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ABSTRACT

High temperature drying studies of wood have been inspired by the need to intensify the exchange of heat and mass transfer for the timber industry, furniture industry and in particular in the areas of: improving methods for wood drying, development of energy-efficient drying systems, environment-related energy-efficiency, lower costs associated with drying and consequently improvement the quality of products.

Unlike the conventional drying process using of hot air drying process of high temperature (above 100^{o}C) using superheated steam or gas-steam mixture should allow not only shorten the drying time, but also a useful property to keep the wood without the danger of significant cracking the material.

Authors wish to present their programme to carry out detailed studies to develop the technology and methodology for the design of equipment for high temperature drying of various types of wood.

1. INTRODUCTION

The dynamic development of the economy following Polish accession to the European Union has not circumvented the wood industry. Thanks to the development of the wood drying techniques using saturated or superheated steam flows and gas-steam mixtures, waiting time for wood material for the furniture industry will be reduced. Wood drying in addition to the technical importance brings economic benefits, such as protection of wood against fungi and fracture, which extends its life, facilitates machining and surface finishing of wood, fast drying (eg steam) improves the balance of wood, and brings savings in transport costs by reducing the weight of wood . The wood that has too high water content is not useful for the production of furniture. Changes in size and shape, occurring in the wood during the evaporation of water contained will affect the quality and dimensions of the furniture. The resistance to weather conditions is also higher.

2. WOOD DRYING PROCESS

Drying in superheated steam is economically justified because of the shorter processing time and reduced energy consumption, while it is, in this respect, better than drying in hot air. In the absence of oxygen there is no oxidation processes in the wood (although high-temperature of medium) and the danger of fire is excluded. Short drying time, low energy and high quality of wood after drying in an atmosphere of superheated steam are in favour of the use of this method in industrial practice.

During drying water is evaporated from the wood and of great importance here are:
• physical properties of drying agent,
• evaporation of water from the timber and free surface,
• hygroscopic properties of wood (depending on the species),
• hygroscopic equilibrium of wood ,
• changes in the wood during the evaporation of water.
During the drying of wood evaporation of free water does not change its shape and dimensions. With the loss of water evaporation zone moves deeper into the wood. The proper conduct of the drying process allows the extraction of more water.

3. EXPERIMENTAL STAND

Construction and working principle of dryers in which the drying environment is overheated steam or steam-gas mixture is similar to the conventional dryers (with the hot air). There are some differences in details of construction resulting from the use of other drying agent. Particular emphasis is placed on ensuring hermetic dryer (both wall connections, and to all openings) to prevent penetration of ambient air into the interior of kiln. Also, we should not allow vapour to condense on internal surfaces of dryer. The temperature of the surface should be higher than the condensation temperature, which can be obtained by well insulation. Regardless of it the inside of the enclosure must be protected against corrosion (e.g. by the use of aluminium). Water vapour contacting the surface of the dried material should not condensate. Therefore, the material must be pre-heated to a sufficiently high temperature and steam flow rate must be sufficiently large.
Our Department has a fully self-drying container, made of stainless materials and equipped with a microprocessor control system to ensure comfortable regulation and control. This dryer is for drying of all timber species in terms of final moisture content to 6% in the high temperature of up to 150 ºC. All walls, ceiling and loading door are made of special panels tightly welded made of acid-proof, alloy construction. Aluminium exterior sheathing is a trapezoidal plate (Fig. 1).

Fig. 1. Experimental kiln: front – loading door (left) and back (right).

4. NUMERICAL MODELLING

Drying chamber model was created consistent with existing experimental rig. As a result, series of computer simulations using Fluent CFD code can be made. The first phase included air flow modelling around wood in the drying chamber was performed. Compliance with the preliminary results of the calculation results of the experiment allowed for the continuation of the simulations using the proposed model (Fig. 2). The next step will be modelling of heat exchange and mass transfer during the processing of wood in high temperature drying conditions steam-gas mixture using a porous body material model for the insert of the chamber.

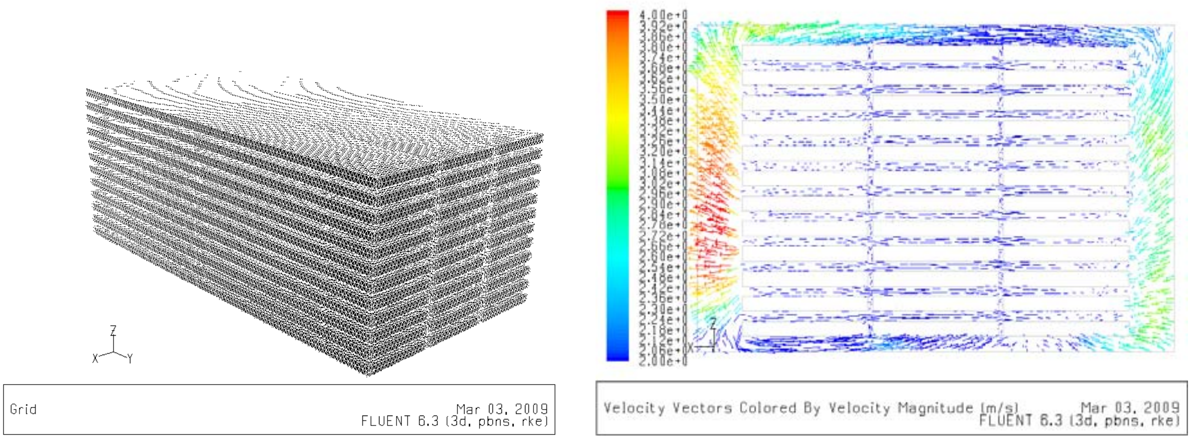

Fig. 2 Numerical grid of wood stack and velocity vectors of air inside the dryer.

5. PRELIMINARY EXPERIMENTAL RESULTS

Preliminary experiments were carried out with Pomeranian region oak lumber with a thickness of 30 mm (Fig. 3). Probe to measure a moisture content of wood is placed in the material so that it was possible to measure moisture content in a number of characteristic points of the chamber, i.e. in the middle of the boards, in the outer layers of the stack.

Fig. 3. View of the wood stack inside the dryer.

In the initial stage of drying hot water was supplied to the chamber to increase humidity and temperature throughout the material. Exhaust gases flown by the heat exchanger to raise the temperature of the mixture in the chamber. As far as humidity and temperature grow, we start with the drying process. The process of drying the material last to achieve the assumed wood humidity of 8%. The next process was the conditioning of wood - slowly cooled chamber with getting hot water to remove the stress in the material which emerged during the whole process of drying. Figure 4 presents the results of preliminary experiments measuring oak lumber drying.

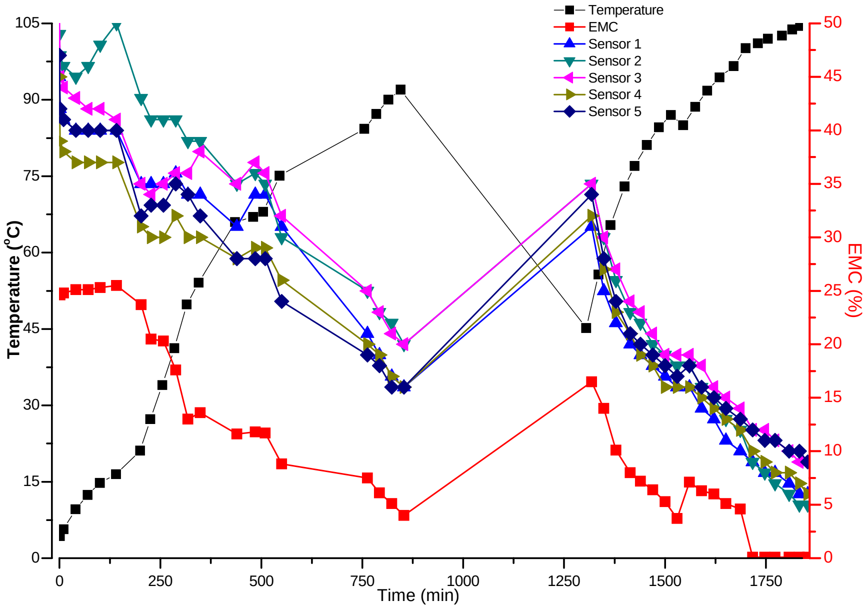

Fig. 4. The results of the drying of wood using steam-gas mixture.

6. CONCLUSION

The results obtained from preliminary tests on the basis of which next steps are planned with the use of coniferous and leafy lumber.

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