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Thermal Analysis & Rheology

THERMAL SOLUTIONS

DETERMINATION OF FIBER SATURATION POINT IN WHOLE WOOD USING DSC

PROBLEM

The fiber saturation point (FSP) of wood is defined as the maximum possible amount of water that the composite polymers of the cell wall can hold at a particular temperature and pressure. Water in excess of the FSP occupies voids, such as cell lumens, within the wood substance, is termed 'free water' and generally displays physical properties reflecting its 'unassociated' nature.

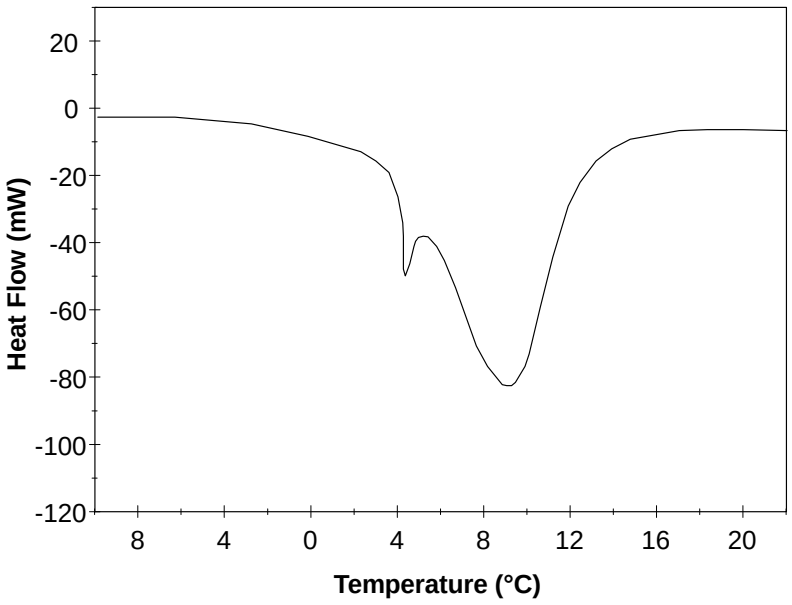
An accurate knowledge of the FSP is important because at this point the physical characteristics of wood, such as strength, elasticity and conductivity, change markedly. In particular, during the kiln drying of timber, little shrinkage occurs until the water content drops below the FSP. A knowledge of the FSP can increase the efficiency of the kiln drying process.

Traditional methods for determining FSP, such as those using measurements of shrinkage, only indirectly measure this point and are prone to large standard deviations.

SOLUTION

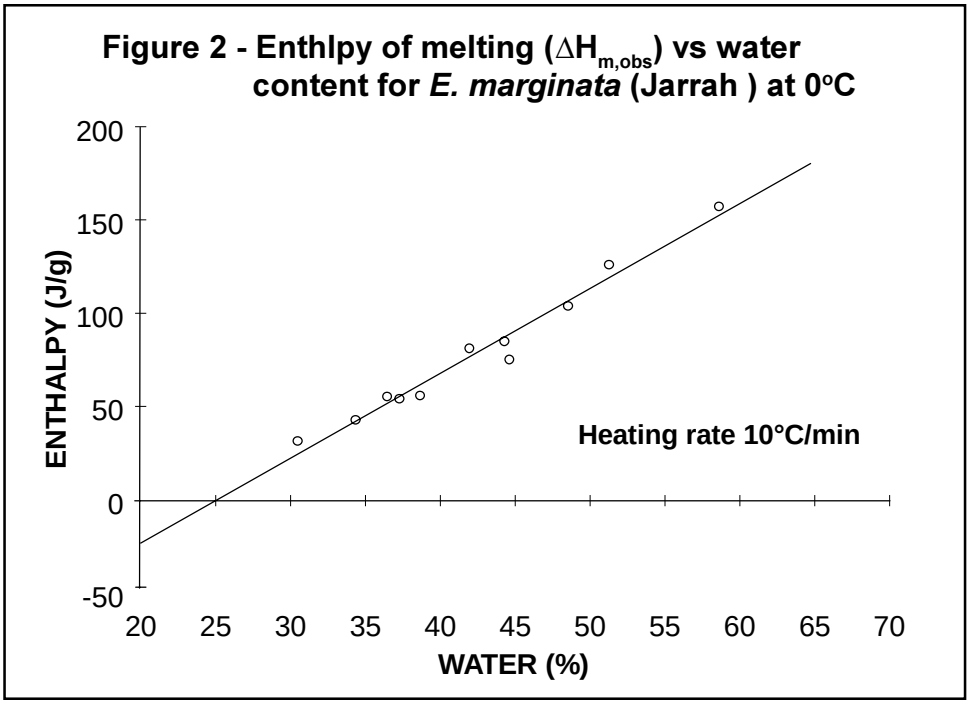
A method based on differential scanning calorimetry (DSC) [1], on the other hand, can directly measure the amount of absorbed water in wood. This method relies on the fact that only the water not associated with cell wall polymers can be frozen and so, a determination of the water content at which there is zero enthalpy of melting provides the FSP. Samples for evaluation are prepared by punching discs of wood (about 3mm diameter) from "green" lumber and exposing them to a range of humidities produced by saturated salt solutions or water saturated cotton wool. Then, immediately prior to the DSC measurement, these discs are sealed in hermetic pans. Weights of the sample and container are obtained before and after the DSC determination and also following puncturing the lid of the pan and drying to constant weight in an oven set to 105°C. DSC scans are conducted from -22°C to around 20°C. Figure 1 shows a typical DSC scan of a 5.91 mg sample of *Eucalyptus marginata* (Jarrah) sapwood performed at a water content of 52.8% and a heating rate of 5°C/min. The peak on the low

Figure 1 - DSC scan of Jarrah sapwood at 5°C/min



temperature side of the melting endotherm is observed only for water contents above the FSP. The temperature and enthalpies of this peak do not change with water content above the FSP which leads to the conclusion that it may be associated with water sandwiched between the non-freezing and 'free' water. A scan rate of 10°C/min and a sample size less than 10 mg is recommended for this technique.

The melting enthalpy observed ($\Delta H_{m,obs}$) is plotted against the water content, and the intercept of the extrapolated line with the ordinate, i.e., when $\Delta H_{m,obs} = 0$ is taken as the FSP. Figure 2 shows the plot for *E. marginata* with the water content represented as a percentage of the sample weight. The FSP at 20°C is then calculated by converting the intercept water content to an oven dry weight basis and decreasing the result by the 2.5% needed to correct the FSP for the temperature increase from 0°C.. This latter correction (-0.1% per °C) is based on studies by Kelsey [2]. In the case of *E. marginata* heartwood, the FSP at 25°C is calculated to be 30.3%.



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2. K.E. Kelsey, *Australian J. Appl. Sci.*, *8*, 42-49 (1957).

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