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MEASUREMENT OF HEAT LOSS IN STEAMING KILN AND POSSIBILITY TO RECYCLING

ABSTRACT

The steaming of wood has a large energy demand. The reduction of energy consumption can decrease the costs and the environmental pollution.

Steaming of wood takes place in practice in steaming chambers. The heat loss of the chamber's wall can be measured with heat flow sensor. The sensors were fixed in different position on the wall and the fundation of the kiln. The foundation made of concrete and the walls is sandwich-structured composite with PUR and aluminum sandwich panel. Heat flow was measured 71.3 W/m^2 and 415.5 W/m^2 in average on the wall and the foundation respectively.

The energy loss of the chamber was calculated by means of a WinWatt technical building energy model program. The rate of heat loss varies by 40% as a function of insulation and the outside temperature, where 20 cm of thermal insulation and 20°C temperature difference was calculated.

The possibility of using a heat exchanger to reduce the waste energy was studied also.

Keywords: steaming, energy consumption, steaming chamber insulation

INTRODUCTION

Steaming is most often used to change the unfavorable properties and color of wood (Majka and Olek 2007; Tolvaj et al. 2006, 2009; Taghiyari et al. 2011; Barański et al. 2017). Beside aesthetical result the steaming can decrease the shrinkage and dwelling of the wood as the effect of moisture change. On the steaming process the wood is warmed up in hot steam and keep in high temperature around 100°C for 24 to 48 hours pending on the desired strength of steaming. Consequently, steaming has a large energy demand, which means specific high cost. The amount of energy used for steaming is influenced by several of factors: time of schedule, lumber's thickness, species of wood, outside temperature, type of steaming, and the condition of chamber (Németh et al. 2013). Energy amount can be separated to three main part, 1) warming up the wood and the chamber; 2) causing thermochemical changes in the wood structure in cell wall level; 3) heat loss. The ratio between this three main part is important from the aspects of energy efficiency.

The used energy is mainly thermal energy, which results high amount of CO_2 emissions. On the other hand, the transportation loss of steam in the pipe usually high, because of the high temperature difference of steam and the ambient. That is why it is desirable the reduction of specific energy consumption of steaming. Therefor the reduction of energy consumption can decrease the costs and the environmental pollution.

The energy used for warming up the wood and the chamber and changing the cell structure is needed for having the result it cannot decreased. The heat loss of the chamber can be significant and would be advantageous to decrease as low as possible. This is the energy amount which disappear in the environment without any useful effect.

In this study was examined the heat loss of an industrially used steaming chamber and was seeking the possibilities of heat loss reduction.

MATERIAL AND METHODS

The chosen steaming chamber located in the saw mill in a forest company in the mount of Bakony in Hungary. The chamber is used for thermal modification of mostly beech wood. The capacity of the chamber is twelve cubic meter, the heating fuel is overheated steam produced in a high capacity furnace. The fuel of the furnace is mostly the waste materials of the saw mill.

During the tests, measurements were performed on steam chamber. Fluke TiR3FT infrared camera with the resolution of 0.1 Celsius, Ahlborn Almemo 2590 data collecting, thermal flux sensor, calibrated temperature sensor was used for thermo vision and thermal flux measurement. During the measurement wasn't any significant wind and air temperature change. Background temperature was set to the measured air temperature and the emission value of the surface was set 0.25 which fits to the dirty rough aluminum surface. The thermal imiger was verified by tactile thermometer. The photos were analyzed by the Smart View software. For measuring heat flow flux meter was fixed on the surface of the chamber in different places. Inner and outer air temperature were also measured. The measurement points were selected to be far away from the corners and inlet points.

Based on the measurement results, a virtual model of the chamber was built with WinWatt software, and the effect of ambient temperature and insulation thickness on thermal conductivity was calculated.

In addition, the use of heat recovery devices has been proposed.

RESULTS

The large heat losses determined with the help of thermal images were solved with seals and insulations (Fig.1).

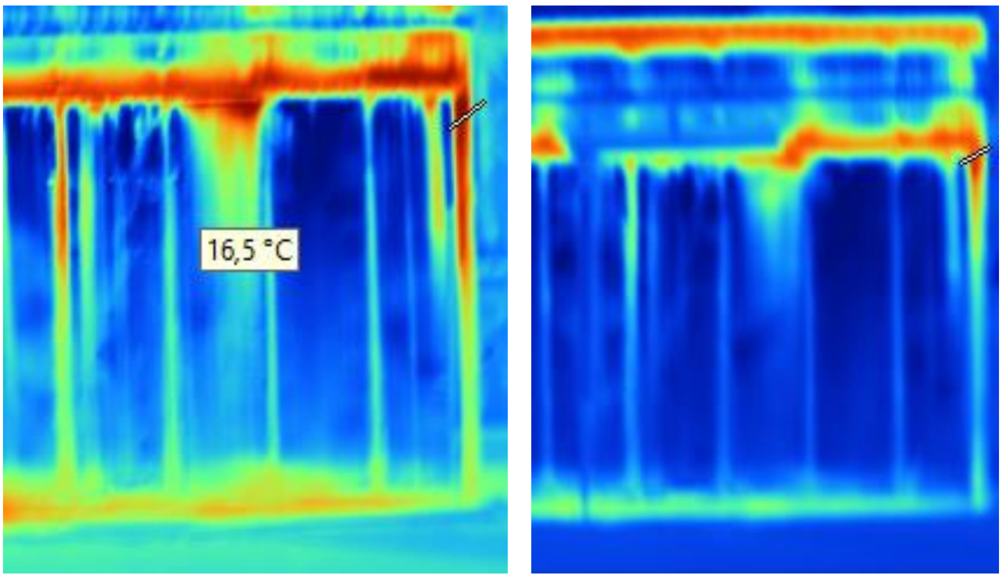

Figure 1

Chamber door's temperature before and after the change of seal

The measured average heat flow can be seen in the Table 1.

Table 1

Measured heat flux in different point of chamber. The point 1 and 2 is on the PUR panel

Surface	**Measuring point 1**	**Measuring point 2**	**Concrete foundation**
Average heat flux [W/m²]	69.7	72.3	415.5

Based on the model of the chamber, 15°C increase of the outer temperature reduce the heat waste about 10% (Fig. 2).

The theoretical insulation of the chamber induced a decreasing heat loss (Fig. 3). The degree of thermal insulation is more important at lower temperatures: at -5°C even the weakest insulation caused an 18% loss reduction, while the double insulation and the separate insulation of the fundation almost doubled this (34%). The difference between the weakest and strongest insulation calculated in percentage point was hardly affected by temperature: it was reduced from 15.7 to 13.4. At higher outdoor temperatures, the reduction in heat loss was greater, reaching 40% with the best thermal insulation. With the best insulation, the outside temperature had little effect on the rate of reduction in heat loss (34.5 to 40%).

Increasing levels of insulation also come with increasing costs. The optimal insulation thickness can be determined by cost and environmental load analysis for the entire life of the chamber, which is the task of the future.

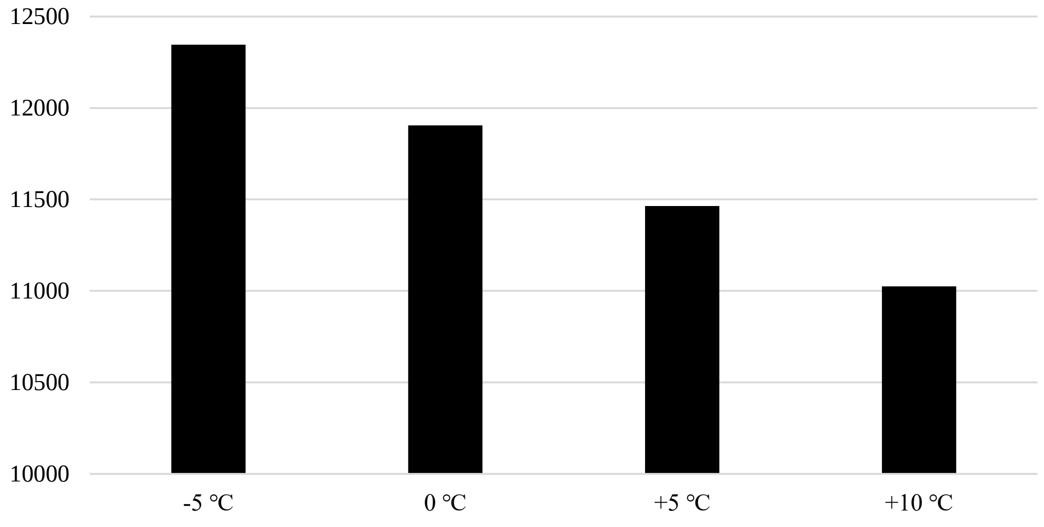

Figure 2

Heat waste [W] during 1 hour with increasing outer temperature

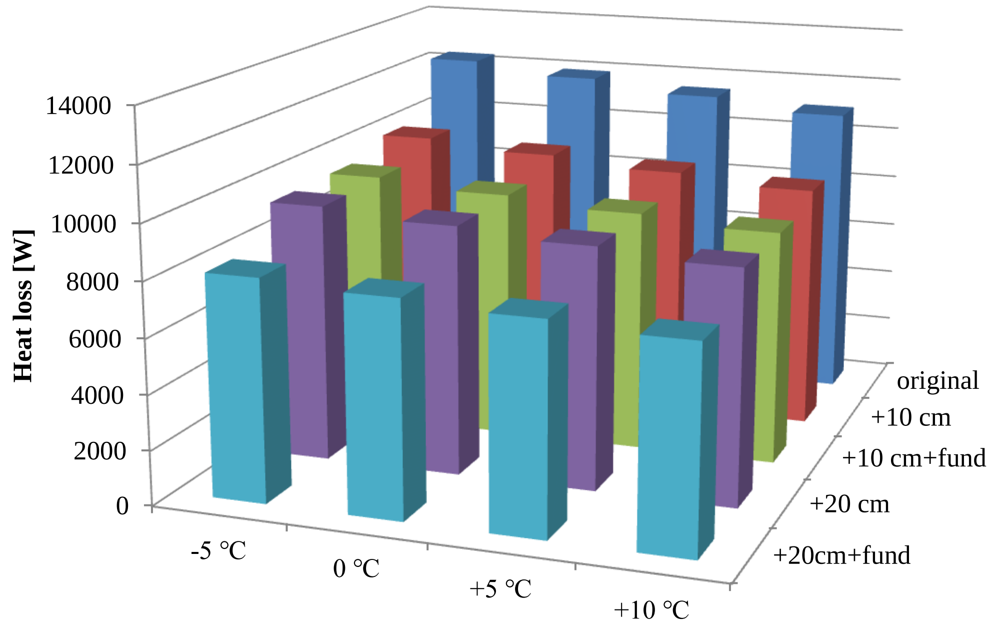

Figure 3
Heat loss as a function of insulation and outside temperature

A further reduction in the energy consumption can be achieved by recycling the heat leaving the chamber in a controlled manner. According to measurements, through the overpressure outlet the air flow is 84.75 m^3/h at 92°C. The exhaust hot air could be used to preheat the water supply to the system via a heat exchanger or possibly with the help of phase change materials the thermal energy can be accumulated and used in other applications. The modeling of the rebuilt system is the task of the future, with which we hope that further significant energy savings can be achieved.

ACKNOWLEDGEMENTS

The work was carried out as part of the „Sustainable Raw Material Management Thematic Network – RING 2017", EFOP-3.6.2-16-2017-00010 project in the framework of the Széchenyi 2020 Program. This project is supported by the European Union, co-financed by the European Social Fund.

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