Challenges using dielectric heating for THM processing of solid wood

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A dielectric heating technique for solid wood bending, i.e. for heating, plasticizing and drying the wood to be bent in one step, is presented and the challenges to use this technique in practise is discussed. The main purpose to use dielectric heating is to decrease the time of the bending process. In practise this means reducing the time to bend and dry a straight piece of solid wood from a moisture content of about 25 % to 6-8 % from about 3 days to about 10 minutes. Plasticizing wood through dielectric heating for shaping wood has been studied for several years [cf. 1-7]. The theoretical approach is well documented by Torgovnikov [8]. Navi and Sandberg [9] have in their recent work described thoroughly a process for bending solid wood by using dielectric heating.

The short processing cycles gives high demands on controlling the moisture content, temperature and the strain fields that occur in the wood during processing. Figure 1 shows the temperature and moisture content in beech wood during a bending process (mean values for 21 wood pieces). The temperature was measured at the centre of each piece. Figure 1 also shows the rejection level of curved pieces, i.e. curved pieces that do not satisfy the requirements in bending radius or are not free from damage, cracks etc. The graph shows the rejected proportion as a function of time. During the heating stage, the rejection is by definition 100 % as the pieces are not yet curved. During the bending stage, the temperature is almost constant and the moisture content drops rapidly. At the end of this stage the moisture content is about 10 %. If the process were stopped at this time, the rejection proportion would be 100 % as a consequence of spring-back of the curved pieces.

Figure 1. Temperature, moisture content and rejection as a function of time during the bending of solid beech wood using dielectric heating.
During the drying stage, the moisture content is lowered to a level where the curved shape is fixed at the required radius. In Figure 1, it is clear that the moisture content falls as long as the drying continues until no or a low amount of water remains in the wood. The temperature rises from 95°C to about 98°C during 360 seconds. The rejection falls from 100% to about 5% during a time period of about 60 seconds. The process should be stopped in this time period, to obtain a low rejection of wood pieces. If the drying continues, the rejection level of bended pieces increases again, and when the bending process is stopped, as in the example in Figure 1, the rejection rate is as high as 40%. The curves in Figure 1 show that there is a relatively short time span during which the process should be stopped to ensure a low rejection rate of the bended pieces and not too low moisture content. The optimal processing time is of course dependent on the energy input into the wood.

Different types of damage that may occur in the wood during the bending process is related to rupture of cell walls if the steam generated within the cells of the wood finds difficulty in escaping, flash-over in the dielectric field, tensile or compressive rupture related to incomplete softening of the wood or to the structure of the wood (deviating fibre orientation, knots etc.).

Conclusions:
Dielectric heating technique can be used for plasticizing and drying wood in a single sequence high-speed solid wood bending process (open system). However, a good control on the moisture content of the raw material is needed and the equipment for bending must be designed to prevent flash-over in the electromagnetic field and to prevent steam in the wood from rupturing the cell walls. To reach a low rejection level in the bending process, the process parameters, i.e. input energy and time for the different processing stages, have to be well controlled since the time-span for optimal bending is very small.

References: