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Application of gas-steam mixture for wood drying purposes

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Abstract: *Application of gas-steam mixture for wood drying purposes.* The high cost of fossil fuel and soaring interest rates have encouraged people in the wood industry to look for faster and more energy-efficient methods to dry lumber. In this paper results of experimental study of flow pattern and heat transfer during application of gas-steam mixture for wood drying purposes are presented. Wood species, namely oak (Quercus L.) and pine (Pinus L.), were subject of steam drying process in a laboratory kiln especially arranged for that reason. Main focus of those tests was to shorten the time of drying process and afterward to check properties of wood. As results of mechanical properties checking are presented in separate paper, here authors focused on numerical predictions of uniform velocity and temperature profiles through the drying kiln, which is of great importance for drying and also for energy saving. Predicted velocities were used in the laboratory kiln for tests. Satisfactory results were obtained as the time of drying process was significantly reduced.

Keywords: wood drying, high-temperature drying, steam drying

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 (e.g. 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 will affect the quality and dimensions of the furniture. The resistance to weather conditions is also higher.

EXPERIMENTAL BACKGROUND

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, lower energy consumption 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 [1].

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.

Wood species, namely oak (Quercus L.) and pine (Pinus L.), were subject of steam drying process in a laboratory kiln. The kiln is equipped with heat exchanger supplied by exhaust gases from furnace. Water, spread from two nozzles, evaporates on exchanger's surface. Generated steam, is distributed between the wood stake by circulating fan. The dryer is dedicated for all timber species of final moisture content to 6 % in the temperature up to 150^{o}C. Detailed description of laboratory kiln was presented previously [6, 7].

RESULTS

Experiments were carried out with Pomeranian region lumber of oak and pine. Probes to measure moisture content inside wood are placed in the material so that it was possible to measure moisture content in a number of characteristic points of the kiln, i.e. in the middle of the boards or in the outer layers of the stack Figure 1. Following figures presents the results of experimental works for oak and pine lumbers.

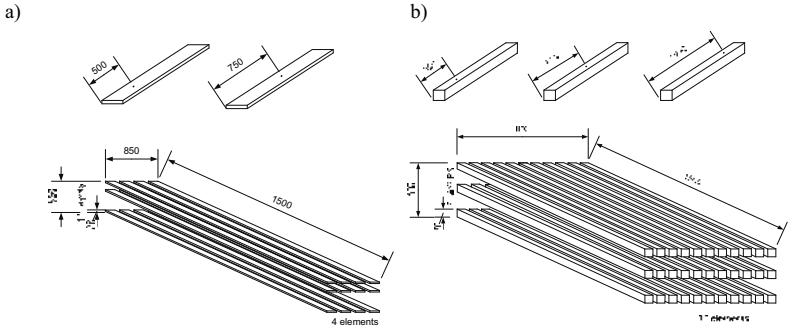

Fig. 1. Dimensions and location of probes for measuring temperature and moisture content during experiment: a) stack of boards b) stack of timber

Hot water was supplied to the chamber to increase humidity and temperature throughout the material in the initial stage of drying. Hot gases flow through the heat exchanger to raise the temperature in the chamber. As far as humidity and temperature grows, we start with the drying process. The process of

drying the material continues to achieve the assumed wood humidity of 10 % EMC (equilibrium moisture content). The next process was the conditioning of wood - slowly cooled down chamber with getting hot water to remove the stress in the material which emerged during the whole process of drying.

Figure 2a presents the results of experimental work of moisture content changes for pine lumber drying. The temperature of drying agent was about 100^{o}C and inlet velocity during heating stage was about 4,5 m/s. During drying and conditioning process, inlet velocity was reduced by control system to about 2,5 m/s. This was necessary to achieve low velocity between wood layers to avoid fractures of wood. Overall process took about 2,5 days. In Figure 2b photo of dried pine lumber is presented. Slight colour changes and no fractures were reported.

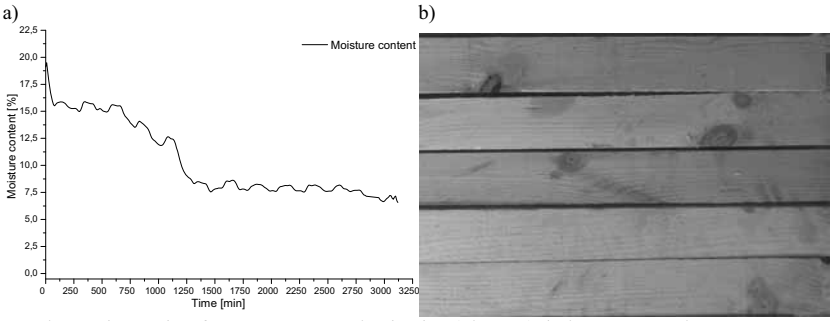

Fig. 2. The results of 7,0 cm x 7,0 cm pine lumber (Pinus L.) drying process using steam-gas mixture: a) time dependence of moisture content, b) fractures and colour changes of wood.

Results of moisture content during oak lumber drying process are presented on Figure 3a. In this case overall time was extended due to achieve proper level of moisture inside wood as hot water was directed on a part of pile. Figure 3b presents a view of dried oak lumbers. Because of high temperature and long time of drying, structure and colour of wood were changed. Fractures of wood after this kind of drying process can be also observed.

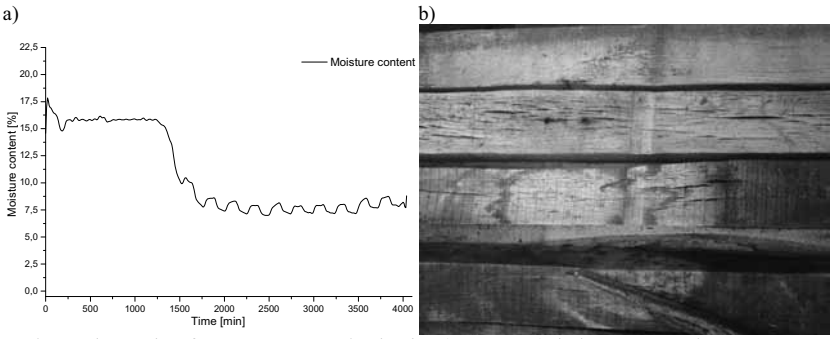

Fig. 3. The results of 7,0 cm x 7,0 cm pine lumber (Quercus L.) drying process using steam-gas mixture: a) time dependence of moisture content, b) fractures and colour changes of wood.\

CONCLUSIONS

The results obtained from tests shows that drying time shortens of about 20 - 40 [%] what justifies further experiments. With the time shortened to 2,5 - 3 days, it is assumed that also energy consumption for drying process of soft wood, such as pine, will decrease. Next steps are planned with the use of coniferous and leafy lumber.

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Streszczenie: *Zastosowanie mieszaniny parowo-gazowej do suszenia drewna*. Zastosowanie mieszaniny parowo-gazowej do suszenia drewna. Badania wysokotemperaturowego suszenia drewna zostały zainspirowane koniecznością intensyfikacji wymiany ciepła i masy na potrzeby przemysłu drzewnego w zakresie: doskonalenia metod suszenia drewna, opracowania energooszczędnych systemów suszarniczych, ochrony środowiska związanej z racjonalnym zużyciem energii, obniżenia kosztów związanych z suszeniem, a w konsekwencji poprawy jakości produkowanych wyrobów. W odróżnieniu do konwencjonalnego procesu suszenia za pomocą gorącego powietrza, proces suszenia wysokotemperaturowego (temperatura medium powyżej 100^{o}C) przy wykorzystaniu przegrzanej pary wodnej lub mieszaniny parowo-gazowej powinien pozwalać nie tylko skrócić czas suszenia, ale także zachować własności użytkowe drewna bez niebezpieczeństwa utraty drożności porów i związanego z tym znaczącego pękania materiału.

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