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Hardwood drying intensification

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Abstract: *Hardwood drying intensification.* The paper considers the aspects of infrared radiation and furnace gases using as non-pipe heater methods for hardwood drying intensification.

Keywords: hardwood, drying intensification, infrared radiation, furnace gases.

INTRODUCTION

The search of new ways to intensify the drying of hardwood has always been topical, but today it is particularly important for several reasons. An increasing value of energy sources (especially of natural gas) puts the new framework on energy efficiency of used technologies.

The most common today is a convectional drying, based on the using of hot water pipe heaters that are running on own waste wood (chips and sawdust, scraps, wood pellets, etc.) firing. This significantly decreases fuel expenses, although thermal sluggishness of the equipment is rather important factor. However, it is known that the cost of the pipe heaters can reach nearly 30% of the entire drying kiln price. This makes them an important pricing factor. For these reasons, in order to reduce the price of drying equipment it may be appropriate to appeal to so-called "non-pipe heater" drying.

OBJECTIVE

It is necessary to find such modern methods of drying, which, on the one hand, make it possible to use cheap and affordable fuel, and on the other hand, allow achieving appropriate quality in shorter terms of drying. In addition, the absence of pipe heaters is desirable.

Drying using infrared rays or furnace gases may meet these requirements. Since each technology has its advantages and disadvantages the main research objective was to detect them.

MATERIALS

The attention to the possibility of infrared radiation application for wood drying had been paid the middle of the last century. According to Лебедев (1955) the advantage of infrared rays is that they are little absorbed by wood and much by moisture, so that the last is heated rapidly. Due to this used energy is spent more efficiently. But these IR-rays have low penetration depth, depending on the wavelength – up to 7 mm, which greatly limits the thickness of the dried sawn timber. However, the low cost of natural gas at that time as well as the low efficiency of contemporary emitting equipment created significant barriers to the use of this method.

Infrared technologies from the very beginning of their appearance were actively applied in military industry, so they were not widespread in other sectors. At the present time infrared radiation is widely used for granular materials drying - grains, dried fruit, peat, clay and more. Also special panels with infrared radiation are available for house heating, which are mounted on the walls and ceiling. The sources of IR-radiation in them are so-called EFH panels – low-temperature electric film heaters that have the shape of thin flexible rectangular sheets. At the heart of them are narrow strips of special alloy with high electric resistance coated on the both sides with polyester film. Surface operating temperature of electric film heater can reach 45°C, generating IR-rays with wavelength of 6-20 μm.

Today EFH panels are offered for sawn timber drying by placing them between the rows of boards in a stack and on internal surfaces of the chamber.

Wood drying using furnace gases always was considered to be promising. According to Кречетов (1961) the essence of this technology is that the furnace gases, mixed in a special chamber with fresh or exhaust air in the right proportion, are directed to a stack of sawn timber. This method makes it possible to transfer relatively cheap heat (waste wood incineration) to wood directly from the furnace. The range of achievable temperatures is rather wide; therefore there is an opportunity to intensify the process considerably. However, a significant obstacle for its application is the difficulty of schedule conditions (that are mostly severe) controlling.

RESULTS

The usage of EFH panels as a source of infrared radiation for sawn timber drying was tested directly in an industrial conditions; but pine was dried instead of any hardwood actually. However, further results allowed to make useful conclusions about the prospects of this technology application.

Functioning of infrared emitters was carried out in "impulse" way – the period of heating was permanently changed with a break. Such an approach was used to save electric energy and to reduce residual stresses, but this particularly prolongs drying duration. During the drying the temperature of wood and air in the chamber did not exceed 47,5°C. The results of the thermal field fluctuation in the chamber measurement after the heating stage in the middle of drying are shown in Fig. 1. The thermocouples that were installed both inside and at the surface of kiln samples after heating were indicating the same temperatures, describing the uniform heating of entire material and the absence of a temperature gradient.

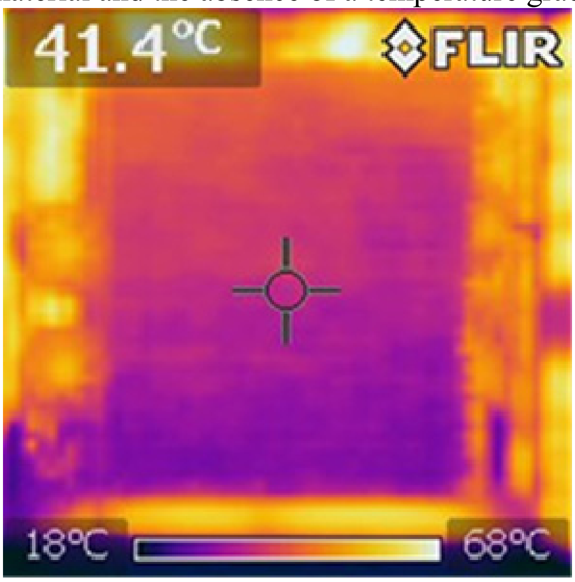

Fig. 1 Picture of thermal field in a chamber taken with FLIR i3 thermal imager during IR-drying

The initial and final moisture content of sawn timber was determined by moisture meter GANN HT 85 T. For 6.5 days of drying average moisture content of wood descended from 27% to 17%, while electricity consumption per 1 m^3 of wood were 221.3 kWh (by electricity meter indicators), which costs nearly 24 €. Drying quality estimation by Ukrainian norm DSTU 4921: 2008 has shown that the results can not be attributed even to the III category, because there was considerable unevenness of final moisture content (± 2 σ = 6%). Also surface checking was observed on the faces of separate boards.

In general, this control drying has shown that significant drawback of this method, which limits its application for hardwood, is the lack of intermediate and final equalizing and conditioning. The relative humidity in a chamber can only be reduced by exhaust fans.

The usage of temperatures below 55°C, which takes place during infrared drying, does not allow sterilizing of sawn timber. Therefore, an alternative may be drying with furnace gases that directly from the furnace after mixing with air enter the drying kiln to evaporate moisture from the material. Their application is most effective for mass wood drying. The thinner boards are, the greater beneficial effect of this drying method is. Furnace gases drying of softwood that can withstand more severe schedules does not look complicated. At the same time, hardwood sawn timber, particularly thick, is very susceptible to cracking. Its drying requires great care, careful monitoring of a schedule, perfect conditions of the kiln equipment.

It is known that the sensible heat of furnace gases does not depend on wood fuel moisture content and is determined by air excess ratio α and, partially, by sensible heat of air entering the mixing chamber or firebox. Amount of air entering the furnace can be controlled by ash-bit damper position.

An implementation of furnace gases drying requires the precision inspection equipment, allowing to control the mixture parameters – temperature and relative humidity, RH. And if temperature of received treatment agent is easier to predict (calculated from the ratio of volumes), relative humidity can vary depending on the moisture content of fuel. Since during hardwood sawn timber drying, especially at the initial steps, it is important to maintain a high RH for a "safe" rate of moisture, it is necessary to calculate the amount of water that must be "injected" to the mixture for its humidification.

Promising when drying with furnace gases is the use of "impulse" approach when heating time ("impulse") is changing the cooling stage ("pause"). Due to this, a "sign" of stresses changes periodically resulting wood does not crack. Also the performance of drying increases, because at the moment of pause wood cools – and the temperature gradient facilitates the movement of moisture out.

It must be effective to use this method in "paired" kilns when a mixture of furnace gases with air first enters the chamber with a soft or thin wood that is less prone to cracking, and then, having acquired the "mild" schedule conditions, moves to the next chamber with thicker or hardwood lumber.

CONCLUSIONS

Comparison of two non-pipe heater methods of hardwood drying intensification showed that each of them has its advantages and disadvantages.

1. The method of infrared rays drying using EFH panels is more environmentally friendly due to lack of air emissions of greenhouse gases, but there are considerable costs of electricity, which makes the cost price of the process quite expensive. Low-temperature drying does not allow to sterilize sawn timber. Lack of equalizing and conditioning does not allow to reduce internal stresses. This method is effective only at the period of free moisture removal, so in order to achieve operational moisture content it must be combined with others, such as drying with furnace gases.
2. Drying with furnace gases is a very effective and economical as it allows to reduce the cost of drying due to a lack of pipe heaters and the use of cheap fuel – waste wood. Its disadvantage is the complexity of the treatment parameters controlling, especially the drying agent humidity. Drying with furnace gases requires engineering work on developing an effective kiln design, corresponding drying schedules and their conditions monitoring systems during drying.

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Streszczenie: *Intensyfikacja procesu suszenia drewna gatunków liściastych*. Praca rozważa możliwości zastosowania promieniowania podczerwonego oraz spalin kotłowych do wspomagania procesu suszenia drewna gatunków liściastych.

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