WOHTOC (Intermediate report)


Wood Heat Treatment, Optimisation and Control

Principle investigator: Pr. Mathieu PETRISSANS

Partners: Laboratoire d'Etudes des Ressources Forêt Bois (LERFoB),

Collaboration: National Cheng Kung University, Tainan, TAIWAN; Université de Brasilia, BRESIL

Context — Heat treatment of wood aims at producing biosourced, biodegradable materials, recyclable at the end of life for energy production. Wood transformation under the heat effect in inert atmosphere (steam, nitrogen, vacuum, smokes), confers to the material durability and dimensional stability. In spite of its strong development since 1980, the new product encounters difficulty gaining market shares. The main reasons to explain this lack of customers' craze are the disparity in the material quality, waste/rebus quantities and customer returns. The bad process control is mainly due to the incapacity to determine or to predict the treatment duration of given wood load (variability inter and intra wood species, moisture or minerals content). The lack of management of the industrial production is linked to the great difficulty to model the curves of wood thermo-degradation. This deficit is noticed at laboratory scale on small samples (quantities of feu milligrams) and consequently on the industrial scale for several kilograms.

Objectives — In an already existing economic circuit (products and market) the research project is positioned in a dynamics of optimization of the heat treatment process with the goal to reach an optimum between production quality and exploitation costs. The aim of the project is then the conception a tool to control and pilot industrial ovens by the development of a numerical tool able to:

1. Predict the treatment duration based on a good knowledge of thermodegradation kinetics, mass and energy transfers at laboratory and industrial scale;
2. Build up exploitation expectations by optimizing costs and environmental impact;
3. Control and pilot automatically industrial ovens taking into account physical and chemical characteristics of the entering wood load.

Approach — The work consists of 5 steps:

1. Improvement of knowledge of the chemical thermodegradation mechanisms under different type of inert atmosphere;
2. Enhancement of the analysis of the modification of wood properties during the heat treatment (physical properties, chemical composition, energy density);
3. Modeling of the thermodegradation kinetics, prediction of curing times to reach a required quality;
4. Modeling of the probability of success on the individual board scale;
5. Validation of the prediction tool in industrial conditions.

Key results —

- Study beginning, May 2016.Implementation of experimental investigation tools and their surroundings on the site LERMAB-IUT Epinal (drying oven, sampling saw, semi-industrial heat treatment oven with dynamic mass monitoring and recording).
- Installation of the semi-industrial heat treatment oven. Calibration and validation of the acquisition chain of curves of wood mass variation during the treatment. Mass measurement precision 1 gram for a total oven weight of 80 kg, follow-up of mass evolution of 2 kg wood sample.
- Development of wood thermodegradation model using the software COMSOL. First model validation using a set of previously obtained experimental data (PhD study Mounir CHAOUCH 2011).
- Campaign of heat treatment experiments for 2 wood species (Pine and Poplar) under 4 temperature levels and longtime acquisition durations (50 hours by experiment).
- Campaign of analyses of treated and untreated wood: elemental and proximate analysis, thermogravimetric analysis (TGA), Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD). These analyses are supported by Green Energy and Fuel Laboratory, GENFUEL, Tainan, August 2017.
- Mass loss kinetic modeling, parameter identification using experimental data. Model validation.
- Numerical analysis of wood thermodegradation mechanism.
- Modeling of elemental composition and Higher Heating Value (HHV) of heat treated wood.

Main conclusions including key points of discussion — After 18 months period, the project is able to model sets of wood thermodegradation data at semi-industrial scale. The numerical tool allows then to predict treatment duration. On the other hand, this numerical tool provides new positions of understanding chemical mechanisms of biomass degradation. Experimental study performed this summer in Taiwan open new ways of comprehension of thermodegradation behavior of different wood species by a diverted TGA use. The TGA was found to be a tool of analysis of wood thermodegradation level after heat treatment.

Future perspectives — The study will be continued according to the following scheme (18 months):

- Campaign of experiments to measure the influence of the heating rate coupled to the process energy consumption. This campaign is devoted to improving the model but also to optimize and valid the process environmental impact.
- Campaign of experiments to measure the influence of the oven's atmosphere composition. Oven's atmosphere is supposed to be inert. However, some elements in the literature suggest that the use of vacuum, steam or various quantities of oxygen traces can affect the process. This campaign is devoted to the model improvement.
- Finally, after integration of heating rate and nature of oven's atmosphere, we hope valid treatment duration predictions at industrial scale: company Silvalbp.

Valorisation —

Conference

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