Specific aspects concerning automatic control of microwave drying of wood

DANIEL POPESCU\textsuperscript{1}, CĂLIN CIUFUDEAN\textsuperscript{2} and ADRIAN-GABRIEL GHIAUS\textsuperscript{3}

\textsuperscript{1}Electrical Department
Technical University of Civil Engineering Bucharest
Bd. Pache Protopopescu nr.66, 021414 Bucuresti Sector 2
ROMANIA
dpopescu@instal.utcb.ro

\textsuperscript{2}Computers and Control Systems Department
“Stefan cel Mare” University of Suceava
Str. Universitatii nr.9, 720225 Suceava
ROMANIA
calin@eed.usv.ro

\textsuperscript{3}Thermal Engineering Department
Technical University of Civil Engineering Bucharest
Bd. Pache Protopopescu nr.66, 021414 Bucuresti Sector 2
ROMANIA
ghiaus@instal.utcb.ro http://www.mech.upatras.gr/~ghiaus

Abstract: The paper presents technical considerations for design and construction of the experimental model for an automatic microwave drying system for construction materials. The main requests of the drying process lead to the system structure automatic control of a microwave dryer for which the aspects concerning automatic control of microwave drying process of wood are elaborated: programmed automatic system, man-machine interface, temperature and humidity measurements, air velocity measurement, protection of personnel that operate the dryer, protection of drying installation.

Keywords: Automatic control, microwave drying, wood, kiln drying, lumber drying.

1 Introduction

The competition in the building and construction material industry has increased dramatically in recent years. The manufacturers have dedicated financial and technical support toward modernizing factories and reducing operating costs [1]. These investments have resulted in lower selling prices and improved final product quality. Usually drying is the final step in any material treatment process. Natural air drying takes a lot of time and depends on weather conditions and season. For example, drying of northern red oak lumber could last from 70 to 200 days [2]. Over 500 commercial woods, both temperate and tropical, all over the world are subject for kiln drying and suggested dry schedules are given for several thicknesses and specialty products (e.g. squares, handle stock, gunstock blanks) [3].

Automation of the drying processes for construction materials is imposed by the following main requirements regarding the operation of these specific processes:
- construction materials could be damaged during the drying process time if the operation parameters are not controlled very accurate;
- diversity of the construction materials requires different conditions and cycles for drying, which can be assured only by automatic control;
- strictly use of drying diagrams imposed by the drying technology and repeatability of these diagrams cannot be assured by manual control of the drying process;
- request for reports regarding the history of the drying processes for different construction materials can be performed by PLC-s, having the capability to memorize hundreds of the drying diagrams.
2 General configuration
The configuration of the automatic operating system for a microwave kiln [4], in „stationary” configuration is showed in figure 1.
PLC is the main part of the automatic operating system. The PLC together with its extension modules, e.g. analogue I/Os, numerical I/Os, temperature sensors inputs, assure the acquisition of the process parameters and the command of the execution elements, which control the evolution of the drying process. Also the PLC can communicate with the human operator through MMI.
A wide range of sensors are used to measure the specific parameters of the microwave drying process and to protect both the human operator and the equipment [5].
Execution elements are controlled by the PLC and the extension modules. Main execution elements are microwave generators, air circulating fans and humidity exhausting fans.

3 Drying process automatization
Microwave drying process can be used for several construction materials but this article we focus only on wood drying, which is a representative process. The configuration of the automatic operating system for a microwave kiln is showed in figure 2.

3.1 Measurement of process parameters
The sensors are chosen depending on the parameters that must be measured by the automatic operating system.

3.1.1 Temperature and humidity measurement
The air temperature is measured with Pt100 type sensors. In order to obtain an accurate information about temperature distribution inside the drying chamber, there must be used at least 3 sensors.
The air humidity is measured with humidity type sensors. There must be used at least 3 sensors in order to obtain an accurate information about humidity distribution inside the drying chamber. The sensors used to measure the air temperature and humidity inside the drying room can also be of dual type.
Measurement of wood temperature can use contact or not contact type method [6]. The IR sensors can give "volumetric" information about wood temperature. For direct measurement of wood temperature Pt100 type sensors mounted directly in the woodpile are used.
Wood humidity measurement can be made by electrical or gravimetric methods [7]. Electrical methods use the wood electrical resistance, wood capacity and radio method measurement.
Gravimetric method is based on measurement of the water weight ratio from the wood volume. Indirectly measurement methods of wood humidity depend on the temperature and other parameters, which make measurement to become inaccurate. For this reason for the wood humidity measurement is used probe weight measurement method. The probe is introduced inside the drying chamber, in the same conditions with the wood. The initial humidity of the probe is measured before being introduced in the drying chamber. The calculation formulas can establish the correlation between humidity and weight [8]. The probe must be positioned in the middle of the woodpile. This method is most precisely and uses a weight sensor and a mechanical weight measurement system for the probe measurement.

3.1.2 Location and protection of the temperature and humidity sensors

Air temperature and humidity sensors are locate so that to measure more accurate the distribution of the air temperature and humidity. They are mounted on one of the walls of the drying chamber as follows:
- on the opposite wall of the access door, if the drying chamber is square;
- on the one of the long walls, if the drying chamber is rectangular.

Wood temperature IR sensor can be placed on the one of the wall of the drying chamber, at the maximum height of the woodpile and having orientation to the middle of the woodpile. Electrical protection of these sensors is made by metallic net, which act like a Faraday cage [9]. In the same time, the metallic net ensure the mechanical protection of the sensors when wood is introduced in the drying chamber.

Weight measurement system of the wood probe is placed in the middle of the woodpile.
The Pt100 sensors, for wood temperature measurement are placed between the woodpile layers, after the construction of the woodpile.

3.1.3 Air velocity measurement

Inside the drying chamber can be placed an air velocity sensor (anemometer), to measure the circulation of the air. The air must have a specific velocity at the wood surface, in order to facilitate the water evaporation. If not, boundary layer which appears will not allow the water elimination from inside to the outside of the wood.

3.1.4 Sensors for the protection of the personal which work with the wood kiln

To avoid the accidentally starting of the drying process when the workers introduce the wood inside the drying chamber and the access door is opened or when the workers are accidentally locked inside the drying chamber are installed the protection sensors.

3.1.5 Sensors for the protection of the wood kiln

These sensors are necessary to protect wood kiln against electrical problems, such as: microwave generator fault, air fan fault, over or under voltage of the main power supply, over current of the main power supply.

3.2 PLC

The PLC is the „brain” of the automatic operating system. The strategy of the drying process is introduced in the memory of the PLC by means of the programming software.

The software read the values of the specific parameters of the drying process (temperature, humidity, air velocity) and controls the execution elements (for microwave generators, air fans). The software also monitors the protection sensors.

To introduce, modify or read the software and / or data in / from PLC it is necessary a PC or laptop with the software installed on his hard disk.

3.3 MMI (Man Machine Interface)

MMI allows to the operator to follow the evolution of the parameters of the drying process and to introduce/modify the values of the references for the parameters. MMI also allow to display the numerical values of the process parameters, to display the text message which helps the operator to control the process evolution, to introduce or modify the values of the references for the parameters and to START / STOP the process. The software is developed on a PC or Laptop and downloaded afterwards in the MMI unit.
4 Conclusions
Microwave drying of construction materials have several advantages comparing to the other drying methods. Only the water contained in the material is heating. The material is heated inside the whole volume and the heat is uniform distributed. Drying process can be controlled by modifying the microwave power. The duration of the drying process is substantially decreased. The energy consumption is reduced.

The preservation of the construction material properties is assured by the drying software made for each type of the construction materials and stored in the PLC memory. The history of the drying process can be saved on PC or Laptop and can be used for technical reports.

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