AUTOMATIC CONTROL FOR WOOD DRYING PROCESS USING GEOTHERMAL ENERGY

SETEL A, ANTAL C., BADEA G.
University of Oradea, Universitatii no. 1, Oradea
setel_aurel@yahoo.com

Abstract - The paper presents the possibility of using geothermal energy in drying wood materials - a complex system with automatic control of the drying process

Keywords: geothermal energy, drying, wood material

1. INTRODUCTION

Aspects regarding the use of geothermal energy as a drying agent for wood material

It is noteworthy that the total flow of geothermal wells in Romania, with wellhead temperature above 80 °C, is 795 l/s under artesian mode. In the future, through the execution of new boreholes and by forced extraction (pumping), the total flow of geothermal water with temperatures above 80 °C which can be used in Romania is estimated at 1,100 l/s. This remark is important because it practically determines the applicability of the technology of geothermal energy conversion into other forms of energy in Romania. Since the drying of the wood material is related to heat consumption, the heat must be supplied to the drying agent from an external source through a thermal agent. Given the drying regime, which is determined depending on the species, the type, the thickness of the material, the drying quality and the initial and final moisture content of the wood in Table 1 is presented the temperature used for drying, depending on the species and assortment of wood.

Table 1. The temperature used in drying, depending on the wood species and range

		Temperatura (°C) indicată pentru:						
Specii	Clasa de dificultate a regimului	Cherestea cu grosimea de:			*RIGLE CU LUNGIMEA DE:*			Frize
		Până la 38mm	40-60 mm	***Peste 60mm***	Până la 400mm	400-1000 mm	Peste 1000mm	
Brad	II	80	75	70	80	75	70	80
Cer	*V*	*60*	*55*	*50*	*60*	*55*	*50*	*60*
Fag	*IV*	*80*	*70*	*60*	*80*	*75*	*70*	*80*
Gorun	*IV*	*50*	*45*	*40*	*60*	*55*	*50*	*60*
Larice	*III*	*80*	*75*	*70*	*80*	*75*	*70*	*80*
Molid	*I*	*90*	*80*	*70*	*90*	*85*	*80*	*90*
Pin silvestru	*II*	*80*	*75*	*70*	*80*	*75*	*70*	*80*
Stejar	*VI*	*50*	*45*	*40*	*60*	*55*	*50*	*60*

Given that certain types of wood from certain species can be dried or pre-dried at temperatures below 80 °C, this allows the use of geothermal water as heat agent in dryers for wood materials, including the reusable ones in compliance with the conditions of using geothermal waters in our country mentioned in above chapters. A drying (pre-drying) system that could be used by a drying chamber where it is inserted a reusable wood material from the beech species with a thickness of 40 mm could be the one shown in Table 2. In order to determine the drying (pre-drying) time it can be used the nomogram shown in Figure 1.

Table 2. A drying system in a drying chamber of the reusable wood material from beech species

PERIOADA	*UMIDITATEA LEMNULUI %*	Temperatura aerului, °C	Diferența psihometrică °C
Umezire inițială	-	70	0-1
	Peste 30	70	2
	30-25	70	4
Uscare propriu zisă	25-20	70	7
	20-15	70	11
	15-10	70	16
Aclimatizare	6-8	Până la 30	15

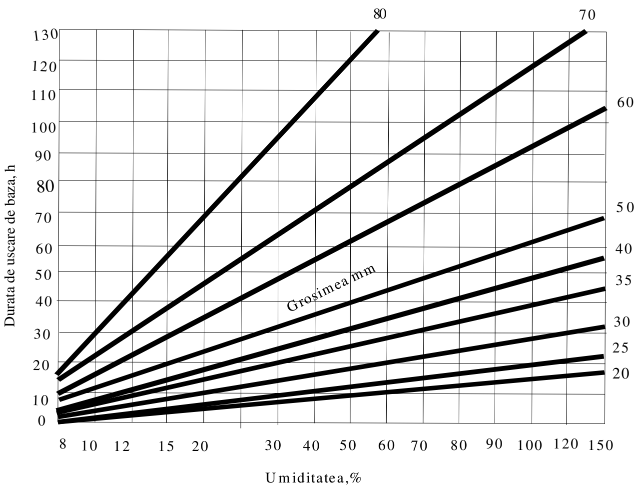


Fig 1. The nomogram for determining the base time (pre-drying - drying)

According to the nomogram, the drying period in the plant for the beech material with 40 mm thickness will be 22 hours. If, in addition to using geothermal water as fuel, in the drying (pre-drying) chambers will be used control and ventilating equipments, the time required for drying (pre-drying) could be reduced by at least 50%. Also we can make great savings on conventional fuel and we can avoid wood losses as far as 25%.

2. DRIVING LOOPS OF PRE-DRYING - DRYING CHAMBER

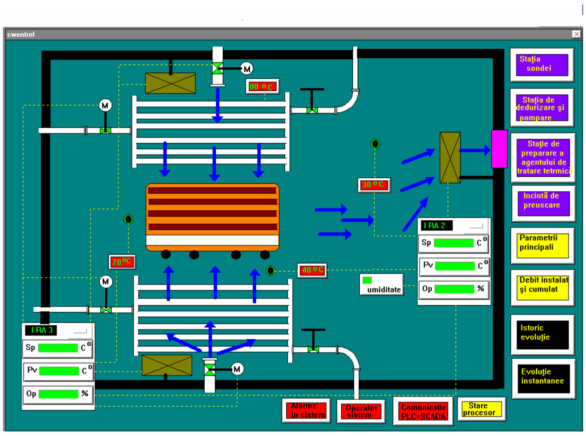


Fig 2. The driving loops of the pre - drying and drying chamber

Figure 2 shows the driving loops of the pre-drying – drying chamber. This system comprises two process controllers that provide the required temperature and ventilation for the pre-drying and drying processes. The agent the passes through the heat exchangers is water from a secondary circuit which takes heat from geothermal water and distributes it to the pre-drying and drying processes.

3. CALCULATION OF HEAT EXCHANGERS SC 1 ÷ SC 4

To determine the necessary heat exchange surface (S_{nec}) will be considered a heat exchanger with a global coefficient of heat exchange $K = 2{,}5\ kW / m^2 K$;

Under these conditions, results:

- Required heat exchange area:

$$S_{nec} = \frac{Q_{nec}^{h}}{K \cdot \Delta t_{med}}$$

Where:

$$\Delta t_{med} = \frac{(t_{pin} - t_{sies}) + (t_{pies} - t_{\sin})}{2}$$

t_{pin} – the primary coolant inlet temperature (geothermal water);

t_{pies} – the primary coolant outlet temperature (geothermal water);

$t_{\sin}$ – the inlet temperature of the secondary agent;

t_{sies} – the secondary agent outlet temperature.

- Required flow rate of the primary agent:

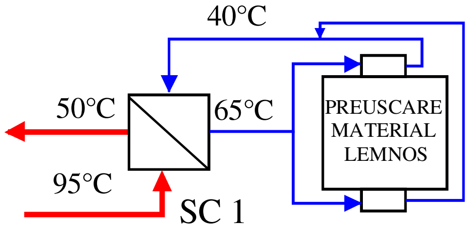
$$\dot{m}_{pnec} = \frac{Q_{nec}^{h}}{c_a \cdot (t_{pin} - t_{pies})}$$

- Required flow rate of secondary agent:

$$\dot{m}_{snec} = \frac{Q_{nec}^{h}}{c_a \cdot (t_{\sin} - t_{sies})}$$

For the heat exchangers SC 1 ÷ SC 4 results:

1. The heat exchanger SC 1 - pre-drying wood material



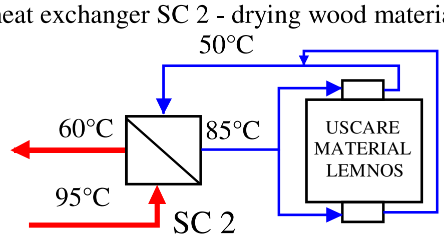
$$\Delta t_{med1} = \frac{(95-65)+(50-40)}{2} = 20°C$$

$$S_{nec1} = \frac{500.000 \cdot 0{,}0011666}{2{,}5 \cdot 20} = 12\ m^2$$

$$\dot{m}_{pned} = \frac{500000}{1 \cdot 3600 \cdot (95-50)} = 3\ kg/s = 11\ m^3/h$$

$$\dot{m}_{snec1} = \frac{500000}{1 \cdot 3600 \cdot (65-40)} = 5{,}5\ kg/s = 20\ m^3/h$$

2. The heat exchanger SC 2 - drying wood material



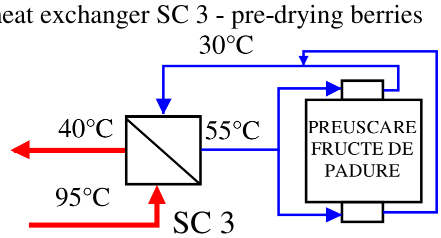
$$\Delta t_{med2} = \frac{(95-85)+(60-50)}{2} = 10°C$$

$$S_{nec2} = \frac{500.000 \cdot 0{,}0011666}{2{,}5 \cdot 10} = 23{,}35\ m^2$$

$$\dot{m}_{pnec2} = \frac{500000}{1 \cdot 3600 \cdot (95-60)} = 4\ kg/s = 14{,}5\ m^3/h$$

$$\dot{m}_{snec2} = \frac{500000}{1 \cdot 3600 \cdot (85-50)} = 4\ kg/s = 14{,}5\ m^3/h$$

3. The heat exchanger SC 3 - pre-drying berries



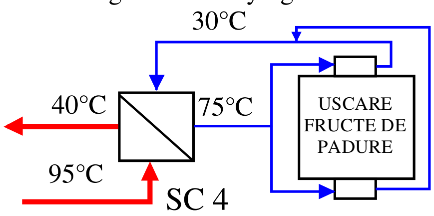
$$\Delta t_{med\,3} = \frac{(95-55)+(40-30)}{2} = 25°C$$

$$S_{nec3} = \frac{500.000 \cdot 0{,}0011666}{2{,}5 \cdot 25} = 8\ m^2$$

$$\dot{m}_{pne3} = \frac{400000}{1 \cdot 3600(95-40)} = 2\,kg/s = 7{,}2\,m^3/h$$

$$\dot{m}_{sne3} = \frac{400000}{1 \cdot 3600(55-30)} = 4{,}5\,kg/s = 16\,m^3/h$$

4. The heat exchanger SC 4 - drying berries



$$\Delta t_{med\,4} = \frac{(95-75)+(40-30)}{2} = 15°C$$

$$S_{nec4} = \frac{400.000 \cdot 0{,}0011666}{2{,}5 \cdot 15} = 13\ m^2$$

$$\dot{m}_{pne4} = \frac{400000}{1 \cdot 3600(95-40)} = 2\,kg/s = 7{,}2\,m^3/h$$

$$\dot{m}_{sne4} = \frac{400000}{1 \cdot 3600(75-30)} = 2{,}5\,kg/s = 9\,m^3/h$$

Results the required flow and outlet temperature of geothermal water:

$$\dot{m}_{nec\ apa\ geo} = \sum_{i=1}^{4} \dot{m}_{pnec\,i} = 11\ kg/s = 40\ m^3/h$$

Temperature of the discharged geothermal water:

$$t_{evac\ apa\ geo} = \frac{\sum_{i=1}^{4} \left(\dot{m}_{pnec\,i} \cdot t_{pies\,i}\right)}{\sum_{i=1}^{4} \dot{m}_{pnec\,i}} = 50°C$$

The geothermal water discharged at a temperature of 50 °C can be used in cascade for:

- preparation of domestic hot water;
- floor heating;
- fan coil heating
- greenhouses heating;
- etc

4. THE DRIVING BLOCK DIAGRAM TO OBTAIN THE AGENT USED TO PREPARE THE HOT AIR IN THE TECHNOLOGICAL PROCESS OF PRE-DRYING OF THE WOOD MATERIAL

The block diagram with the automation loops of the system of obtaining the preparation agent for the hot air required in the technological process of pre-drying - drying wood material is shown in Figure 3. In Figure 4 is shown the driving block diagram for the installation from Figure 3, the controller RG1.

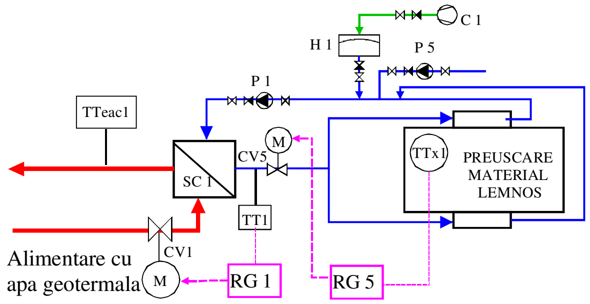


Fig 3. The driving block diagram for obtaining the preparation agent of hot air necessary in the technological process of pre-drying of the wood

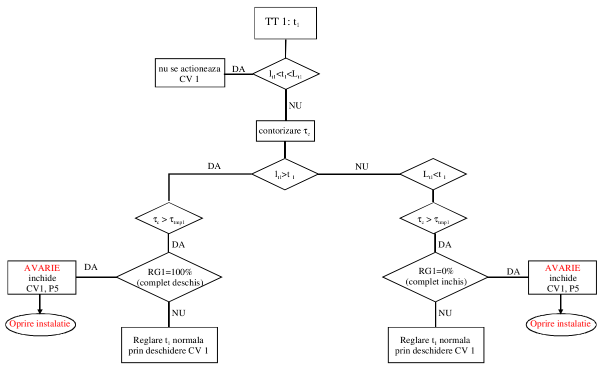


Fig. 4. The driving block diagram for the installation

Also it provides the static pressure in the system through the command made by the operator from SCADA, of the pump P5 and compressor C1.

The driving block diagram for the controller RG5 is similar.

5. DRIVING BLOCK DIAGRAM FOR OBTAINING THE AGENT USED TO PREPARE THE HOT AIR NECESSARY IN THE TECHNOLOGICAL PROCESS OF DRYING THE WOOD MATERIAL

The block diagram with automation loops system for obtaining the agent for the preparation of hot air required in the technological process of drying the wood material is shown in Figure 5. In Figure 6 is shown the driving block diagram for the installation presented in Figure 5, the controller RG2.

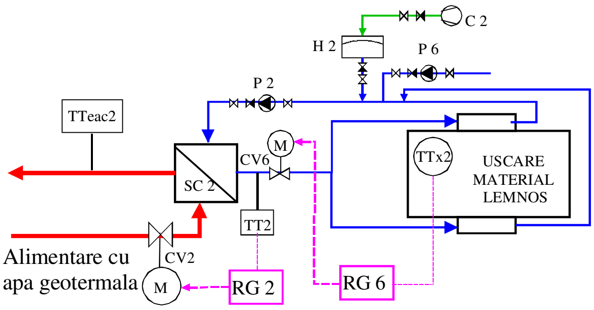


Fig. 5. Driving block diagram for obtaining hot air agent necessary in the technological process of drying wood material

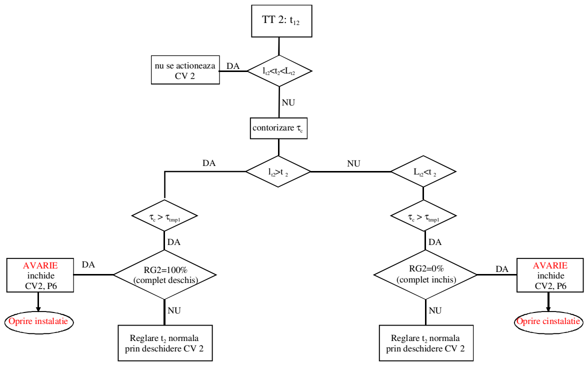


Fig. 6. Driving block diagram for the installation

Also it provides the static pressure in the system through the command made by the operator from SCADA, of the pump P5 and compressor C2.

The driving block diagram for the controller RG6 is similar.

6. CONCLUSION

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

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