BEST
Bioenergy and
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# BIO-LOOP Chemical Looping for efficient biomass utilization


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COMET Modul: Cooperation project of the Sub-Areas 1.1, 1.2 and 2.1

## Introduction

With respect to the climate objectives Chemical Looping (CL) processes constitute a promising alternative to traditional thermochemical conversion routes. Through the application of solid materials, so-called oxygen carriers (OC), instead of air as oxygen supply, $CO_2$ can be easily separated from the flue gas. By this, biomass can be used for hydrogen production (Chemical Looping Hydrogen, CLH) or it can be burnt without $CO_2$ emissions (Chemical Looping Combustion, CLC).

BIO-LOOP aims the development of a fixed-bed reactor for hydrogen production (sub-project 3) as well as a fluidised-bed reactor for heat and power production (sub-project 4). Fundamental research is performed in sub-project 1 on the kinetics and behaviour of the OC material. In sub-project 2 a CFD-based multi-physics toolbox is under development in order to support the overall technology development. The results of the sub-projects obtained so far are presented.

## Project 1: Fundamental experimental and theoretical investigations

The oxygen carrier represents the key element of the chemical looping technology. Numerous experiments have been carried out to identify the most important OC properties and the requirements they need to fulfil.

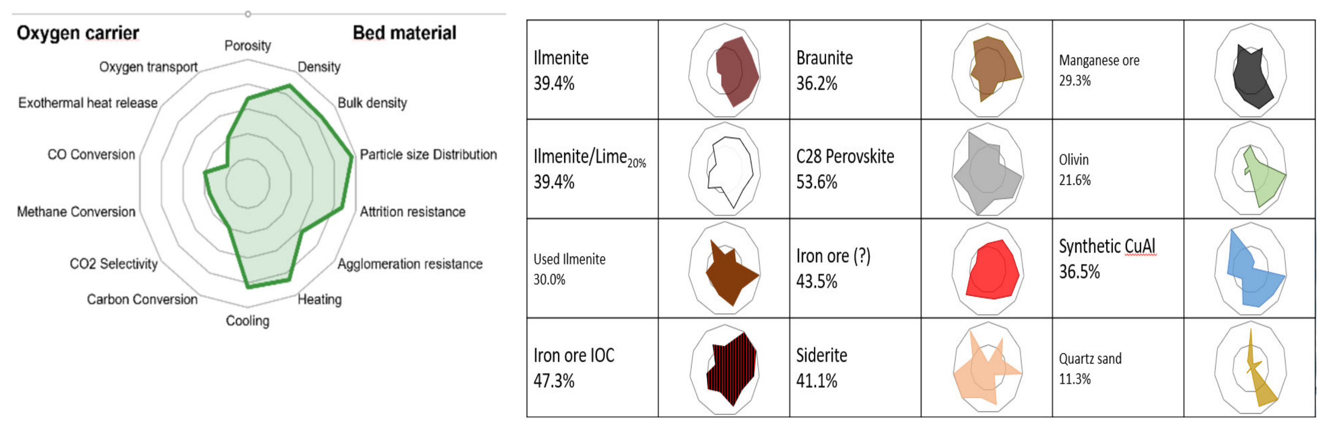


Fig 1: Oxygen carrier properties

In addition to environmental sustainability and costs, the materials investigated were experimentally evaluated based on specific OC properties and general bed material properties. The materials can be compared using so-called spider charts (Fig. 1), where the area within the line directly reflects the material's suitability.

## Project 2: Development of multi-physics CFD-based simulation toolbox

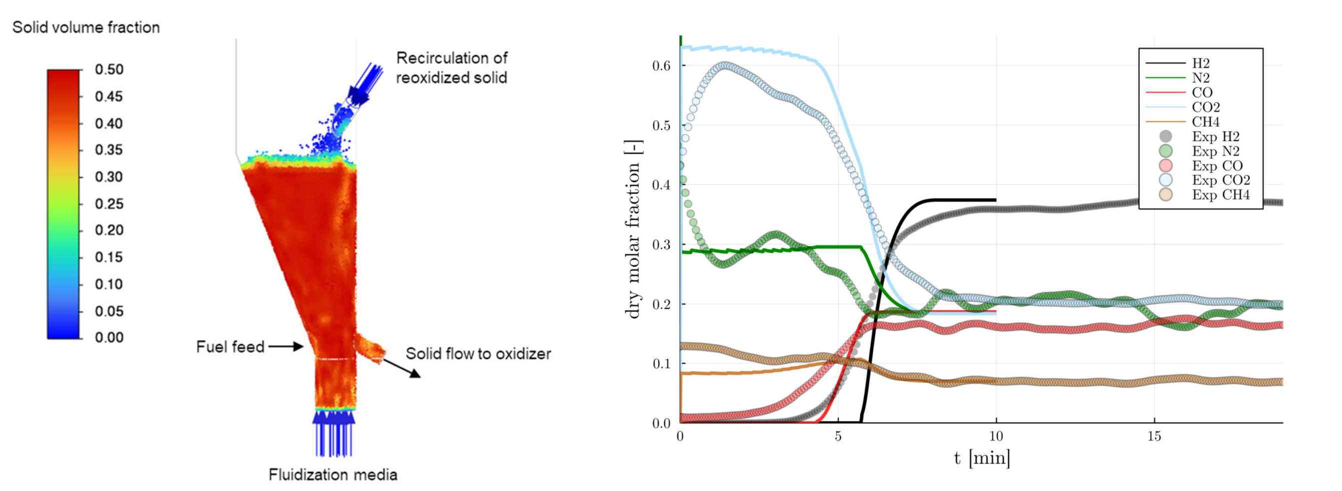


Fig. 2: CFD results of a fluidized bed system (l.) and 1D simulation results fixed bed systems (r.)

Multiple process scales have to be considered in order to describe the conversion of OC´s. On the smallest scale, chemical reactions between gases and solids take place. However, in systems with larger particles (e.g. pellets) gaseous reactants and heat have to be transported into the particle which leads to an retardation of the conversion process. Finally, a reactor model and a particle model have to be coupled to describe the transport processes in the reactor. The first simulation results show promise of a successful description of the overall processes (Fig. 2).

## Project partners:

- Chalmers University of Technology
- TU Graz (ITE, CEET)
- TU Wien
- NIC Ljubljana
- CSIC Spain
- Rouge H2 Engineering GmbH
- SW-Energie Technik GmbH
- TG Mess-, Steuer- und Regeltechnik GmbH
- Rohkraft- Ing. Karl Pfiehl GmbH
- Aichernig Engineering GmbH
- AVL List GmbH
- Christof Industries Austria GmbH

## Project 3: System integration - biomass fixed bed chemical looping technologies

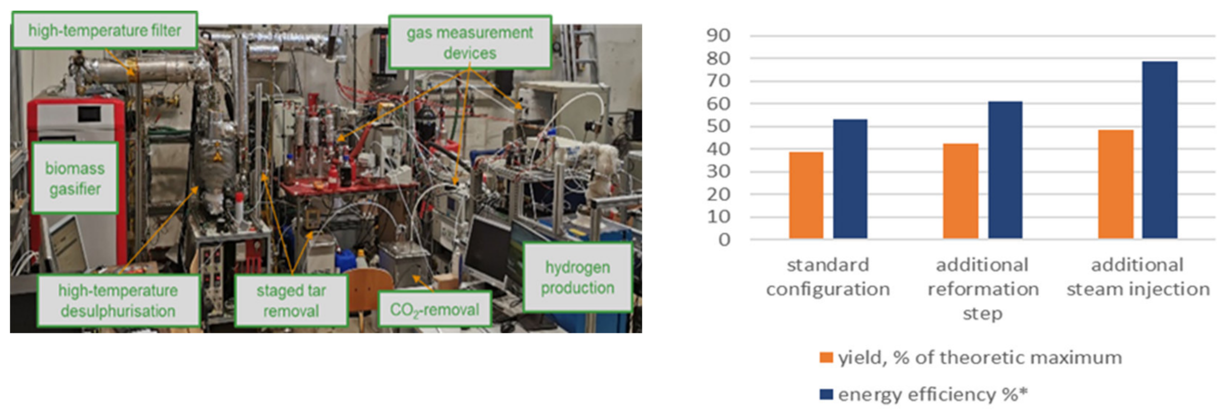


Fig 3: Investigations of the CLH system

The coupling of a fixed-bed gasification system and a CL hydrogen production system was implemented on a pilot scale setup. First, impurities were removed from the generated raw gas and the $CO_2$ content was reduced (standard configuration). To increase the reduction potential of the gas, the setup was supplemented with an additional reformer. Finally, the influence of an additional steam injection was also investigated. Here, a final hydrogen purity of 99.9922 vol% was achieved Similarly, the produced hydrogen yield and process efficiency could be significantly improved (Fig. 3).

## Project 4: System integration - biomass fixed bed chemical looping technologies

Various test campaigns were successfully carried out in the DFB pilot plant with two fluidized beds - one with natural ilmenite and limestone and one with a synthetic oxygen carrier. For both campaigns, stable autothermal operation was achieved and solid samples were taken for further analytical evaluations. Furthermore, the influence of various process parameters such as the process temperature, the carrier circulation rate and the position of the constrictions in the counter current column of the fuel reactor on the CLC process was determined.

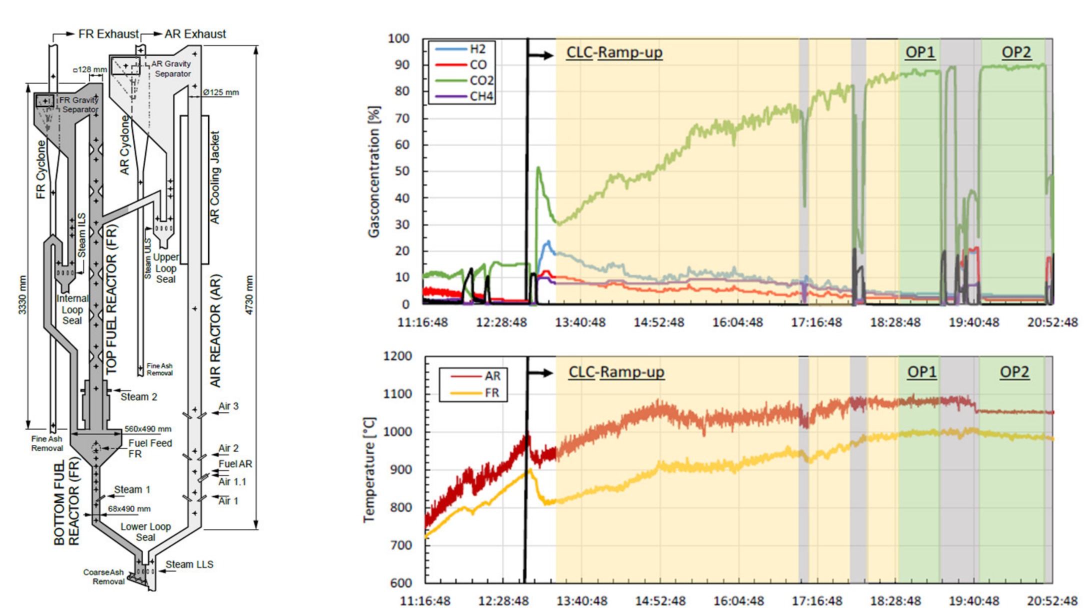


Fig. 4: CLC benchmark experiment in the DFB pilot plant with Ilmenite (Limestone as additive)

In addition, a methodology was developed to determine the formation of ash layers on the particulate oxygen carrier material in an oxidizing atmosphere. With the developed methodology, the growth of the layers on ilmenite was investigated and the influence on relevant oxygen carrier properties was determined.


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