SUPERHEATED STEAM/VACUUM DRYING TIMES FOR THICK LUMBER

Luiz C. Oliveira  
J.F.G. Mackay  
Forintek Canada Corp.  
Vancouver, B.C.

Background

Superheated Steam/Vacuum (SS/V) drying is a process in which the lumber is dried under a vacuum and therefore at temperatures above the boiling point of water. Because of the relatively low boiling point of water due to the vacuum, the lumber is exposed to mild drying temperatures when compared to other processes thereby reducing the risk of drying degrade. Research and industrial experience with numerous wood species have indicated that SS/V is faster than conventional methods because the mass flow of water movement resulting from boiling water is faster than the diffusion process that occurs when drying under conventional drying methods.

In today’s market lumber producers are faced with difficult issues related to their drying practices mainly because of customer demand for better quality, increased drying costs, the need to better utilize the wood resource and the economic potential and market accessibility for producing higher value specialty products. Producers are therefore having to focus on a number of issues such as: a) Development of faster drying schedules to maximize current productivity levels; b) Demand for increased kiln capacity flexibility, that is, the ability to dry smaller volumes for various types of specialty products; c) Reduction of moisture content variation amongst lumber pieces distributed in different regions inside the kiln; d) Production of lumber with uniform moisture content throughout its thickness, especially when the lumber product is to be remanufactured; e) Improve grade recovery; f) Opportunity to dry high quality thicker lumber (thicknesses greater than two inches); g) Development of drying schedules or strategies to deal with difficult-to-dry wood species such as those containing wet pockets (subalpine fir, hemlock).

For certain cases SS/V drying may represent an interesting alternative because of the possibility of achieving faster drying times with satisfactory quality and final moisture content distribution.

Drying Requirements & Expectations

Lumber products are facing an increased competition from wood substitutes and engineered wood products. High quality and stable lumber products must be produced if certain markets are to be maintained. Thus, lumber producers will have to concentrate on improving grade recovery throughout the processing phases, especially during the drying operation.
Overseas as well as domestic customers are quickly demanding better quality and developing special engineering criteria known before to only a few types of products (establishing product requirements). For example, shrinkage or swelling tolerances are examined on the basis of the possible moisture content variation for the product during normal service conditions. Thus, certain customers required final moisture contents varying between a relatively narrow interval such as 10 to 14%. An increased number of customers are becoming concerned in relation to the problems associated with moisture content variation between shell and core. Large differences in moisture contents between shell and core may result in reduced dimensional stability and create quality problems if the product is remanufactured.

Lumber producers on the other hand, expect to choose a particular drying process and strategy to address customer requirements and maintain their competitiveness and possibly access new and more profitable markets. The exercise is then to understand customer requirements and design a processing strategy to achieve the expected results. In certain cases, producers may have to explore different drying strategies for different products. For example, drying times for thick lumber products may prove to be uneconomical when using conventional drying methods. European industrial experience has shown that SS/V may dry 3 to 5 times faster producing satisfactory final product quality. Under these circumstances, SS/V drying can represent the best choice for products that cannot be economically dried under conventional methods.
Drying Times

One of the most important issues related to drying times, in addition to inherent wood characteristics, is lumber thickness. Thick lumber is known to dry slower than thin lumber simply because moisture has to move through a longer path before it reaches the surface. The best drying schedules focus not only on drying times but also on characteristics such as grade recovery and shell and core moisture content uniformity.

The main idea behind the SS/V drying technology is to boil the water inside the wood to speed up its movement towards the surface. If the boiling point is achieved throughout the thickness of the lumber then it is expected that the final moisture content will be more uniform because the differences in drying rates between shell and core will be minimized. Thus, at the same time that faster drying times should be developed, it is crucial to develop a criterion to relate average drying time with moisture content uniformity, that is, minimize the difference between shell and core moisture contents. For example, Figure 1 illustrates final moisture content differences between shell and core when drying hem-fir window stock under two SS/V drying schedules, namely: conservative and accelerated. As can be seen in Figure 1, the accelerated drying schedule produced moisture content differences between shell and core about 2.6 times larger than found for the conservative schedule. Even though visual inspection of the lumber dried under the accelerated drying schedule was considered reasonably satisfactory, the moisture content differences between shell and core represent potential quality problems during remanufacturing. Figures 2 and 3 illustrate the drying times and drying conditions for conservative and accelerated drying schedules respectively. The conservative schedule required just over seven days whereas the accelerated schedule dried the product in about three days.

**FIGURE 2.** Drying curve for conservative drying schedule.
FIGURE 3. Drying curve for accelerated drying schedule.

Figures 4 and 5 show drying rates as a function of average moisture content for the conservative and accelerated drying schedules. Average drying rates for the accelerated drying schedule were about 2.5 higher than the drying rates observed for the conservative schedule. Although it is possible to dry hem-fir window stock between 3 and 7 days, results indicated that the drying time of about 7 days resulted in a better product in terms of quality and dimensional stability. Future research towards improving drying times should aim to reduce the heating up period which because of the vacuum may be too long. Using higher pressures during or injecting steam might reduce the heating up time and therefore optimize the overall drying time.
FIGURE 4. Drying rate for conservative schedule.

FIGURE 5. Drying rate for conservative schedule.