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In situ CT-scanning for detection of internal checking and cell collapse during drying of hardwood species

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ABSTRACT

During the drying of sawn timber, hydrostatic tension forces within the cell may exceed the compressive strength perpendicular to the grain of the thin cell wall and the cell then collapses. This phenomenon is common in hardwoods such as *Sequoia sempervirens*, *Thuja plicata*, *Tsuga heterophylla*, *Juglans nigra* and many species of eucalyptus and oak. Usually, this leads to severe surface deformation, and both surface and internal checking (honeycombing) may occur. The quality of the final product is lowered by these cracks and deformations.

The aim of this study was to investigate, by CT-scanning samples throughout the drying process, whether it is possible to detect when and how cracking and deformation occurs and develops in specimens of *Eucalyptus nitens*. Based on this knowledge, better drying schedules can be developed to improve the yield and ensure a higher quality of the sawn timber.

Three specimens, one specimen in each drying run, of *Eucalyptus nitens* were used for the tests. Their cross-sectional dimensions, prior to drying, were 105x23 mm^2 and their length was 70 cm. A specially designed laboratory drying kiln that fits within the gantry of a Siemens Somatom Emotion medical CT-scanner was used (Fig. 1). With this equipment, it is possible to scan the inside of the kiln without interrupting the drying process.

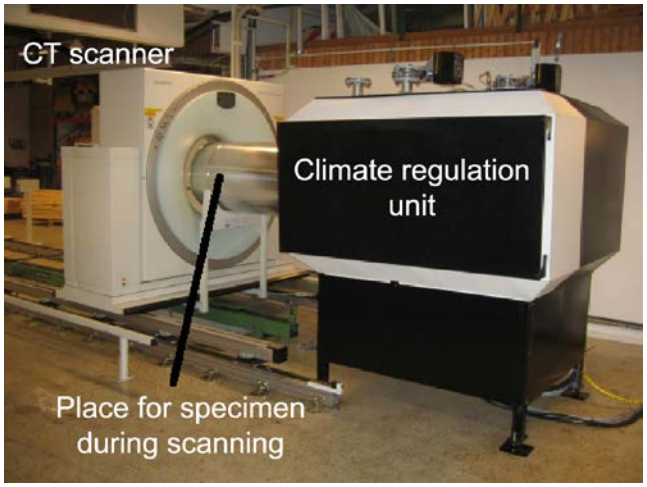

Figure 1: X-ray computed tomography (CT) with the climate chamber installed for CT measurements

The dryer works as a regular heat and vent kiln, and the drying takes place under atmospheric pressure. Prior to drying, the specimens were soaked in water for 24 hours and the ends were sealed with a heat-resistant silicone. In the three drying runs, the dry bulb temperatures were set at ca. 50, 82 and 103°C respectively while the wet bulb depression varied as the drying progressed (Fig. 2). The warming-up took place in a saturated atmosphere at a rate of 30°C per hour. The specimens were scanned periodically and at different spans. Three thermocouples, type T, connected to a PC-logger (Intab AAC-2), and placed in holes drilled in the specimens, were used to achieve complementary data. Two of the thermocouples were placed in the centre of the specimen cross section and one at a depth of approximately 3 mm from the surface. The data obtained were used to make videos of the process following the changes in the specimens with the CT-images and a temperature graph.

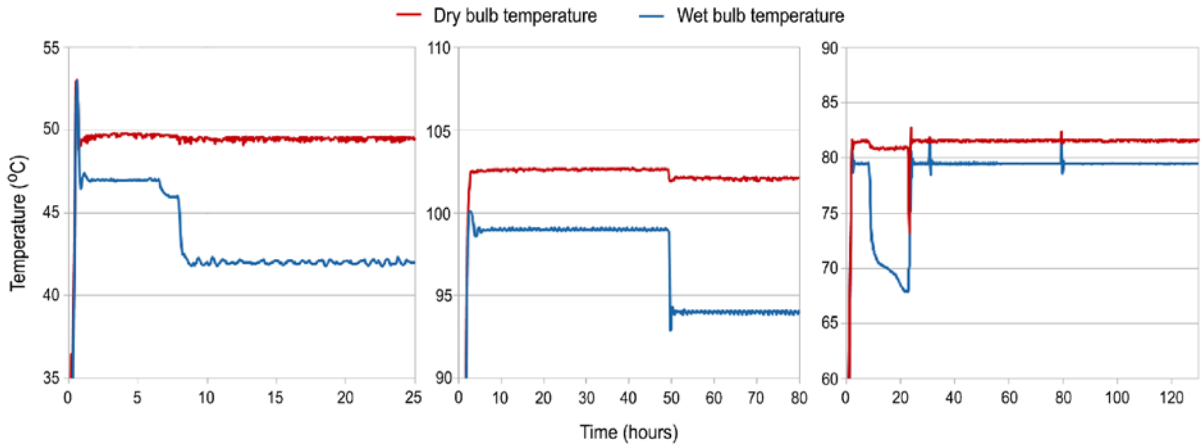

Figure 2: Wet bulb and dry bulb temperatures of the drying runs. From the left: | 2.1 dry bulb temperature 50 °C | 2.2 dry bulb temperature 82 °C | 2.3 dry bulb temperature 103 °C

The method makes it possible to study changes in the cross section of the specimens at intervals during the drying process, such as how internal cracks start and develop. The pixel size of the images corresponds to 0.1 x 0.1 mm2 in the specimens. The depth of the voxel was 10 mm, so that the data given for each pixel corresponds to an average value of such a volume. It is possible to see a good level of detail with such parameters, but it could be possible to adjust the settings to achieve even higher spatial resolution. Collapse seems to become noticeable before any internal crack is visible. In the early stages of the drying process, a wavy deformation in the otherwise flat surface was clearly noticeable (Fig. 3).

This study shows that the CT equipment provides the means to study internal changes in wood during drying to a high level of accuracy, making it possible to better understand of the internal cracking and collapse behaviour during drying of Eucalyptus nitens or any other wood species.

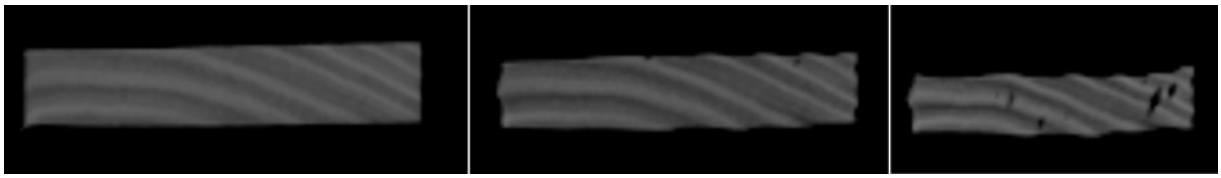

Figure 3: Sequence of the same specimen. From the left: | 3.1 beginning of the drying. | 3.2 collapse is visible at the surface of the specimen before any checking. | 3.3 internal checking is visible well after the collapse