INSTALLATION FOR IDENTIFICATION OF HEAT CONDUCTIVITY COEFFICIENT OF WOOD

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ABSTRACT

The experimental installation for identification of coefficient of heat conductivity of the wood that models the running of processes similar to operating conditions of devices for pyrolysis of wood is offered. The description of installation elements and their functional purpose is given. The dependence of coefficient of heat conductivity of a pine on temperature expressed in polar coordinates is received.

INTRODUCTION

Development of production of charcoal by a pyrolysis method requires improvement of technology at all stages. To have the process of pyrolysis to be most productive and energy efficient, it is necessary to operate with value of coefficient of heat conductivity for wood raw materials of each breed. Uniqueness of the offered installation is in the use of a known method of determination of heat conductivity coefficient of solid bodies in industry [1,2]. The installation allows taking into account not only the nonlinear dependence of heat conductivity coefficient of wood on temperature with its increase till 600 °C, but also anisotropy of heat-conducting capacity of a material [3].

Determination of coefficient of heat conductivity of wood as a function of its breed and temperature will allow to use most reasonably the required amount of energy at each stage of production of pyrolysis products. It will cause economy of energy and, as a result, essential reduction of the enterprise expenses connected with losses of heat [4]. Besides, reduction of waste emissions from use of fuel during production will favorably affect an ecological component of technology [5].

It is obvious that the value of coefficient of wood heat conductivity has to correlate with the value of temperature at which this parameter is defined. Due to features of pyrolysis process the coefficient of wood heat conductivity can change even in isothermal conditions since wood is continuously transformed with removal of volatile components from its structure.

Different breeds of a tree have individual thermal properties due to the structure of wood [6] therefore their behavior at heating to high temperatures cannot be the same for all considered breeds (even for similar types of wood from the botany point of view).

For correct determination of temperature dependence of thermal conductivities of wood it is necessary to neglect the geometry of the body during heat transfer through the body whose heat conductivity is measured. Such problem is solved by using methods of mathematical modeling and the corresponding algorithms of indirect searching of magnitudes.

Statement of experiment objectives

For studying the heat-conducting capacity of wood during pyrolysis it is necessary to create the corresponding experimental installation.

The analysis of the existing installations showed that the most suitable method for determination of heat conductivity of materials [7-9] is the method of creation of a radial heat flux. This method requires the use of wood sample of a cylindrical form 70 mm high, external diameter of 64 mm and internal – 10 mm.

Around the sample the ceramic heater of block type creates the heat flux directed from the periphery of the cylinder to its center where by pumping of a cooling liquid through a copper tube a sink of the heat that travelled through the wood sample.

The temperature difference of a coolant at an input and exit of the installation is determined by signals of thermocouples (see below) and corresponds to the amount of heat that passed through a wood sample during a particular time interval of measurements. By variation of the amount of heat it is possible to change the inside temperature of the sample.
The fullest transfer of heat to the surface of the heat receiving objects is provided at their side-by-side contact with the heat generating elements. For this purpose the ceramic heaters of contact type were manufactured using the original technology [10] and mounted by high-temperature heat-transmitting glues on external surfaces of wood samples. The heat flux produced by heaters passes through the body of the sample and creates in it a temperature field. Temperatures are fixed in the volume of a cylindrical sample along and across of fibers, as shown in Fig. 1, by means of thermocouples in a quartz braid with a diameter of 0,1 mm of graduation of THA. Thermocouples were placed at the distance of 35 mm from a face surface and at the distances of 14, 23 and 32 mm from the sample axis. Thermocouples 1-3 were placed along wood fibers, and 4–6 were placed perpendicular to the first three ones (Fig. 1).

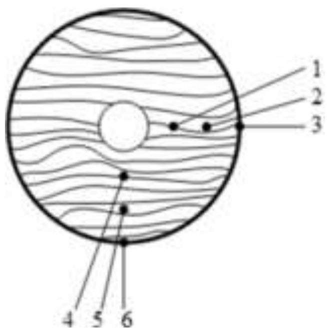

Fig. 1. Placement of thermocouples in a wood sample relative to fibers

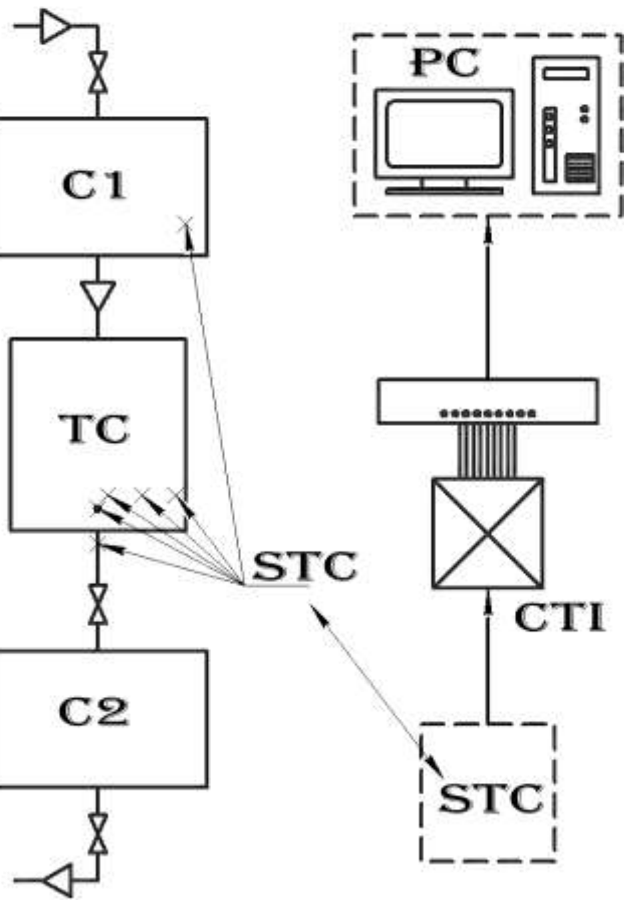

Fig. 2. Conditional scheme of experimental installation:
C1 – the initial capacitance, C2 – capacitance for collecting water, TC – the thermal camera, STC – a set of thermocouples, CTI – the converter of thermometric information, PC – the personal computer.

In the center of each cylinder made from the breed of a tree being studied along its vertical axis there is a hollow channel with a copper tube embedded in it through which water is pumped over. Water discharge is determined by means of rotameters and is regulated by stop valves.

Description of elements of experimental installation

Installation for determination of coefficient of heat conductivity of wood includes (Fig. 2): the thermal chamber, two vessels for water, connecting tubes, a set of nine thermocouples, the device for processing thermometric information that transmits signals to the personal computer.

The thermal chamber consists of the following elements (Fig. 3): a copper tube (a), the studied sample in the form of the wooden cylinder (b), the heater of a block type (c), a double layer of thermal isolation (d), the MKRV-200 felt with the aluminum foil pasted on its external surface and the case made of the polished foil 0,15 mm thick of an alloy 20X80H (e) and the joints in the case are sealed by a high-temperature silicone germet (for simplicity in the picture the top and lower covers of the case isolated is the same way aren't shown).

Fig. 3. Elements of the thermal chamber:
a) the copper tube, b) the sample, c) the block of heaters from current outputs,
d) two-layer thermal isolation, e) case

The block of heaters (Fig. 3, c) is made of four ceramic heaters of cylindrical shape connected in series with their external surface covered by the thin layer of a silicone reflecting a radiant component of a heat flux into object being studied [11].

To minimize the thermal losses of the block of heaters due to its heat conductivity and radiant energy emission into its environment, the two-layer thermal isolation (Fig. 3, d), skintight both to external and to face surfaces is used.

The case of the thermal chamber (Fig. 4, e) is made with a maximum level of sealing for creation of the conditions corresponding to that in wood pyrolysis devices.

The cut of the thermal chamber ready for use is given in Fig. 4.

Fig. 4. The thermal chamber in cut

Except the thermocouples located directly in the studied wood sample in the thermal chamber there is also a thermocouple that measures temperature in an isolation layer.

The registering equipment, as a part of the converter of a signal, the power secondary device and the personal computer, fixes changes during the operation of installation per identical periods of time. These data correlate with the heater power for each temperature and time intervals.

With the help of this installation the temperature dependences of a cylindrical sample of a pine have been studied and after the corresponding mathematical processing of these data the following dependences of the coefficient of heat conductivity on temperature expressed in polar coordinates have been received:

CONCLUSION

The experimental installation is developed for identification of coefficient of heat conductivity of wood in the range of temperatures up to 600oC. The installation models the processes similar to functioning conditions of devices of wood pyrolysis. The description of design elements of installation and their functional purpose is given. The dependences of coefficient of heat conductivity of a pine on temperature expressed in polar coordinates are received.

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