Fast Determination of Lignin Content in Feedstock Material for Pulping Process Monitoring and Optimization

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Pulping process is delivering pulp fibers which are further used in the production of paper (Figure 1). The reactor is fed with feedstock material in the form of wood chips. Moreover, cooking chemicals are brought at several points into the reactor. Previous studies have shown that the knowledge of the feedstock material properties which are highly variable is limited. One of the most important parameters is the lignin content, which has to be dissolved, this requires a significant residence time. The residual lignin in the resulting pulp after the process is measured in the form of Kappa number. Inappropriate application of cooking chemicals could lead to large variations in the Kappa number, low fiber quality and other issues. Therefore continuous characterization of the feedstock material is required.

One of the available methods for non-destructive characterization of feedstock material is NIR spectroscopy. Presented study is conducted in order to assess the possibility of determining lignin content using NIR method. The spectroscopy work flow consist of four major steps i.e. sample preparation, spectral data acquisition, data pre-processing and multivariate calibration (Figure 2). We used test samples from 13 different tree species, which were tested in the form of wood chips, pulverized wood and mixture of both. Acquired spectral data were pre-processed mainly by second derivative[1] and standard normal variate transformation[2]. PLS regression with full cross validation was used for the development of a calibration model based on selected wavelengths. Acquisition of reference variable has been done according to standardized procedures[3] and it represents the total amount of lignin in the sample.

The results of lignin characterization in feedstock material by NIR are very promising. The resulting PLS regression model includes 2-factors and uses 16 predicting variables, resulting in R^2 = 0,975, RMSE = 0,885 wt% (Figure 2). In the next step, presented work will be improved by applying large amount of samples, independent validation data set and by simulation of conveyor belt movements.

The objective of this research is to test the NIR method at a real pulp digester, in order to improve monitoring and optimization of the process. Furthermore, continuous characterization of the feedstock materials is intended to be used for the improvement of the control process. The measured lignin content will be compared to the content calculated within the pulp digester physical model[4] and the Kappa number (Figure 1). This will be used for improving the digester physical model accuracy and as an input to advanced model based control, where the correlation will be made not only to lignin content but also with the feedstock material reactivity.

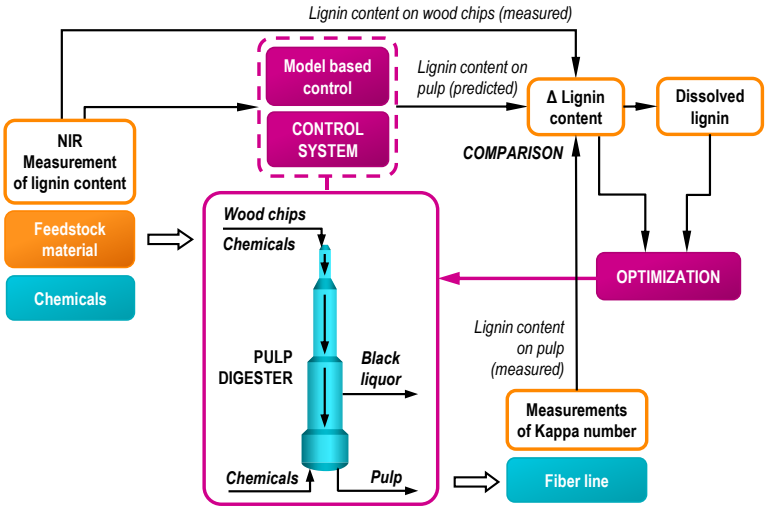

Figure 1. Scheme of pulping process with suggested integration of online NIR measurements

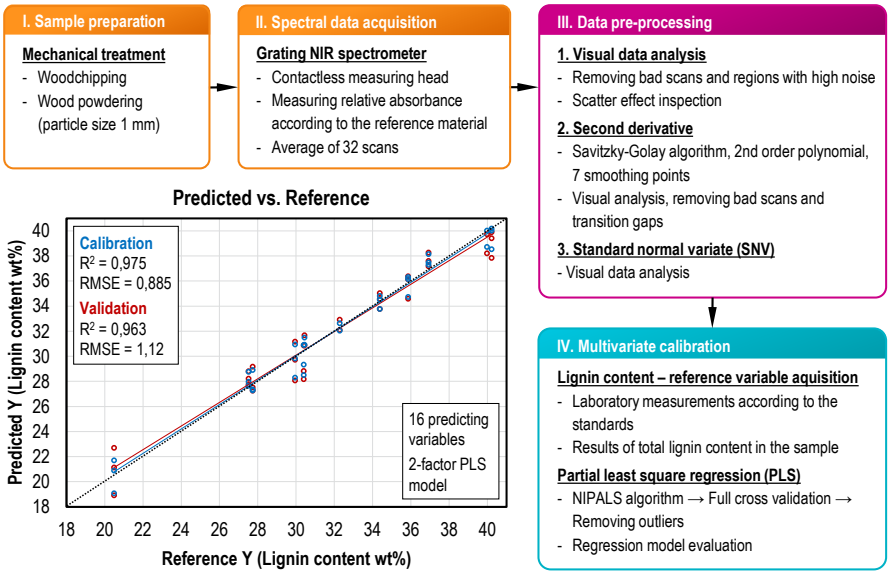

Figure 2. Spectroscopy work flow, Predicted vs. Reference plot for resulting PLS model

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