Maximized wood chip impregnation efficiency validated by new miniaturized X-ray fluorescence techniques

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Summary

Manufacturing of chemi-thermomechanical pulp (CTMP) is increasing due to increased demand for packaging materials such as cardboard as well as tissue and other hygiene products. Today high yield pulp (HYP) is produced from different wood species. It is well-known that chip-refining is normally responsible for more than 60% of the electric energy consumption in most high yield pulping process. There are opportunities to improve energy efficiency and quality stability in defibration processes by means of optimizing impregnation. Impregnation is a key unit operation in CTMP production as well as in all chemical pulping and biorefinery systems. The efficiency of the impregnation is known to be crucial (Ferritsius et al. 1985; Gorski et al. 2010). Early research showed difficulties to achieve even distribution of sulphite and sodium ions in wood chips resulting in inhomogeneous fibre properties (Bengtsson et al. 1988). Increased and homogenous sulphonation leads to reduced shive content, which is a key factor in all end product applications. To address this issue developing a new type miniaturized X-ray based technique (XRF) to measure local concentration of sulphur and sodium across wood chips and in individual fibres could become a key tool.

The presence of elements as sulphur and sodium can be detected by X-ray fluorescence (XRF) or spectral absorption. At the XRF, images the surface of the sample using specific energies from K-shell or L-shell fluorescence. This method is investigated at the X-ray laboratory in Mid Sweden University research centre STC (Sensitive Things that Communicate) (Norlin et al. 2018). At the spectral absorption, images specific K-shell absorption energies in transmission X-ray images of the sample, a method widely used in medical diagnosis. This transmission method might also be further investigated for this application in the future (Frojdh et al. 2013; Reza et al. 2013). Both methods can be validated by using monoenergetic radiation from synchrotron facilities.

An XRF imaging system uses a collimated X-ray source and a spectroscopic detector. The sample is scanned to make an image of the content of the substances of interest. A specific challenge in this case is that the low energy fluorescence photons from sulphur (S) and sodium (Na) are easily absorbed in air, which makes imaging in a different atmosphere necessary.

The measurement setup has been simulated using MCNP (C. J. Werner, 2017) to validate the system setup and to select the correct, geometry, shielding, filtering and atmosphere for the measurement. The solution was to use titanium (Ti) box flooded with helium to minimise the absorption of fluorescence photons and to shield from scattered photons that might disturb the measurement, fig 1. A filter has been added to the X-ray source to make it nearly monoenergetic and to avoid emission of photons with energies close to the expected fluorescence. The system has been used to estimate sodium and sulphur content in low grammage handsheet (CTMP) or single wood chip samples. It is possible to build a laboratory instrument similar to the prototype setup to obtain the distribution of sodium and sulphur in XRF imaging.

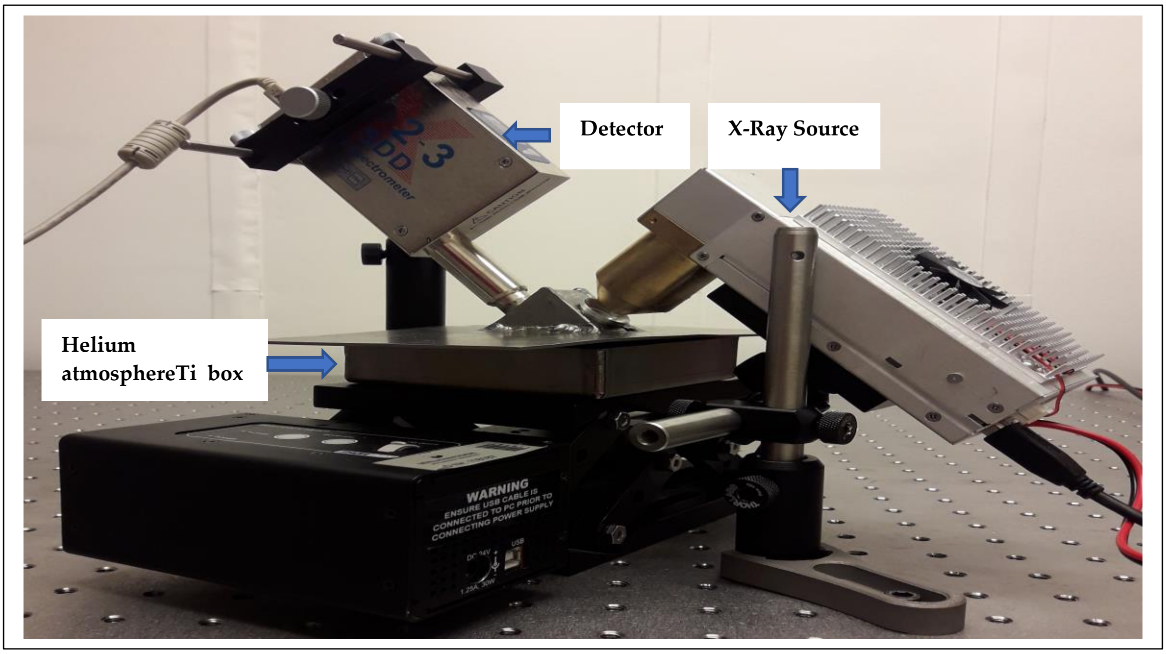

Figure 1: Photograph of XRF measurement setup with a moveable Helium atmosphere Ti box

However, the technique we are developing can become useful in mills to improve and control process efficiency, product properties and to find solutions to process problems in future. In addition, a more even distribution of the sulphonation can reduce specific energy demand in chip refining at certain shive content.

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