Defence of a Doctoral Thesis in Chemical Engineering

Aspects of optimizing pulp fibre properties for tissue and packaging materials

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Abstract

To improve the competitive advantages of pulp fibre-based materials for tissue and packaging over fossil-based products, it is essential to increase knowledge of the selectivity of the cooking and the chemimechanical processes by optimizing the unit operations of impregnation, cooking and refining. A general goal in pulping processes is to achieve as efficient and even fibre separation as possible. A key to achieving this is to improve impregnation uniformity. In the case of chemical pulping, we need to study how a more even distribution of lignin at the fibre level via easily impregnated wood chips can be achieved using classic measures such as equalized hydroxide ion concentration, increased initial sulphide ion concentration, low sodium ion concentration and a low cooking temperature combined with an oxidative and reductive environment. In the case of chemithermomechanical pulp (CTMP) manufacturing, we need to achieve as even a degree of sulphonation as possible at the level of the individual fibres by means of improved sulphite ion distribution within the wood chips before they are pre-heated prior to entering the refiner.

Firstly, we have studied selective cooking systems for sulphate pulp manufacturing in oxidative (polysulfide) and reductive (sodium borohydride) environments. The yield increased from 48% to a maximum of 53%, which resulted in faster dewatering when mimicking a tissue papermaking process. This could explain how the advantage of the increased yield (fewer fibres and a more open sheet structure) outweighs the negative effects of the higher hemicellulose content on the dewatering properties. Moreover, the increased proportion of hemicellulose in the fibre walls resulted in improved bonding and increased tensile index at a certain refining energy.

Secondly, we have studied the uniformity of impregnation at the fibre level by developing an accurate way of measuring sulphur and sodium content in measuring points that are 5-10 μm in diameter with miniaturized X-ray-based technology. This technology is considered cheap and efficient enough to be introduced in industrial labs and/or in online equipment. Our newly built miniaturized energy dispersive X-ray fluorescence (ED-XRF) demonstrates the capability of imaging sulphur and possibly sodium distribution in wood chip fibres or individual fibres on a micro scale.

In parallel, to the above research we have studied a new catalytic lignin-selective cooking method where a substantial portion of the dissolved lignin can be extracted as vanillin, creating significant value and opportunities for new cost-efficient wood biorefinery systems.

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