Estimation of heat treated wood properties by FT-NIR spectroscopy and multivariate analysis

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Introduction

Wood is thermally modified to improve dimensional stability and biological durability by high temperatures, 160–230°C. The most evident change of the wood properties is the darkening of the colour throughout the wood. Other changes are reduced equilibrium moisture content, reduced weight, reduced bending strength in high temperatures and increased compression strength. The object of the present work was to establish whether it is possible to apply near infrared spectroscopy (FT-NIR) to determine the effect of heat treatment on the above mentioned wood properties.

Materials and methods

Pine boards were heated in a special kiln at four different temperatures, 160°C, 180°C, 200°C and 220°C, Figure 1. The effect of the treatment time was tested by treating the wood at the same temperature 200°C for different periods of time (3h, 5h and 7h).

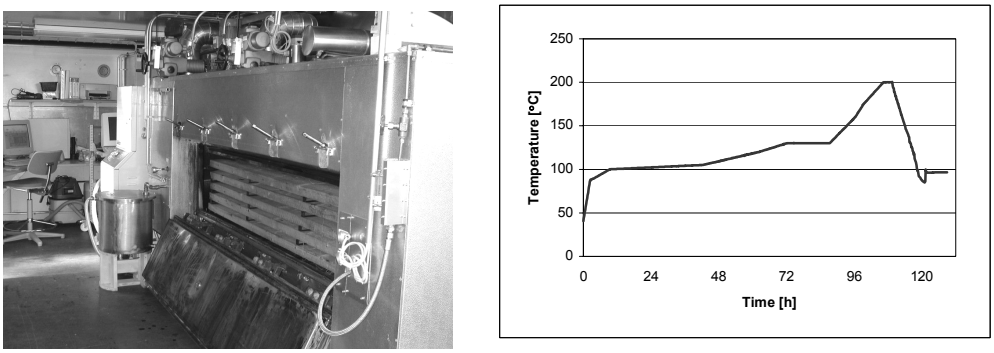

Figure 1. Wood boards were heat treated in a special kiln, left. The profile of the temperature during the heat treatment process, right.

After the heat treatment and conditioning at constant temperature and humidity the NIR reflectance spectra were recorded with a PerkinElmer FT-IR System 2000 spectrophotometer using a fibre-optic probe. The wave number range was 10000–4000 cm^{-1} and resolution 8 cm^{-1}.
Data analysis was performed using the Unscrambler program, Version 7.6 (Camo, Norway). A total of 168 samples were analysed of which 132 were used to create PLS with full cross validation and 36 samples was left out in a separate test set. The spectrum and full cross validation were used to make the models for moisture content, density, colour parameters L*, a* and b*, and strength. The strength properties were measured according to the standards EN 408 and DIN 52185.

Near Infrared Spectroscopy: Proceedings of the 11th International Conference.

Results

The temperature of the treatment was the most significant factor affecting the properties of wood. There were no significant differences between wood heat treated of the same temperature (200°C) for different periods of time (3h, 5h and 7h). In partial least squares (PLS) regression models the best correlation coefficients in models and predictions of the test set were obtained for moisture content, colour L* and colour b*. The R^2(pred.) were 0.94, 0.87 and 0.85, respectively. Fairly good results were achieved for density, bending strength, and compression strength R^2(pred.) 0.74, 0.70 and 0.67. There was no correlation between spectra and colour a*, as the R^2(pred.) was only 0.26, Table 1 and Figures 2 and 3.

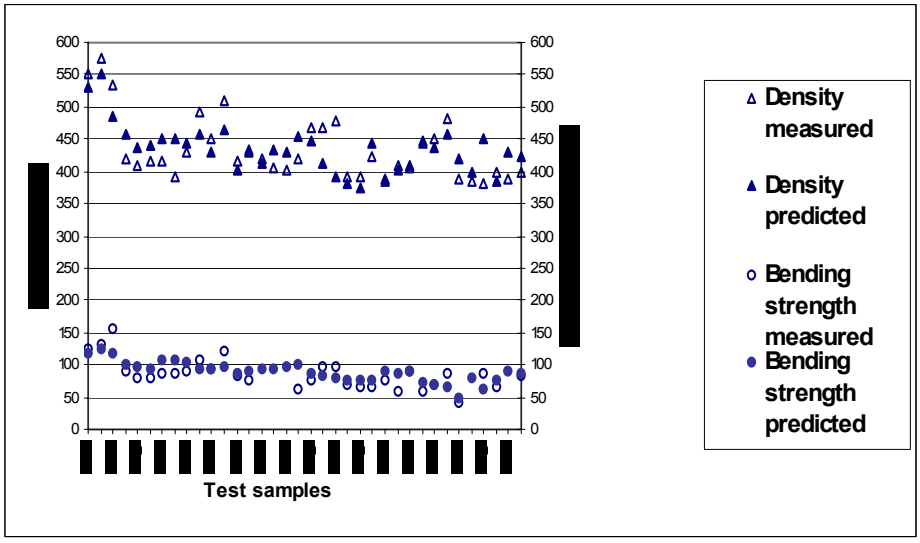

Figure 2. Measured and predicted density and bending strength.

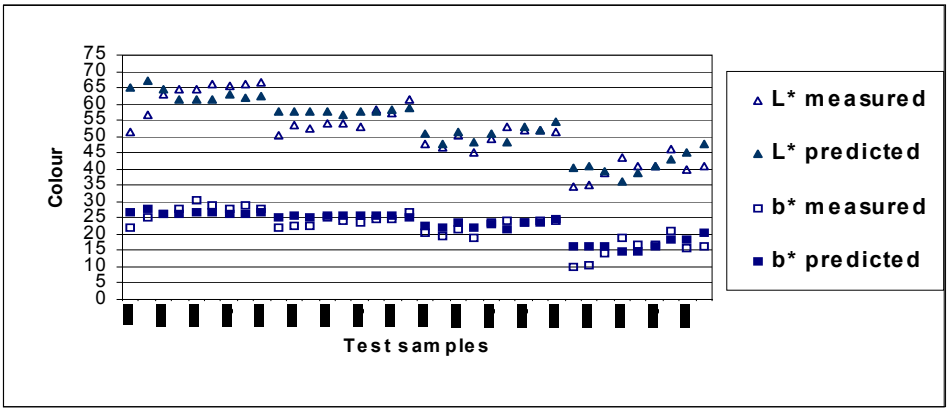

Figure 3. Measured and predicted colour L* and colour b*.

Table 1. Results of the predictions.

Parameters	Range [all]	R^2	*SEP*	PC
Moisture [%]	4–9	0.94	0.39	2
Colour L*	34–68	0.87	4.6	2
Colour b*	10–30	0.85	2.7	3
Colour a*	3.7–9.0	0.26	0.7	4
Bending strength [MPa]	40–160	0.7	16.7	3
Compression strength [MPa]	28–58	0.67	4.1	6
Density [kg/m^3]	385–580	0.74	33.0	7

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