SMART TECHNIQUES

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We live in a society where the customer is king, and those customers are becoming more demanding in terms of the performance of products and their value. With such a vast range of material options available for any product application, wood as a material, has serious challenges to face. As in any biological material, wood is highly variable yet the most important of all performance criteria is uniformity. To overcome this we need to build uniformity into the material. This can only be achieved through precise knowledge of performance material properties, and will require measurement techniques several generations on from those currently practised.

When an aluminium smelting plant purchases bauxite or coke it pays based on the quality of the ore, when a dairy farmer sells his milk his payment is based on the fat content of that milk; when an oil refinery buys crude it specifies very precisely the quality of that crude in terms of its chemical composition. The reason for this is quite simple, the ultimate product is very precisely defined and the cost of conversion of the raw material into that product is very directly linked to the material properties of the raw material, and the plant configuration.

Can we extend this analogy to the sawmilling industry? Given that we are moving toward a situation where there is going to be greater scrutiny of ultimate product performance, then there must be a very direct link between raw material performance properties and product performance properties. We are seeing signs of this already with greater interest in density measurement as a grading tool. However, this is only the beginning, hence the considerable effort at ***Forest Research*** into developing ever more sophisticated and more powerful tools to determine material performance properties, in particular into wood chemical fingerprinting - a technique we have “codenamed” SMART technology.

The material performance properties we are interested in are: stiffness, strength, workability, appearance and stability. From a processing perspective we can add moisture content and propensity for checking to this list. From an historical perspective we have looked for surrogates or indicators for these properties, such as density, presence of knots and other defects for stiffness, strength and workability. Stability, including dimensional change with changing humidity and propensity for twist, is much more difficult to predict and we have relied upon visual checks again such as distance from the pith, presence or absence of compression wood as very crude estimators.

Wood can be described as a polymer. However, the biological nature of the material in reality presents us with a much more complex chemical structure. It is therefore not unreasonable to expect that the presence of certain components, or the way in which these components are combined, ultimately dictates the performance properties of each element of the wood. For example the presence or absence of certain functional groups will dictate the response to atmospheric moisture and hence dimensional stability. The thickness of the cell wall will indicate the stiffness of the element, or perhaps a certain combination of chemicals will indicate a propensity for internal checking during drying. Other features that provide a chemical profile are the amount of bound or unbound moisture that is present or even the colour of the element.

Analysis of chemical structures by spectroscopic, chromatographic or by magnetic resonance techniques are well established practices in chemistry and are rapidly supplanting classical wet chemistry techniques. Application of the same principles to complex wood structures is a simple and logical extension of these practices. A chemical fingerprint is produced which can be correlated to chemical components or most importantly directly to material properties.

Establishment of these relationships is a very complex process in itself and we are still in the learning process. Linking these fingerprints to performance properties is only made possible by greater accessibility to powerful processing systems and advances in both chemical analytical techniques, technical advances that have been made with such equipment and also advances in computational statistics.

Already this approach is supplanting classic wet chemistry techniques in the fibre analysis area relevant to pulp processing and we are now striving to make the same advance for solid wood.

These "fingerprinting" techniques can be used to determine what chemical profiles give certain material performance characteristics. This is interesting from a material development point of view and may provide valuable clues for the tree breeders as they seek to perfect wood quality. However, of immediate relevance is the application of these techniques in measuring material characteristics of logs to direct them to the optimal processing regime, or on boards and cut lumber to direct that material into the right product stream.

Our vision, therefore, is a simple, robust tool that can be positioned as part of the processing system that provides real time intelligence into the manufacturing process itself leading to optimal processing and segregation of material into groupings of identical performance with the outcome being a satisfied customer.

This vision is daily getting closer to reality. Although a combination of analytical tools such as Nuclear Magnetic Resonance Spectroscopy, Mass Spectroscopy, Infrared Spectroscopy and so on provide the most complete answers, results to date indicate that Infrared Spectroscopy may be accurate enough on its own. This is a non contact tool that produces a spectral "photograph" of the material representing the chemical composition of the wood. This is a technique that has been well proven in industries such as the dairy industry and the kiwifruit industry to measure moisture content and sugar content to very high levels of accuracy, so it is proven in industrial situations.

We are confidant that these SMART techniques are the direction for the future. Very soon we will have completed a rigorous analysis of the currently identified tools and be able to quantify the true value they provide and the next steps forward in taking these technologies into the mill and even looking at applying them in the forest itself. At that time we will be very close to being able to fulfil that vision of an inventory tool to tell us what raw material is in the warehouse and also to have changed wood processing plants from sawmills into wood products manufacturing operations producing products with very exacting client driven performance characteristics.