Division of Energy Technology
Department of Space, Earth and Environment
Chalmers University of Technology

Magnetic separation of oxygen carriers from bed ash in heat and power plants – Experimental investigation and modelling

We are looking for one or two students who would like to help us developing new combustion methods with low emissions. More specifically, you will investigate magnetic behavior of oxygen-carrying materials that have been used in Circulating Fluidized-Bed (CFB) boilers or in Chemical-Looping Combustion (CLC) test units. The work involves measurements of magnetism, phase and elemental composition, as well as phase simulation. If interested, the student can sample bed material directly at a commercial heat and power plant (≥ 70 MW). The measurements are to be evaluated with the student's own code (e.g. Matlab or Excel). To conclude this project, the results are to be presented (presentation and written report). The work is conducted at the Division of Energy Technology, which is part of the Department of Space, Earth and Environment.

Background – Chemical-Looping Combustion (CLC) is an innovative combustion process, in which the CO_2 from the combustion is obtained as a separate stream. CLC can be used to produce steam for generation of electricity or heat. If the separated CO_2 is compressed and stored underground, CLC can be part of a so-called "carbon capture and storage" (CCS) scheme. The use of fossil fuels in CLC with CO_2 storage would create a carbon neutral process, whereas the use of biomass fuels would result in a reduction of atmospheric CO_2 ("negative CO_2 emissions").

In Chemical-Looping Combustion, fuel and combustion air, which contains about 80 % of N_2 and only 20 % of O_2, are never mixed. Hence, an expensive and energy-intensive gas separation step can be avoided. The oxygen from the combustion air is transported to the fuel by a so-called oxygen carrier. The oxygen carrier is typically in the form of a powder, which consists of metal-oxide particles in the size range of 100-300 µm. These particles undergo cyclic reactions with the combustion air and the fuel: in the air reactor the oxygen carrier is oxidized, and in the fuel reactor the oxygen carrier is reduced (the fuel, in turn, is oxidized). This principle is visualized in Figure 1.

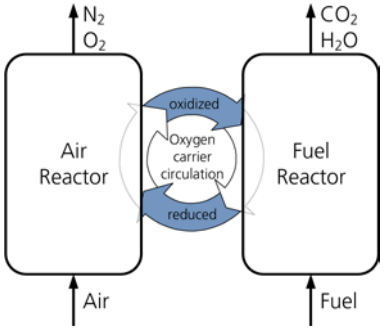

Figure 1: Chemical-Looping Combustion process schematic

Chemical-Looping Combustion is a novel technology and does not exist at a large scale, yet. The testing of oxygen-carrying materials, however, is a critical aspect, in terms of both fuel conversion and economic feasibility. Therefore, oxygen-carrying materials are tested in existing, commercial, Circulating Fluidized-Bed (CFB) combustors, see Figure 2, where they replace quartz sand, which is normally used as bed material. This process is called Oxygen Carrier Aided Combustion (OCAC), and the ability to separate the oxygen-carrying material from the fuel ash and to reuse it in the process has a significant impact on the economy of the process.

Aim and method – We are looking for one or two students to conduct a master's thesis project, who experimentally and theoretically assess and compare the magnetic properties of different oxygen-carrying materials. The objective of the project is to facilitate determination of the magnetic fraction, as well as creating a method to predict magnetic properties of a material used in a CFB boiler.

The project includes both theoretic and practical work and a project layout could be as follows. (1) Survey different samples and sources for samples, (2) conduct measurements (for example: magnetic separation using a band feeder with a permanent magnet, measuring magnetic susceptibility, elemental analysis using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX), and phase analysis using X-ray diffraction (XRD) analysis), (3) perform phase equilibrium calculations (e.g., using the software FactSage) and (4) compare data from measurements, calculations and literature, as well as creating a model.

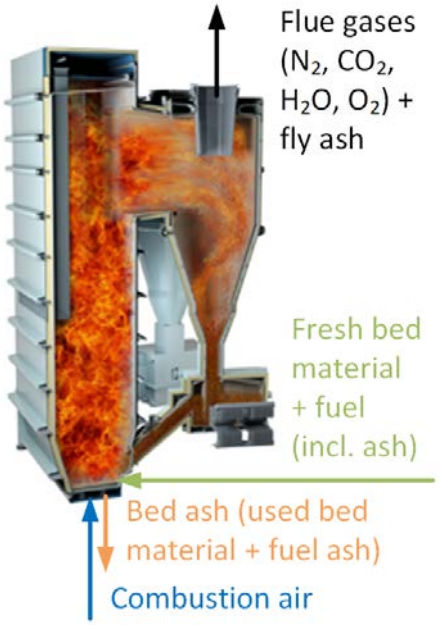

Figure 2: Combustion in a Circulating Fluidized-Bed (CFB) boiler with the principal in- and outgoing mass flows shown.

Keywords: Chemical-Looping Combustion (CLC), oxygen carrier aided combustion (OCAC), circulating fluidized-bed (CFB), material technology, CO_2 separation, sustainable energy technology

Working areas: process engineering, chemical engineering, material technology, mechanical engineering, energy technology

Type and length: research project, Master's thesis, 1-2 students, 4-6 month, starting date flexible

Requirements

- Studies within natural- or engineering sciences
- Ability to work independently and hands-on
- Fluent in spoken and written English
- Laboratory or workshop experience are an advantage

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