# Master of Science thesis at the Department of Space, Earth and Environmental Science, Department of Energy Technology

*Negative $CO_2$ Emissions with chemical-looping combustion using calcium manganate*

Chalmers is a world leader in the development of chemical-looping combustion (CLC), where the greenhouse gas carbon dioxide ($CO_2$) can be captured without expensive gas separation. If used with biomass negative $CO_2$ emissions can be obtained, thus removing $CO_2$ from the atmosphere. The technology uses metal oxide particles that transfer oxygen from air to fuel. These constitute the bed material in two interconnected fluidized beds: the fuel and the air reactor. In this way, a combustion can be carried out without mixing the fuel with the combustion air, with the result that the combustion products, carbon dioxide and water vapor, are obtained as a separate flow from the fuel reactor. Ideally, pure carbon dioxide can be obtained by condensing the water vapor. We believe that the process can halve the cost of capturing carbon dioxide and we are developing the process for use with biomass to achieve negative emissions.

Our research shows that cheap ores can be used in the CLC process. Manufactured materials with higher reactivity are believed judged to be too expensive to use with solid fuels.

An important exception may be calcium manganate, $CaMnO_3$, which should be possible to manufacture from cheap manganese ore and limestone. But then we need to find a manufacturing process that is cheap and works on a large scale. The production includes crushing / grinding and possibly granulation, heating to around 1340°C, crushing and sieving. One idea is to look at industrial processes where materials are sintered at high temperatures, e.g. lime burning, sintering of iron ore or ceramic materials, such as porcelain and electrical insulators.

The project aims to investigate possible ways to produce $CaMnO_3$, that could be of relevance for large scale production. Further, the study would include impact of ore used and manufacturing parameters, e.g. grinding of raw materials and sintering temperature. Evaluation may include crushing strength, attrition, X-Ray Diffractometry (XRD), density and reactivity tests in lab reactors. One goal could be to create a basis for, or even prepare, a scientific publication in a high-quality scientific journal.

Another goal is to produce material that can be further investigated in pilot plants. (There is funding for such a project.) Furthermore, the results may form the basis for a larger project where we, in collaboration with industry, produce 20 tonnes for use in Chalmers 10 MW boiler.

*We are looking for 1 or 2 students. The project can be applicable for students in many programs, including, but not limited to, energy systems, chemical engineering and material chemistry.*

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