ParisTech

Arts et Métiers Sciences et Technologies

RESEARCH TOPIC FOR THE PARISTECH/CSC PHD PROGRAM

Field: Materials Science, Mechanics, Fluids
Subfield: Mech. Engineering, Applied mathematics, Environmental sciences
Title: Simulation of biomass pyrolysis and combustion in fixed-bed reactors
ParisTech School: Arts et Métiers Sciences et Technologies
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Research group/Lab: Institute of Mechanical Engineering (I2M).
Lab location: Bordeaux
(Lab/Advisor website): *https://www.i2m.u-bordeaux.fr/*

Short description of possible research topics for a PhD:
Biomass conversion techniques can be split into three main routes: biochemical, physicochemical, and thermochemical. In this work the focus will be put on thermochemical conversion, which regroups pyrolysis (production of char and bio-oil), combustion (production of heat), and gasification (production of a combustible gas). Pyrolysis allows converting second generation biomass - that is, non-food biomass in general and wood in particular. During the pyrolysis process wood releases bio-fuel and loses about 50% of its mass and volume. The solid residue is a pure carbon char. In thermochemical industrial processes, wood particles of millimeter to centimeter scales are transformed in fixed-bed reactors. The overall geometrical shrinkage and the intrinsic microstructural evolution strongly impact heat and mass transfer at the particle scale. Heating rate and pyrolysis gas transport within the pores of wood are key phenomena in the conversion process, not only affecting the rate of production but also the nature of the molecules that are produced. Understanding and modeling shrinkage in combination with heat and mass exchanges at the process scale, that is, at the fixed-bed scale, is critical to guide innovation in progress in the field of biofuel production. The objective of the PhD is to pursue the development of appropriate pyro-mechanical models at the particle scale and of volume-averaged fixed-bed models that account for particle shrinkage at the macroscopic scale. This work will be implemented in the Porous material Analysis Toolbox based on OpenFoam, released Open Source by NASA and I2M (www.pato.ac).
Required background of the student:
- Computational fluid mechanics (CFD)
Five representative publications of the group

1. J. Lachaud, N. N. Mansour. Porous material analysis toolbox based on OpenFoam and applications. Journal of Thermophysics and Heat Transfer, 28 (2): 191-202, 2014.
2. J. Lachaud, N. N. Mansour. Porous mate J. Lachaud, J. B. Scoggins, T. E. Magin, M. G. Meyer, N. N. Mansour. A generic local thermal equilibrium model for porous reactive materials submitted to high temperatures. International Journal of Heat and Mass Transfer. 108: 1406-1417, 2017.
3. Ucar, E., Mobedi, M. & Ahmadi, A., Interfacial convective heat transfer for randomly generated porous media, Heat Transfer Research 49 (1) :1–14 (2018).
4. F. Torres-Herrador, V. Leroy, B. Helber, L. Contat-Rodrigo, J. Lachaud, T. Magin. Multicomponent pyrolysis model for thermogravimetric analysis of phenolic ablator and lignocellulosic biomass. AIAA Journal. AIAA Journal, 58: 4081-4089, 2020.
5. J. Lachaud, M. Meyer, C. Metayer, M. Virey, W. Jomaa, J. Meurisse, F. Panerai. Modeling wood shrinkage during pyrolysis: a major challenge for second generation biofuels. InterPore 2020, in mini-symposium MS4: Swelling and shrinking porous media, Aug. 31 - Sept. 4, 2020.