CFD Simulation of Low Temperature Carbonisation in a Heated Rotary Kiln

D. Sofialidis[1], O. Faltsi[1], G. Skevis[1]
*G. Skodras[2,3,4], S. P. Kaldis[2,3] & G. P. Sakellaropoulos[2,3]

[1]SimTec Software and Services Ltd., Thessaloniki Greece
[2]Lab of Chemical Process Engineering, Dept. of Chemical Engineering, Aristotle University of Thessaloniki, Thessaloniki, Greece
[3]Lab. of Energy and Environmental Processes Chemical Process Engineering Research Institute, Thessaloniki, Greece
[4]Institute for Solid Fuels Technology and Applications, Ptolemais, Greece

**P.O. Box 1520, Thessaloniki 54006, Greece*
Tel: +30 2310 996225, Fax: +30 2310 996168
E–mail: skodras@vergina.eng.auth.gr

Abstract

The present research constitutes a simulation study of the physico–chemical processes occurring inside a heated rotary kiln reactor, where solid fuel (coal, lignite or biomass) is treated for the production of clean solid fuel. The kiln operates at vacuum conditions, so that hazardous air pollutants like sulfur, nitrogen, mercury and chlorine are released to the gaseous phase, by the action of the reductive thermal treatment and collected for further treatment. The produced solid fuel, i.e. "clean coal", contains practically no chlorine or mercury, too low sulphur and low nitrogen, as well.

Computations are performed by means of the FLUENT6 commercial Computational Fluid Dynamics (CFD) code. The model accounts for the rotation of the external kiln walls and the internal mixing blades separating annular disks, multiphase modeling of the solid (solid fuel) and gaseous (mixture of gases) phases, heat transfer between phases and the kiln walls, turbulence and chemical reactions (heterogeneous and/or homogeneous between phases).

The objective of the study is to arrive at a reliable model for such a complex process in order to provide a design tool for kilns, depending on the fuel feed properties/requirements (e.g. size distribution, volatile and carbon content, moisture content, desired residence time).

The model development included two steps (a) cold flow simulation and (b) full hot model. The cold flow simulations provided the confirmation of an industrial–scale kiln design able to offer a residence time between 5 and 18 [min], for coal particles of 0.0006 m diameter. While the full hot model includes the chemistry kinetics for the production of the clean gases and heat transfer mechanisms.

Keywords: rotary kiln, computational fluid dynamics, low temperature carbonisation

* to whom correspondence should be addressed