

The Deformation Behavior of Wet Lignocellulosic Fibers (2006)

A Dissertation by Rob Lowe

Abstract: As some companies in the paper industry struggle to shift from commodity grades to value added products, technical challenges and opportunities have grown tremendously. These new products require more stringent manufacturing specifications and improved performance relative to those of lignocellulosic fibers currently being produced. Hence, topochemical and mechanical modifications of pulp fibers have moved to the forefront of many corporate strategies. Researchers are beginning to develop new tools to help better understand the fundamental mechanisms of fiber modifications and how to most efficiently apply them. Two novel approaches are presented.

First, a new method to observe single fiber crossings is developed. It was found that refining reduces the stepheight in the fiber crossing for both hardwood and softwood kraft pulps by increasing the tendency of the fibers to collapse, deform, and assume a lens like shape. The effect of pulp type, bleaching, drying, wet pressing, and fiber charge were also investigated. Graphs of stepheight versus freespan were linear through the origin suggesting that the freespan (flexibility) of the crossing fiber is largely unimportant to the formation of fiber crossings. Quite surprisingly, the ratio of stepheight to freespan remained relatively constant no matter the treatment. Only bleaching and the addition of surface charge via CMC had any independent impact on freespan. The data do not fit bending or shear mechanisms that have been developed in the literature suggesting that another mechanism may be responsible for the deformation behavior of single fiber crossings.

Also, a method employing fluorescence microscopy and fluorescence resonance energy transfer is used to image the areas of a fiber-fiber interface while they were bonded. Analysis of the FRET signal from fiber crossings indicate that wet pressing increased the FRET occurring between the two dyed fiber surfaces. The results are consistent with the increased amount of interdiffusion expected with higher levels of wet pressing.

These two novel techniques are used to investigate fundamental aspects of fiber deformation behavior and fiber-fiber bond formation. As these methods are further refined and utilized they will provide new avenues for researchers to explore and expand the property space of fibers and paper sheets.