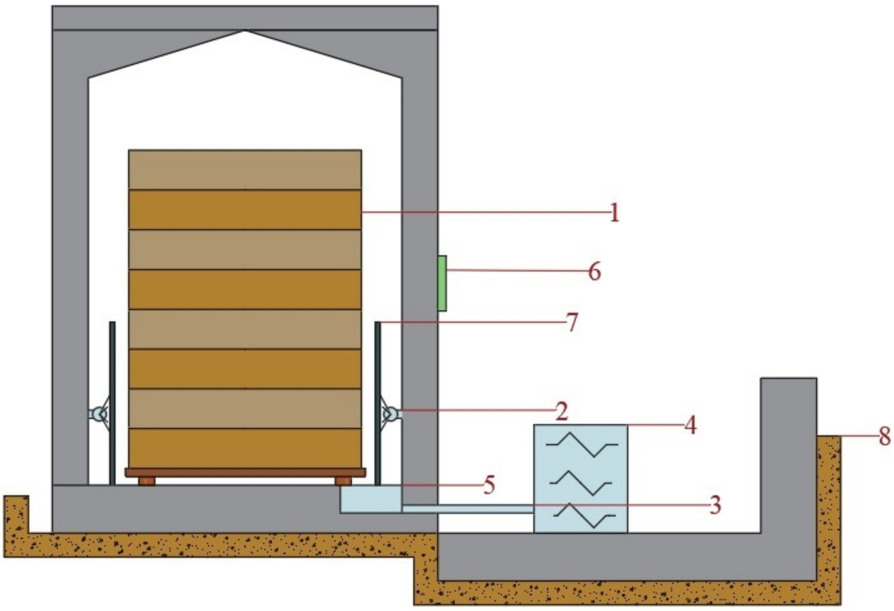

Figure 1. *Cross-section of a steaming chamber with direct vaporization*
1) milled lumber, 2) perforated pipes, 3) condensate drain opening, 4) condensate collection container, 5) condensate canal, 6) remote thermometer, 7) protective separator, 8) soil.

In the steaming chambers with direct vaporization, an aluminum sheet (7) is placed between the perforated pipes (2) and the chamber with milled lumber (1), which acts as a protective separator, thus preventing the direct impact of water vapor on the timber. This technique decreases the possibilities for occurrence of defects and damages on milled lumber. Through the openings of the pipes, the heated water vapor is sprayed into the chamber interior. The steam gives off heat and condenses in contact with the wood, the walls, the door and the ceiling of the chamber. The condensate flows into the canal (5) and it contains: acids (formic, acetic, phosphoric), small particles of bark or wood, and flows through the opening (3) for draining the condensate into the collection container (4). The condensate is clear at the beginning of the steaming, but as the process progresses it becomes cloudy, and at the end of the process it clears again. This color change of the condensate can serve as an indicator of the progress of the steaming process. From the collection container (4), when the condensate is heated and has temperature of about 100 °C, if it is not returned to the boiler, it is carrier to a pool, cooled and taken to a pit through a canal.

It is of particular importance for the process of direct vaporization to know that steaming is done with saturated water vapor and under no circumstances superheated water vapor can be used. The superheated vapor intensively dries the surface of the lumber. This also leads to different moisture contents on the surface and in the internal layers of the lumber. This difference in moisture content causes internal stress and appearance of defects in steamed lumber.

The temperature of saturated water vapor in the chamber ranges from 95 to 100 °C. Relative humidity of the air is φ = 100 %. Vapor pressure in the chamber depends on the construction, hermeticity, thermal insulation, durability of the steaming process and the steaming mode. The pressure in the chamber is controlled by the reducing vapor valve.

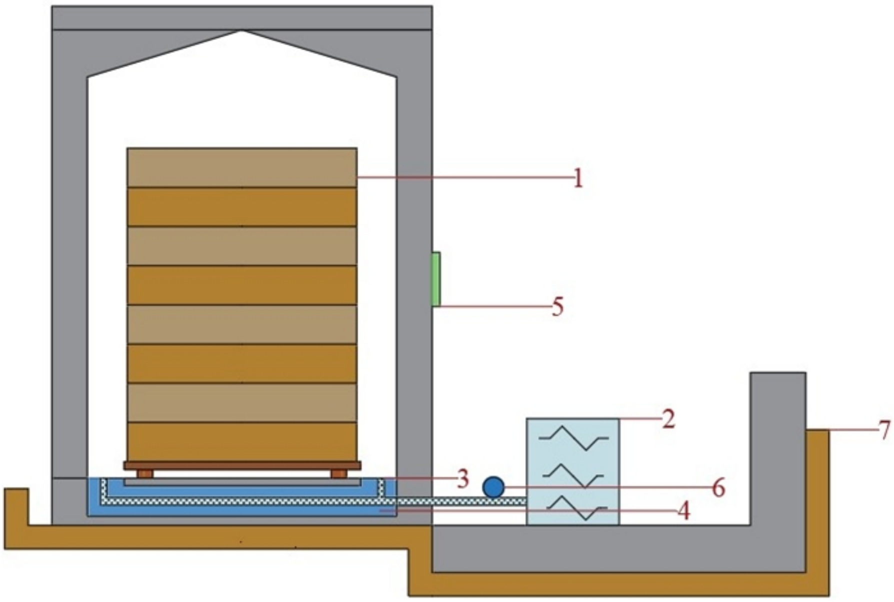

Figure 2. *Cross-section of a steaming chamber with indirect vaporization*
1) milled lumber, 2) water container, 3) heating appliance, 4) water canal, 5) remote thermometer, 6) condensate pump, 7) soil.

A cross-section of chamber with indirect vaporization is presented in Figure 2. The method of indirect vaporization of lumber compared to the method of direct vaporization differs. The difference is in the construction of the chamber floor. In the direct vaporization chamber, there is a canal (1) filled with water in the floor. The water in the canal is at height of h = 10 ÷ 15 cm. The heating appliances (2) are placed in the canal, through which a water heating medium passes. Water vapor, boiling water or pure thermostable oils are used as mediums of heating. Practice has shown that the most rational way of heating is heating with water vapor. When heating with hot water, whose temperature does not exceed 120 °C, there is a need to increase the length of the heating pipes. This occurred due to the lower heat transfer coefficient. In recent times, heating with pure thermostable oils, referred to as "thermo-oils", has also been applied. The advantage of the oil is that it can quickly reach temperature of up to 300 °C, without pressure. However, heating systems using thermostable oils are rarely used in practice due to the high cost of oil, its storage, the greasing of pipelines, etc.

The milled lumber (3) is arranged in the chamber. According to the applied mode, the process of gradual heating begins. Water is heated by transferring the heat from the heating appliances to the water. The heated water from the canal evaporates and moves to the upper zones of the chamber. In doing so, water vapor penetrates the milled lumber and the steaming process starts.

Temperature in the range between 90 and 100 °C and relative air humidity φ = 100 % are maintained during the steaming process in the chamber. Steaming time ranges within the limits Z = 24 ÷ 96 h. The total steaming time depends on the wood species, the initial humidity of the lumber, the thickness of the lumber and the temperature of water vapor.

The heating appliances are placed in a canal filled with water. They are at a distance of 5 cm from the bottom of the canal. The water level in the canal can be up to 15 cm high, and is controlled by a water level regulation system. In order for the water to heat and evaporate, the heating pipe is constructed with the necessary heating surface. Water vapor acts as a medium for water heating in the canal. For that reason, the vapor should have pressure of at least 2 bar. At the exit of the chamber, the pipeline is connected to a container for condensate collection. The collected condensate is returned to the boiler, thus improving the heat regulation system.

3.2. Milled lumber steaming chambers

The steaming of milled lumber is carried out in closed space called steaming chamber. This chamber can be constructed from building materials (masonry), or made from aluminum structural profiles in combination with panel walls. The panel walls are made of pure aluminum with internal filling consisting of thermal insulation materials.

Typical parameters for masonry chambers are their length, which ranges from 6 to 16 m, width from 2 to 2.2 m and height from 2.2 to 2.5 m. For construction of this kind of chamber, materials with good thermal insulation properties are used, in order to reduce heat loss at the highest level. The walls are single-layered and are built from reinforced concrete. The wall thickness ranges from 20 to 51 cm. The walls are coated with acid-resistant materials, and can be constructed from several layers, as follows: reinforced concrete - burned brick - air space - cement mortar - acid-resistant materials based on bitumen. A cross-section of a masonry steaming chamber is shown in Figure 3.

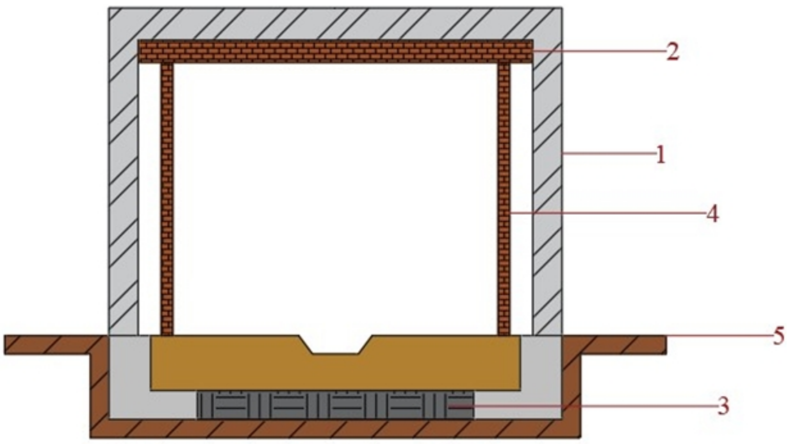

Figure 3. *Cross-section of a masonry chamber*
1) reinforced concrete, 2) burned brick, 3) stone base, 4) air space, 5) soil.

Metal steaming chambers can consist of one or more steaming rooms. They are superior compared to other constructional types. The most important advantages are: great possibility for maintaining a constant temperature and pressure in the chamber, good thermal capacity of the walls, easy manipulation of the lumber with standard trolleys or trolleys with a lifting platform, heat energy saving. They are easy to install and maintain. Their structural parts are made of aluminum grid construction or aluminum profiles. The walls are made of aluminum panel plates with internal thermal filling of mineral wool or hard polyurethane with a thickness of 120 mm. The doors of the steaming chamber are made of the same materials as the walls, i.e., aluminum - thermal insulation - aluminum. The mechanism, which is used to close the door, allows the doors to adhere firmly to the wall, which improves the ambience in the chamber. This means that temperature and pressure oscillations are reduced.

The chamber celling is structurally constructed in the form of a vault, in order to avoid the condensate dripping directly on the milled lumber. The vaulting of the ceiling in the form of an arch is made of pure aluminum. The condensate, that is created during the steaming process, flows from the vaulted ceiling to the walls and out through a canal outside the chamber. Metal steaming chambers are shown in Figure 4.

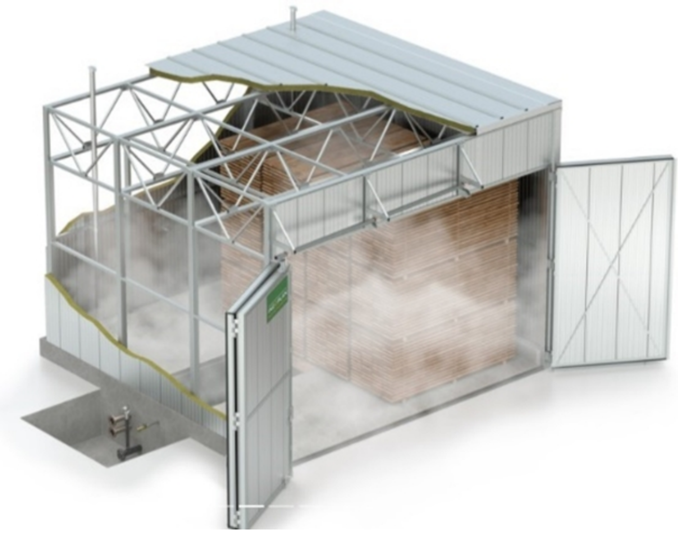

Figure 4. *Metal steaming chamber*

3.3. Steaming chamber automatization

One of the key factors for successful management of the steaming process is the level of automatization of the steaming chamber. Automatization allows full monitoring and control of the process. The automatized process is shown in Figure 5.

Figure 5. *Chamber with fully automatized steaming process*
1) printer, 2) internet connection, 3) computer, 4) communication link between the adapter and the computer, 5) communication adapter, 6) metal chamber, 7) automatic monitoring device for the steaming process.

3.4. Industrial installation in the steaming chambers

Industrial installation in the steaming chambers with direct and indirect vaporization consists of the energy and water supply installation. Energy heating installation is much more complicated and complex than water supply installation. Energy installation begins with an installed vapor boiler, which is the main part of this installation.

Water vapor created in the boiler (1) is carried through the main pipeline (3) to the vapor separator (4). To control the parameters of water vapor (temperature, pressure and increased volume of vapor in the chamber), the following equipment is used: thermometer (5), pressure gauge (6) and safety valve (7). Water vapor from the output vapor valves (9) is repurposed for use by other users (dry kilns). This vapor is directed through the pipelines (10), with the valves (8) into the steaming chamber (11). Condensate from the steaming process is collected in condensate container (12). Through a pipeline, the condensate is collected in the condensate collector (13). Excess condensate from the collector is collected in the condensate overflow collector (14). A pump (15) is used to transport the collected vapor to the water tank (16). In the cistern it mixes with the water, and as it is heated, it transmits a certain amount of heat to the cistern, which is useful for raising the heat capacity (temperature) of the water. The water heated in this way is drawn from the cistern and transported to the vapor boiler (1) by a boiler feed pump (20). This principle of operation is quite economical in terms of reducing solid fuel consumption. It is considered that saving of solid fuel ranges between 20 to 25 %, of the total amount of solid fuel required for steaming. The cistern is supplied with fresh water from a water supply source or a well (17), for which purpose a pump (18) is used. The cycle repeats itself. The described installation is shown in Figure 6.

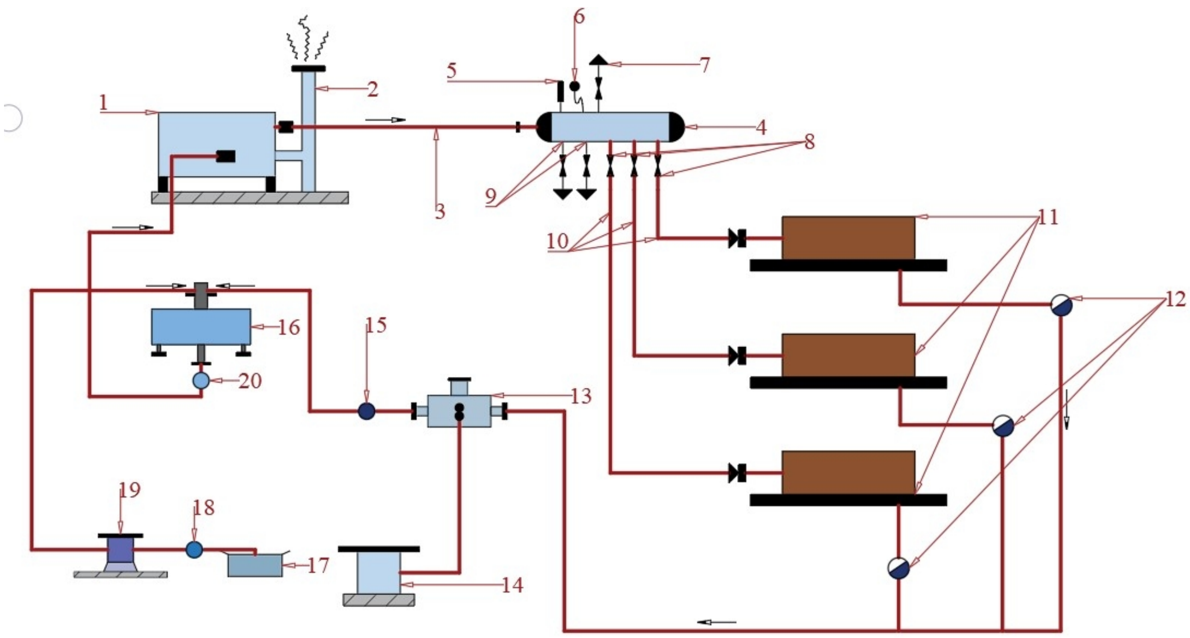

Figure 6. *Industrial power and water supply installation for milled lumber steaming*
1) vapor boiler, 2) chimney, 3) main vapor pipeline, 4) vapor separator, 5) thermometer, 6) pressure gauge, 7) safety valve 8) vapor valves for the steaming chambers, 9) vapor valves for other consumers, 10) vapor pipeline for the steaming chambers, 11) steaming chambers, 12) condensate container, 13) condensate collector, 14) condensate overflow collector, 15) condensate pump, 16) water tank, 17) fresh water, 18) fresh water pump, 19) fresh water preparation device, 20) boiler feed pump

4. CONCLUSION

Lumber steaming process is an important and complex operation. It is an essential part of lumber processing. It takes place in closed spaces called steaming chambers, under normal barometric pressure. The steaming process can be executed by two methods, direct and indirect vaporization. Direct vaporization is carried out with saturated water vapor, which is brought through a system of pipes inside the chamber. Water vapor is supplied through the pipelines from the boiler. The pipelines are perforated and are located behind a protective separator. The temperature of water vapor ranges from 95 to 100 °C, and the relative humidity of the air is $\varphi = 100$ %.

In the indirect vaporization chambers, the floor consists of a water canal. Heating appliances are immersed in the water, through which water vapor circulates. The heating appliances transmit heat to the water and heats it. The heated water from the canal evaporates and thus the steaming process begins. The air temperature ranges from 90 to 100 °C, and the relative air humidity is $\varphi = 100$ %.

Steaming chambers can be built from building materials, i.e., they can be masonry or they can be metal, i.e., they are made of aluminum structural profiles in combination with thermal insulation materials.

A key factor for a successful steaming process is the degree of the process automatization. Automatization consists of equipment for monitoring and controlling the steaming process.

Industrial installation for steaming consists of the energy and water supply installation of the chambers. The main part of the energy installation is the vapor boiler. Water vapor is supplied from the boiler. The main part of the water supply installation is the water tank.

REFERENCES

[1] Hamm, Đ., Lovrič, N. (1971): Parionice za bukovu piljenu građu. Drvna industrija, br. 9 – 10, god. XXIII, Šumarski fakultet, Zagreb.
[2] Hamm, Đ., Lovrič, N. (1971): Parionice za bukovu piljenu građu. Drvna industrija, br. 11– 12, god. XXIII, Šumarski fakultet, Zagreb.
[3] Nikolič, M.: Parionice za drvo, NIGOS, Niš.
[4] Rabadjiski, B. (2019): Parilnici za parenje na biceni sortimenti. Tehnologii, masini i energetika vo drvnata industrija. Seminar, 4 – 5 april, Kavadarci.
[5] Rabadjiski, B., Zlateski, G. (2007): Hidrotremicka obrabotka na drvoto, I del. UKIM, Sumarski fakultet, Skopje.
[6] Rabadjiski, B., Zlateski, G. (2015): Hidrotremicka obrabotka na drvoto, II del. Plastifikacija na drvoto, UKIM, FDTME, Skopje.

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