DRYING OF LUMBER WITH LARGE CROSS-SECTION

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ABSTRACT:

This paper focuses on research in the field of large-scale lumber drying section. The main focus was to find optimal drying of lumber.

1. INTRODUCTION

During the last years the demand for low-rise constructions has increased particular for the constructions of houses made out of wood. Wooden houses are ecological and create a specific microclimate in the living space due to such property as the “breathing” of wood. Wooden houses are aesthetic and wood as natural material often doesn’t require a finish what reduces the costs of the construction.
Wood is used since decades as building material manly in the form of lumber and sawn beams. Nowadays new materials have replaced the traditional ones because of different reasons.
Today one of the best-known materials are glued laminated beams (GLB). It is a high-tech product that has undeniable advantages. Firstly, GLB is more durable, it is made with removing from timber stress concentrators, which reduce the strength of the whole material. Secondly, GLB can be made of different sizes. Thirdly, GLB does not shrink during construction. The most significant disadvantage of GLB is the quite high price with the result that not everyone can afford a house made out of GLB.
Profiled sawn beams would be a good alternative for GLB but it has different disadvantages. The main disadvantage is the moisture content. Typically, new sawn beams have high moisture content and have to be air-dried before application. However atmospheric drying takes too much time. The long duration of atmospheric drying affects the productivity and the profit of the enterprise. Therefore it is preferred to collect house of sawn timber and fill up chinks caused of shrinkage. Using kiln-drying significantly reduces the drying time but only a few producers own such chambers because of the high amount of drying failure. The main drying defect at beams are cracks, they can be nearly half-depth of the cross section, which preclude use of these beams for construction.
There are materials such as railroad ties and poles of power lines. They need to be dried as they are impregnate with preservatives and the impregnation of green wood is useless. Thus, there is a demand of dried lumber / beams of big dimensions.
There are some other methods of drying beams like microwave chambers and vacuum dryers. They provide good quality of dried products, but their volume capacity is rather small. Such equipment is

extremely expensive and power-consuming what significantly increase the prime cost of beams / lumber. It is more rationally to realize large lumber drying in convective kilns.
Standard of drying schedules is provided only for sections up to 100 mm. So we tried to describe the large lumber drying technology to ensure a decent drying quality.

2. JUSTIFICATION OF THE CHOICE OF DRYING PARAMETERS

There are several methods for monitoring the drying parameters during the process:
- Hygrometric method;
- Psychrometric method;
- The system of UGL.

We chose the last because it is automated and allows operating the process with your PC.

2.1. Selection of the temperature level

Temperature is a very important parameter of the drying process. The higher the temperature, the faster the drying passes, the more quickly moisture comes to the surface of the material and the faster it evaporates. However, excessively high temperatures are harmful for wood. They are the primary source of cracks, cause of the overpressure inside the beams. Therefore as a principle: as thicker the material as lower the temperature. This is especially true for beams. The distance the moisture must overcome from the center to the surface is more than in conventional lumber and accordingly more time is needed for its removal. By this, as lower the temperature as lower also the likelihood for cracks. Moreover, softwood contains a resin which gets liquid at temperatures above 52-55 ° C and can move to the surface, partially cured. This can lead to blocking moisture conductive channels.
Another important factor associated with the temperature is blue stain. At temperatures below 38 ° C, the fungus begins to develop. To prevent this, the temperature must be above this mark. Thus, the temperature range should be selected within 40-55° C to prevent the failure.

2.2. Choosing UGL

UGL is another important factor that influences on cracking of wood. UGL is the equilibrium moisture content of drying agent which is responsible for the transfer of the moisture from the core to the surface of the material. Accordingly, if it is low, then the surface will retain moisture, and as a consequence there cracks appear as a result of compressive stresses. Therefore, it is important to maintain a relatively high humidity at the surface. But excessive humidity is harmful for the drying process as it can stop the process of evaporation. As final moisture content is 18 ± 2, the level of UGL should be approximately 13-15 early in the process, and reduces to 8-10 at the end.

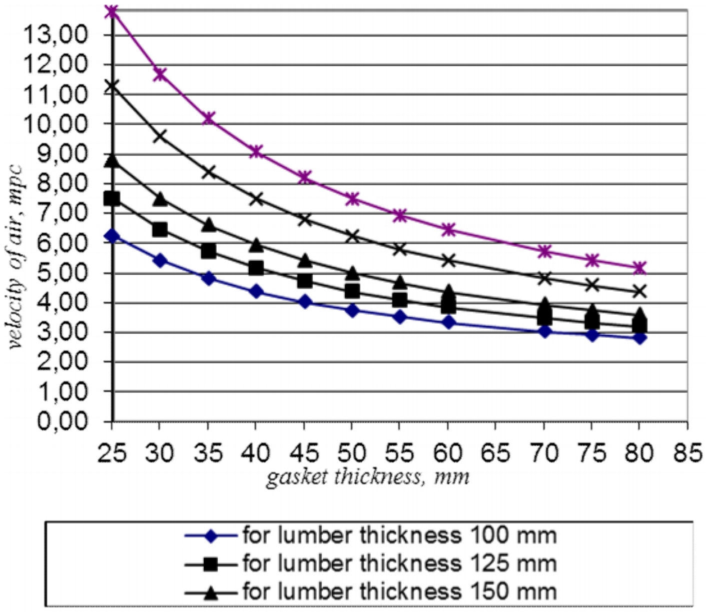
2.3. Air circulation

Another important parameter is the speed of the drying agent circulation. This air carries the moisture from the surface of lumber. If the velocity is too high, then the surface becomes over dried. In opposite, if it is insufficient, it will significantly slow down the drying process. For large lumber this option is particularly important to ensure the high quality of the resulting material. Typically, drying kilns are equipped with fans providing a constant air velocity (1.5 - 3 per. sec). But beams are not standard material for drying, therefore with the formula for the volume of air circulating in the chamber (1) air velocity for different thicknesses of lumber and used gaskets were calculated.

$$v = \frac{V}{f} \quad (1)$$

Where v – air circulation velocity;
V – volume of circulation air;
f – square of pile section.

The results of calculation are shown on the picture below:

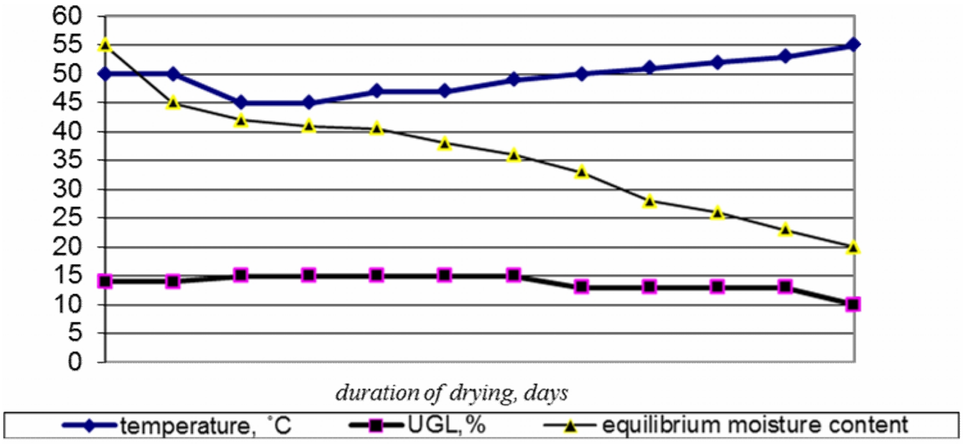


pic. 1 "Relation air circulation velocity of gasket thickness"

The calculation shows that the speed of air circulation is not provided, moreover, the real speed is in several times higher. This can significantly increase the flaws rate during drying. Therefore, the air velocity must be reduced, especially for large sections lumber it is preferably also be controlled depending on the rate of evaporation of moisture from the surface.

2.4. Chosen drying schedule and duration of process

Thus chosen drying parameters can be shown as a diagram:

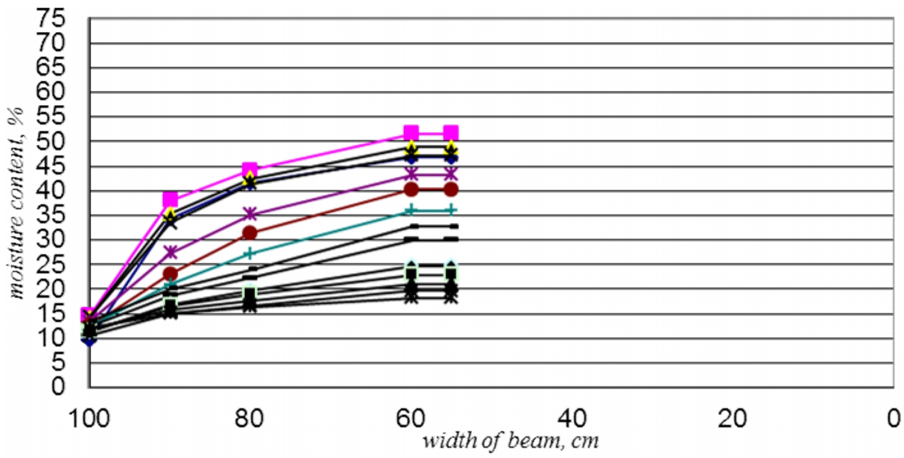


pic. 2 " Experimental drying parameters"

After drying parameters have been carried out theoretically, an experimental drying was realized on the factory. Drying kilns with capacity of 160 m3 were used. Drying quality was assessed visually (cracks, warp) and the moisture distribution over the cross section of lumber was monitored as visualized in Figure 3.

Visual inspection showed that the presence of cracks and warping was minimal.

Figure 3 shows that by the end of the process, moisture is distributed evenly over the cross section and the beam is substantially uniformly within the value of 18 ± 2.



pic. 3 "Dependence of changes beam moisture content over the section depending on depth of sensor placing"

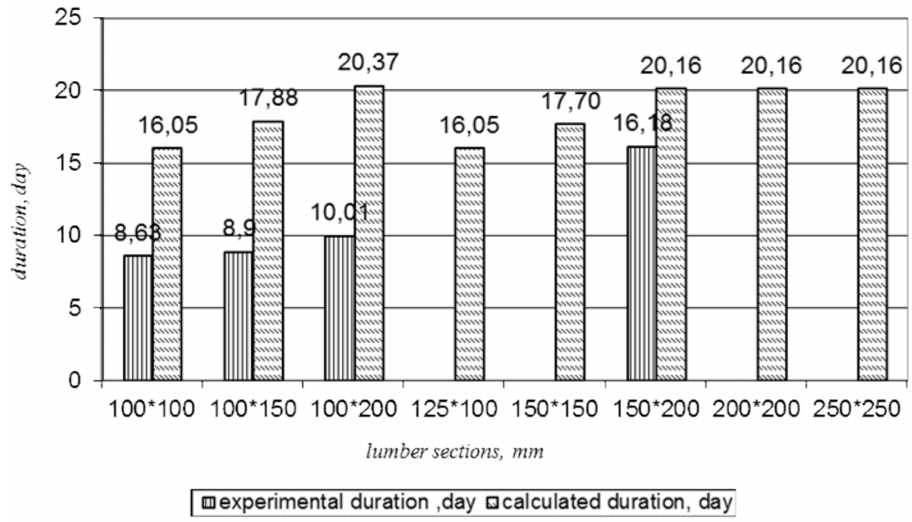
Also the calculation for the duration of the drying process to compare it with the experimental results was performed.

Using formula 2 following calculation was made:

$$\tau_{dr} = \tau_{in} \cdot Ar \cdot Ac \cdot Ak \cdot Av \cdot Ad \quad (2)$$

Where - τ_{in} initial duration of the actual drying of lumber with given species, thickness and width.
Ar - coefficient taking into account the applicable category of the drying.
Ac - coefficient taking into account the nature and intensity of circulation.
Ak - coefficient taking into account the category of drying quality.
Av - coefficient taking into account the initial and final moisture content of wood
Ad - coefficient taking into account the influence of the cut length for the duration of the process.

According to the formula 2 the drying time for the different sections were calculated.
Figure 4 shows a comparison of the duration established during experiments and calculations.
As it can be seen from the figure, the difference is quite large . It is due to the fact that the calculation of the drying method has been developed for smaller cross-sections lumber and it is assumed that large dimensions should be calculated from the maximum. But as it turned out, it is false. But the design of enterprises is determined by the duration of the calculated drying. With such a rough mismatch of theoretical and actual values, you can incur large losses by building factory using incorrect data.



pic.4"comparison of experimental derived and calculated duration of drying"

3. CONCLUSION

Analysis of the experimental dryings showed that chosen schedule satisfied the quality demands. The resulting material had minimum amount of cracks and warps and a nearly uniform distribution of moisture in the lumber section. The current method of calculating the duration of the drying process for lumber is not correct for lumber with large cross-section, what could affect the further calculations of the enterprise design.

4. REFERENCES

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