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STUDIES ON THERMO MODIFICATION OF WOOD IN A MEDIUM OF FLUE GASES

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Abstract

The technology and equipment for the implementation of thermo modified wood in medium of combustion gases that reduces the energy costs of the process and carries out heat treatment without decreasing the quality of the material.

Key words: *thermo modification, thermo wood, flue gas, equipment, technology of heat treatment.*

Thermo modified wood is a natural, environmentally friendly material which is absolutely superior to the traditional materials of wood on a number of important characteristics: resistance to decay, the stability of geometry in the operation, low equilibrium moisture content at the level of 3-5%, the ability to obtain any shade from light yellow to almost black on the depth of products, low water absorption, low thermal conductivity. Products made of thermally treated wood are used without restrictions in all climatic conditions. They do not need a preservative treatment, impregnation, tinting, dyeing. Hydrothermal treatment emphasizes and brings out the beauty of natural wood, gives new technological and decorative properties of valuable species. All these properties make thermowood a very popular product on the market of building materials. It has been widely used in European countries and became applicable in Russia. Meanwhile, production of such materials is limited by their high cost, as in the existing apparatus thermo modification mainly takes place in a medium of superheated steam, which requires high energy and leads to a rapid deterioration of the equipment.

Therefore, the development of technology and equipment that reduces energy costs in the process of thermo modification is an urgent task. In this regard, there has been proposed and investigated the possibility of carrying out the process in an environment of flue gases. Scheme of the designed technology is shown in Fig. 1.

Thermo modification of timber is performed as follows. The chamber 1 is loaded with waste timber through the open cover 2, then cover 2 is closed, and pre-dried timber 3 is loaded into the chamber 4 through the modification of the open gate 5, after which they are tightly closed. Timber for pre-drying 6 is loaded into the drying chamber 7 through the open gate 8, which, after downloading is tightly closed. Further, the process of gasification of wood waste is run in the chamber 1, and as a result of the synthesis gas is fed into the chamber afterburner 9, where the after-burning synthesis gas with excess air ratio 0.95 - 1 with the formation of the flue gases. After that the flue gases with a temperature of 600 -

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700 ^{o}C with the help of a fan10 are loaded into shell and tube heat excharger11. Then the temperature of flue gases is lowered up to 200 - 240 °C, then the cooled flue gases with the set temperature are going in the modification chamber 4. At this point, gate valve 12 is left open and the gate valve 13 is closed so that flue gases from the heat exchanger 11 are not released in the atmosphere. The process is a gradual modification of wood by heating it to a temperature of 200-240 ^{o}C, depending on the desired degree of modification and subsequent keeping at this temperature for 5-7 hours prior to the acquisition of timber of specified properties. The temperature in the chamber is regulated by slide valves 12 and 13. Waste gases from the furnace chamber 4 are removed through branch pipe 14.

After completion of thermo modification, gate valve 12 is fully closed and the gate valve 13 is fully open and the flue gases are discharged through a pipe 15 into the atmosphere - the stage of cooling of timber starts. To intensify the cooling of timber into the chamber 4 through the modification of the nozzle 16 water is dispersed from central water supply by opening the valve 17.

Excessive heat energy, rejected during cooling of the flue gas in heat exchanger 11, during the entire process is transferred to the drying chamber 7 by means of a water heater 18 and pump 19 for pre-drying lumber before thermo modification.

After cooling the timber to 100 ° C further it is unloaded from the modification chamber 4.

The lower limit of excess air ratio, which characterizes the amount of oxygen supplied to the combustion process, is assumed to be 0,95, as less important factor leading to inefficient use of afterburner. The upper limit of the air-fuel ratio equals to 1, since a larger amount of oxygen fed into the chamber, is not fully involved in the process of combustion and, consequently, the unreacted oxygen entering the modification chamber may cause corruption or inflammation of the treated wood.

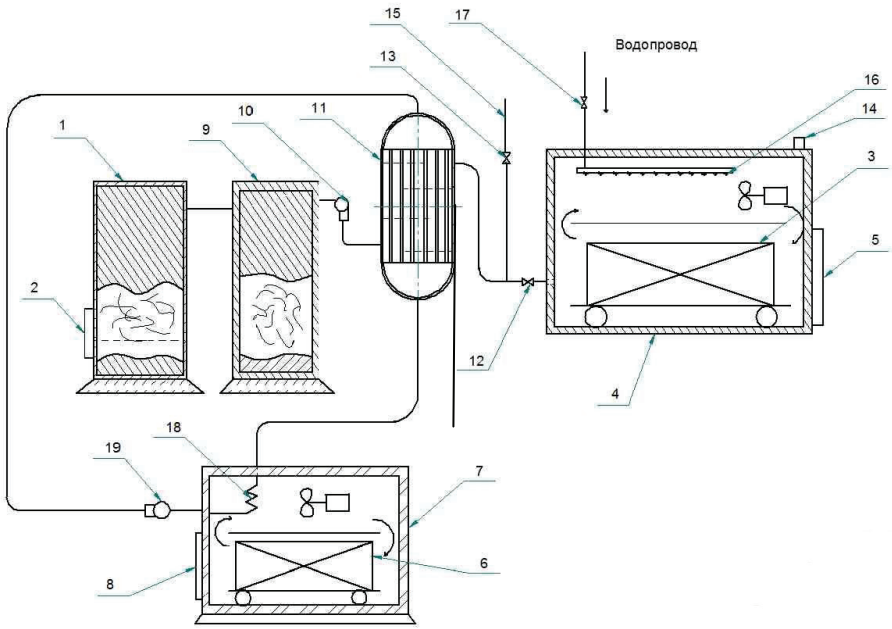

Fig. 1. Scheme of wood thermo modification process in the flue gas medium.

The scheme of the timber thermo modification camera in a medium flue gas is shown in Fig. 2. After loading the timber into the chamber doors 2 are tightly closed and there starts the feeding of the flue gas from the furnace into the chamber 13 through the first gas branch pipe 3. To do this, the gate valve 5 is opened and the gate valve 6 is left closed. At the bottom of the chamber 1 in zone 3 first duct ejector 10is installed, which is designed to create a vacuum and suction of flue gases from the furnace 13. Flue gases from the furnace 13 through the first gas duct 3 are served in the area of raised-floor 7, and through its perforations come into the interior of the chamber for an initial high-temperature drying process, which is carried out at a temperature of 105 - 130 ° C. Further, the flue gases which pass through the stack of timber 12, flow through perforated raised-ceiling 8 in flue 14. The circulation of flue gases in that the inner contour of the aerodynamic is carried out by means of a centrifugal fan 9. The fan 9 has a special cover-snail 15, equipped with two outputs 16 and 17. The smaller gas flow is directed to the output 16 to be discharged into the atmosphere through the ejector 11, contributing to leak flue gases from the furnace 13. The larger gas flow is directed to outlet 17, and then in the gas duct 14 for circulation in the inner region of the chamber 1. At the outlet duct 14 ejector 10is installed, which creates a vacuum in the area and contributing to leak flue gases from the furnace 13 through the first duct 3 in the interior of the chamber 1.

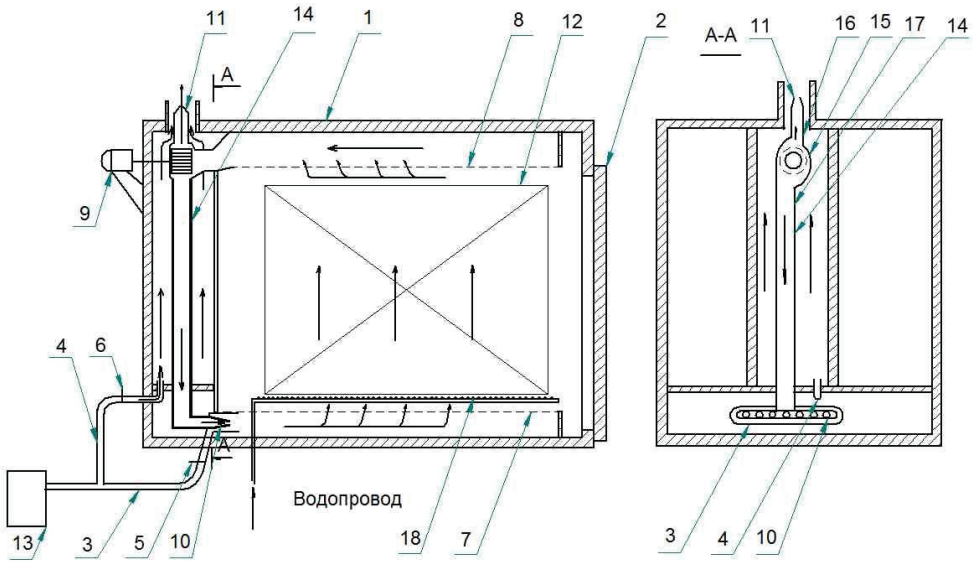

Fig. 2. Scheme of wood thermo modification process in the flue gas medium.

After drying the material to air-dry state the chamber temperature is raised to 1 160 - 170 ° C to start the process of thermo modification. The concentration of flue gases in the chamber 1 was adjusted to a high level of 95 - 100% by volume. In the combustion chamber 13 the oxygen supply is constantly monitored, to prevent it falling into the workspace in chamber 1 in order to avoid charring and burning of wood material 12. At a temperature of 160 - 170 ° C availability of the flue gas in chamber 1 is terminated by closing the gate valves 5. In this case the slide valve 6 is opened. Further heating of the gas mixture circulating in the working cavity of the chamber 1, is accomplished by heat transfer through the wall of the duct 14 to achieve a chamber temperature of 180 - 220 ° C. After reaching the desired temperature the timber is maintained for 3 - 5 hours depending

on the level of heat treatment. After completion of thermo modification the wood material is cooled to 100 ° C by dispersing water into the chamber through a water pipe nozzle 18. Then the cooled timber is discharged from the chamber through the open branch pipe 2.

The value of transition temperature equals to 160 - 170 ° C due to the fact that a higher temperature in the chamber with uncontrolled oxygen content in the furnace can lead to oxidation and charring wood, and at a lower temperature increases the duration of the stage of raising the temperature to the desired value by reducing the intensity of the heat due to heat transfer through the walls of the duct as compared to direct-fired flue gas.

The lower limit of the flue gas temperature is taken equal to 180 ° C because lower temperatures do not allow to achieve the necessary degree of modification. The upper limit temperature of the flue gases in the modification chamber, is assumed to be 220 ° C because higher temperatures can lead to uncontrolled decomposition of wood (pyrolysis).

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