Experimental investigation of novel fluidized bed combustion processes for gaseous fuels

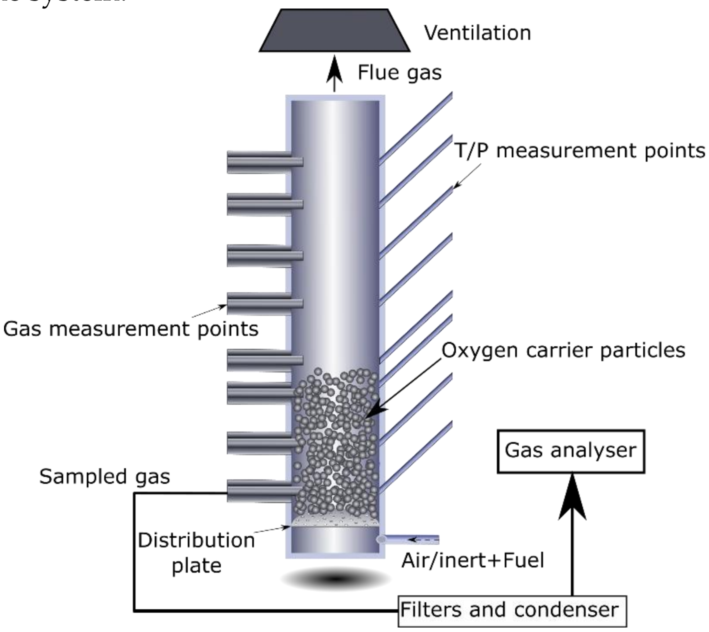
We are looking for 1-2 students to conduct a MSc project within the field of energy technology. The project would probably be most suitable a students with background in chemical engineering or mechanical engineering, but students with other backgrounds will also be considered.

Fluidized beds are an important technology that currently is used in many processes that relies on interaction between solids and fluids (e.g. combustion, gasification, heterogeneous catalysis, chemical looping combustion, adsorption, drying, heating, cooling). The largest industrial application in Sweden is fluidized bed combustion of biomass and waste fuels. One of the suggested applications for using gaseous fuels in fluidized bed combustion is to use the fluidized bed as a heat source for endothermic chemical processes such as steam reforming or steam cracking. For these processes several different fluidized bed configurations are possible, all with its own advantages and drawbacks. Common for these cases is that gaseous fuels such as CO, H_2, CH_4 and other light hydrocarbons are converted.

In fluidized bed combustion the conventional choice for bed material in this process is silica sand, which however has several known drawbacks. Various alternative bed materials containing certain transition metals such as Fe, Mn and Cu have been suggested where several of these have been tested in full-scale commercial boilers. Such materials are referred to as oxygen carriers, since they can interact with fuel and oxygen. In zones rich with fuel the metal oxides will be reduced, while it will be oxidized in zones rich with air. The net effect would be improved mixing of fuel and oxygen both in the space and the time dimension. The concept is invented at Chalmers and sometimes referred to as Oxygen Carrier Aided Combustion (OCAC). Another use of oxygen carriers is found in chemical-looping combustion (CLC) where the oxygen carrier is circulated between interconnected fluidized bed reactors in a system which enables inherent capture of CO_2. In CLC the oxygen carrier transports the oxygen to a reactor where fuel conversion takes place resulting in a nitrogen free flue gas stream and simple CO_2 capture from condensation of steam. Both these concepts can be used to design a system to generate heat for the mentioned chemical processes mentioned above but to better understand the difference between these configurations more experiments are required with suitable oxygen carrier materials. The conclusions should not only be interesting for the suggested application of using the fluidized bed as a heat source but also to increase the general knowledge about fuel conversion in OCAC and CLC.

The aim of this project is to evaluate the apparent kinetics (including both kinetics and mass transfer) behind combustion of gaseous fuels in systems for OCAC and CLC. The target is to perform experiments in a newly built lab-scale bubbling fluidized bed reactor system mainly for gaseous fuels to better understand the reaction mechanisms for fuel conversion for the two systems for commonly used bed materials.

Many experiments have been carried out on CLC and OCAC but the newly built reactor systems open up new opportunities to study both concepts in one unit where batch experiments can be carried out for CLC and both continuous and batch experiments can be carried out with OCAC. The experimental setup (see attached Figure of the system below) is equipped with measurement equipment to monitor gas concentrations, temperature and pressures in the system.



The results from the project will be valuable for possible future industrial implementation of the suggested processes and could also be suitable for publication in a scientific journal. The project will be performed at the Division of Energy Technology at Chalmers. It is part of an ongoing Swedish Energy Agency project about possible use of fluidized beds as heat source for processes.

About the possibility to do a 60 HEC MSc thesis: A typical master thesis at Chalmers encompasses 30 HEC. It is possible to make an extended thesis of 60 HEC, reducing the course requirements with 30 HEC. Our group is restrictive with this opportunity, but will consider it for highly motivated students with above average marks. The expectation on a 60 HEC MSc is a significant increase in the scope of the work, an honest interest in academic research and the ambition to reach a level that would allow for publication of the work in a scientific journal.

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