Drying Techniques
to obtain White Beech

Ottaviano ALLEGRETTI
IVALSA- CNR Timber and Trees Institute – National Research Council (ITALY)

Livio TRAVAN
NARDI INTERNATIONAL s.r.l, Drying Kilns (ITALY)

Rodolfo Cividini
Senior Scientist, Private Consultant Trieste (ITALY)
BEECH (*Fagus sylvatica*)

- Heartwood is **undifferentiated** from sapwood and is diffuse porous.
- **MC** of wet from saw wood is very **high** (85%-95%).
- **FSP** 30-32%.
- **Basic density** is 560 kg/m³ (very variable).
- **Total shrinkage**: R = 2% to 9%; T = 9% to 20%; V = 11% to 29%; (high deformability).
BEECH (*Fagus sylvatica*)

• Checking and splitting in wood, even before kiln drying.

• Normal wood has a high permeability, false heartwood is impermeable.

• It is perishable, in warm and humid conditions, especially if felled at the beginning of the growing season.

• Has a uniform white-yellowish colour, often containing false heartwood.

• Immediately after felling, the colour of wood starts turning to reddish.

• When wet, colour changes rapidly; it slows down approaching hygroscopic MC and becomes stable when dry < 20%.
BEECH in the wood industry

- The maximum value of the wood material is in the production of furniture and interior decoration. In these products superficial colour is the principal factor which undergoes the vagaries of fashion.

- Starting from the 80’s and 90’s, market started to demand light colour furniture; natural beech, without false heartwood (red heart) was now much appreciated.

- The “white” colour was usually obtained following traditional air drying, down to 20% MC.

- In the kilns, it is difficult to preserve the light colour of wet beech.
WHITE BEECH

• White beech is not clearly defined, ranging from white to pale reddish, with subjective and indistinct interpretations by the operators.
The darkening of the beech material at high temperature and humidity seem to be related to the enzymatic oxidization of accessory compounds, like high condensed phenolic extractives formed during drying (Koch, Bauch, 2000).

Combination of temperature and moisture content which triggers the enzymatic oxidization.

Time is another important factor because a long period of warm and humid conditions increases the oxidative action.
DARKENING - SANDWICH EFFECT

The most evident and unwanted discolouration is a darkening of the inner core while the surface portions remain light in colour, producing what is called the “sandwich effect”.

In general because of the dynamic of transport of water in wood during drying this problem is proportional to the thickness of the sawn timber.
On the other hand, thick beech boards are prone to casehardening due to a too high drying rate during the II drying stage. Casehardening produces several problems, one of these is an inhomogeneous colour with a thin light dry shell and a dark and humid core.
SANDWICH EFFECT

There are infinite gradation of results between the perfect homogeneous white beech and the worst sandwich effect.

The absence of standards and methods for grading the quality of colour creates confusion and misunderstanding between buyers and sellers.

The manufacturing of end-products demands different colour hues that are often all called white beech. Difficulties arise, for example, when having to match different lots of dried material.
This work presents a proposal for the characterization of the term “discolouration”, through spectrophotometric colour analysis. This technique overcomes the problem of the subjectivity of the perception of the colour.
COLORIMETRIC OBSERVATION

Our attention was mainly focused on the colour differences, trying to understand if it is possible to graduate the intensity of colour difference in the discolouration called sandwich effect.

<table>
<thead>
<tr>
<th>$0,2 &lt; \Delta E$</th>
<th>Not visible difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0,2 &lt; \Delta E &lt; 2$</td>
<td>Small difference</td>
</tr>
<tr>
<td>$2 &lt; \Delta E &lt; 3$</td>
<td>Colour difference visible with high quality screen</td>
</tr>
<tr>
<td>$3 &lt; \Delta E &lt; 6$</td>
<td>Colour difference visible with medium quality screen</td>
</tr>
<tr>
<td>$6 &lt; \Delta E &lt; 12$</td>
<td>High colour difference</td>
</tr>
<tr>
<td>$\Delta E &gt; 12$</td>
<td>Different colours</td>
</tr>
</tbody>
</table>

$$\Delta E = \sqrt{(L_2 - L_1)^2 + (a_2 - a_1)^2 + (b_2 - b_1)^2}$$
COLORIMETRIC OBSERVATION

Compared to white beech, the colour of the normal beech is darker and more saturated. The average $\Delta E$ between white and normal beech = 12 (high colour difference).

The difference of colour in the sandwich effect mainly concerns $L^*$ which become darker going from the surface (av. $L = 75.5$) to the core (av. $L = 69.8$) while the saturation shows a slight increment (av. $\Delta C = 1.6$). The global colour variation $\Delta E$ measured is in the range 5.7 – 6.5 (sensible colour difference).

<table>
<thead>
<tr>
<th>$\Delta E$</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.2 &lt; \Delta E$</td>
<td>Not visible difference</td>
</tr>
<tr>
<td>$0.2 &lt; \Delta E &lt; 2$</td>
<td>Small difference</td>
</tr>
<tr>
<td>$2 &lt; \Delta E &lt; 3$</td>
<td>Colour difference visible with high quality screen</td>
</tr>
<tr>
<td>$3 &lt; \Delta E &lt; 6$</td>
<td>Colour difference visible with medium quality screen</td>
</tr>
<tr>
<td>$6 &lt; \Delta E &lt; 12$</td>
<td>High colour difference</td>
</tr>
<tr>
<td>$\Delta E &gt; 12$</td>
<td>Different colours</td>
</tr>
</tbody>
</table>
DRYING TECHNIQUES AND TIPS

• too high temperature produces a reddish discolouration;

• too low temperature produces moulds and decaying;

• diminishing EMC of air improves colour but causes drying stresses (casehardening).
- very short time between sawing operations and start of drying;

- the drying time for the I and II drying stage should be as short as possible;

- temperature of I and II drying stage must not exceed 30-35 °C.
DRYING TECHNIQUES AND TIPS

• oversized vents,
• very efficient air circulation system
• more than 6 MC probes.

Short drying times and low temperatures are not always easy to combine in a conventional kiln especially during summer.

Furthermore pre-dried material is usually already affected by discolouration (white shell or sandwich)
DRYING TECHNIQUES AND TIPS

In winter, if frozen material is present, this must undergo a de-icing phase to avoid the further occurrence of casehardening and discolouration.

To load the kiln with semifinished pieces (typically 5 x 5 cm pieces for furniture) in order to avoid, mitigate or to conceal the sandwich effect.
A series of different drying schedules are presented in the paper.

They are the results of a long practical experience of the authors in this field coming from the observation of hundreds of drying cycles performed in industrial kilns.

All this can be considered the state of the art of the topic and it must be applied taking into account all the rules for a correct management of the process.
CONCLUSION

The conduction of the drying process is a complicate equilibrium between fast drying rate to avoid colour change and slow drying rate to avoid mechanical degradation.

The problem is proportional to the thickness of the sawn boards so that is practically impossible to obtain white beech when it is thicker than 40-50 mm.

Colorimetric analysis at the industrial level could be developed for the control of the process and for the in-line after process selection of wood pieces.

Definition of some grading classes for colour difference and a standard method for the measure.
CONCLUSION

THANK YOU FOR YOUR ATTENTION!