STUDY ON GEOTHERMAL ENERGY UTILIZATION ON WOOD DRYING

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Abstract - The paper presents the possibility of using geothermal energy in drying wood materials - a complex system with automatic control of the drying process and the results obtained from testing the system.

Keywords: geothermal energy, drying, wood material

1. INTRODUCTION

In this study we started from a wood drying system using as heat carrier the geothermal water whose constructive functional diagram is shown in the figure below:

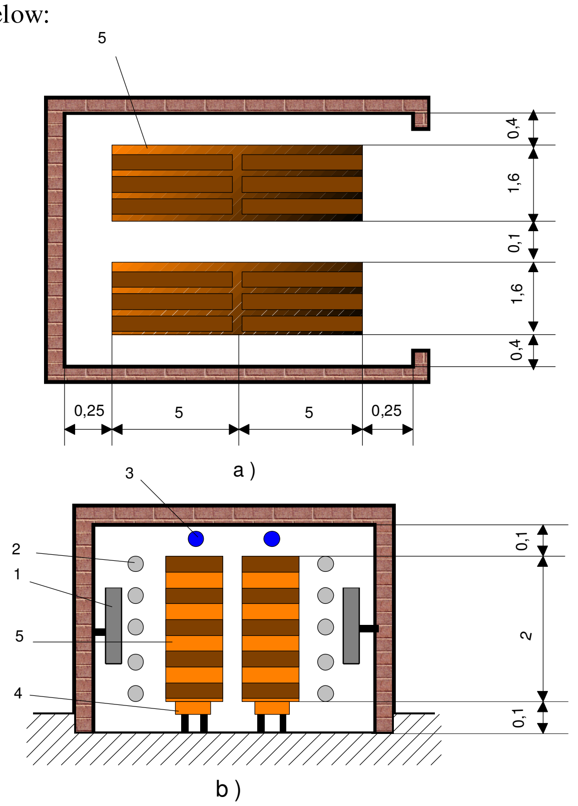

Fig. 1. Drying chamber diagram
a) plane section; b) cross section; 1- fans; 2 - heating registers; 3 - wetting pipe; 4 - tub;5 - stack

The main parameters considered in this study are:

- The amount of wood: 16m ³
- Type of wood: Beech
- Geothermal water temperature: 95 ° C

The temperature of the air required for drying of the timber: 80 ° C

2. THE DRYING SYSTEM CHARACTERISTICS

The system shown uses as heat carrier, geothermal water from a geothermal drilling, probe 4796 (85°C, 30 l/s artesian flow). A pressure transducer TP1 and an electrically operated valve CV0 are provided. In the probe there is installed a well pump, “shaft” type, placed at a depth of 90m and driven by a electric motor of 65 kW (manufactured by General Motors , USA), located at the top of the pump-shaft assembly. The system includes: a buffer tank of 300 m^3, placed in close proximity to the probe station, which has the role to degas and to gauge the system operation; a pumping station, placed in the vicinity of the probe station, fitted with two Grundfos pumps and auxiliary equipment required. The pumping station has the role to provide geothermal water with the flow and pressure characteristics required by the downstream equipment. The system works both in “artesian condition”, in which case the probe station distributes the geothermal water directly into the main distribution pipes system, as well as in “pumping condition”, in which case the probe station distributes the geothermal water to the buffer tank nearby, and the pump station takes the water from the reservoir and pumps it into the main pipe from where is distributed to different consumers.

The study of the systems behavior always has as a starting point a real system, a physical system designed to solve different issues that arise in all areas of human activity. The ability of physical systems to solve a particular type of problem depends on the intrinsic characteristic of these systems. In general, the physical system enters in connection with human activity as a tool able to make the work easier, this being achieved by the change, in time, of internal parameters.

Although we can consider as a physical system any mass of bodies, real objects that mutually interact, the interest of this paper are those systems that are meant to replace the observation, decision and action of man, called automatic control systems. By appropriate choice of the components, the automatic control systems are designed to provide a given sequence of events, in which case they are called automatic command systems, or are designed to maintain the set point of one or more elements of the system, values that tend to change over time due to specific conditions, such as disturbances. In this case the systems are called automatic adjusting systems.

Since in this case is intended to maintain constant parameters, the physical systems developed for achieving this objective are, primarily automatic adjusting systems. Therefore, further the phrase physical system means automatic adjusting system, whenever this is not explicitly mention.

The issue of adjusting a real process is as follow: that size or parameter that must be maintained at the desired value, at some point, during the process, has a certain value, different from the desired value, which will be called the system response. The difference between the system response – meaning the value measured with a sensor – and the set point – which is the desired value – is named ε error, and its appearance is due to various disturbances affecting the real process. The main goal of any adjusting system is to reduce this error keeping it as close as possible to zero. To do so, the error is pointed out to a physical system that has the ability to act on the real process in order to reduce this error. This element is called *the controller*. The general definition of the controller can include elements that are not part of the controller itself, but which are indispensable to the control loop. These elements are: *the sensor, the comparison element and the actuators*. The sensor takes the momentary value from the real process and transforms it into a physical quantity that can be compared to another value of the same physical quantity, corresponding to the desired value of the physical quantity targeted in the process. This action is handled by the comparison element that provides the result to the controller itself. The controller, in its turn, will control an actuator that will modify the physical system state so that the real value will be maintained as closed as possible to the desired value.

3. THE DRIVING LOOPS OF THE DRYING CHAMBER

The figure below shows the driving loops of the drying chamber. This system contains two process controllers that provide the necessary temperature and ventilation for the pre – drying and drying processes. The agent that passes through the heat exchangers is water from a secondary circuit that takes thermal energy from the geothermal water and distributes it to the drying processes.

These driving loops will not be analyzed, as they are intrinsic for the drying units. The maximum temperatures for the components are 30, 40, 70, 80°C.

The heat carrier flow required for heating the chamber, is adjusted based on the temperature from the chamber measured by the temperature sensor TTx2. In a section of the program is calculated the delivery temperature of the heat carrier necessary for heating, temperature that represents the preset value (SP set - point) of the controller *RG6*. Depending on the value of the process variable PV (controlled) it is indicated the value of the command given by the controller (OP) to the valve *CV6*. The required flow rate of geothermal water is adjusted based on the temperature of the secondary agent measured by the temperature sensor TT2. In a section of the program is calculated the delivery temperature of the secondary agent, temperature that represents the preset value (SP set - point) of the controller *RG2*. Depending on the value of the process variable PV (controlled) it is indicated the value of the command given by the controller (OP) to the valve *CV2*. In another section of the program the outlet temperature of the geothermal water is determined, measured by the temperature sensor TTac2. It is also indicated the operating mode of the controller (Man = manual, AUTO = automatic).

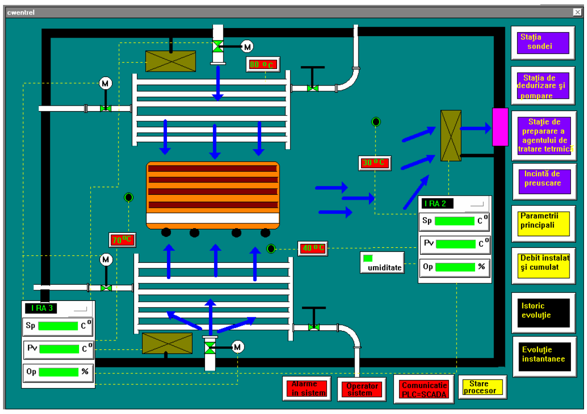

Fig. 2. The driving loops of the pre - drying and drying chamber

The figure shows the value of the commands (OP) given by the controllers *RG2* and *RG6* to the valves *CV2* and *CV6* based on the delivery temperature set point (SP) of the secondary agent and the temperature from the pre – drying chamber, and also the measured value (PV) of the same temperatures.

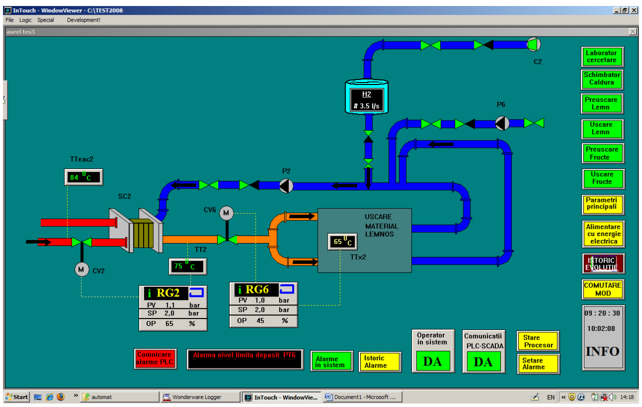

Fig. 3. The graphical interface for interactive testing of the "drying wood" system

4. MEASUREMENTS MADE REGARDING THE OPERATION OF THE MODULE "DRYING WOOD"

The figure below shows, as an example, the results of the time evolution of some parameters which are characteristic to the "drying wood" module operation, on 14.04.2008, between 10 and 14, both at the startup of the module and at the occurrence of a disturbance. Thus, the evolutions of these parameters where followed:

- The temperature from the pre - drying chamber *TTx2* as a random factor,
- Secondary agent outlet temperature from the heat exchanger *TT2*,
- Outlet temperature of geothermal water *TTac2*,

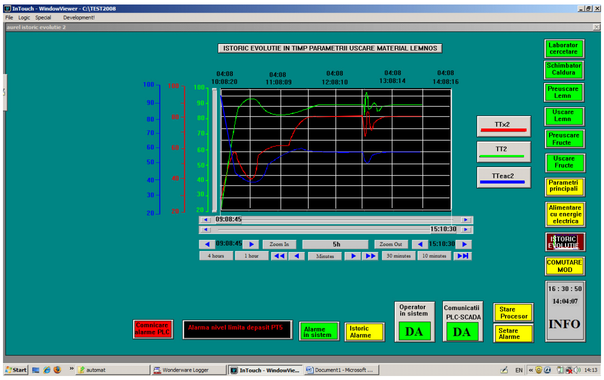

Fig. 4. The histogram of the parameters characteristic to the "drying wood" module

Regarding the functioning of the "*drying wood*" module, we note:

- At startup, the system stabilizes relatively hard, in one hour and 41 minutes, between the hours 10.10.00÷11.51.23. The controllers which provides control for the module operation are *RG2* and *RG6*. The controller RG6 is controling the appropiate flow of secondary agent (through the command given to the electrically operated valve *CV6*) in order to maintain a constant temperature in the drying chamber (the temperature value from the drying chamber is obtained by the temperature sensor *TTx2*). The values at which the system stabilizes are: $TTx2 = 80°C;\ TT2 = 88{,}5°C;\ TTac2 = 59°C$.
- Upon the occurrence of a disturbance, in this case lowering the temperature from the drying chamber with 15°C (from 80°C to 65°C possibly due to the opening of the door of the drying system), the system stabilizes relatively quickly, 26 minutes (12.30.00 ÷ 12.56.40). The control circuits involved in this case are: $TTx2 \div RG6 \div CV6$, respectively $TT2 \div RG2 \div CV2$. In this case, the values at which the system stabilizes are: $TTx2 = 80{,}2°C;\ TT2 = 88°C;\ TTac2 = 60°C$.

5. CONCLUSION

This study has highlighted the benefit of an automated drying system as against the conventional one, because with the automated modules we can respond quickly and easily to the emergence of disruptive events, to remedy them. This can not be achieved in conventional systems where these phenomena lead to significant damage, damage that can even lead to the deterioration of the wood subjected to drying process.

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