Chemical Looping Combustion CO_2-Ready Gas Power

CLC GAS POWER

EU contract no 19800 (STREP)

Project objectives

The critical issues that need to be addressed for an up-scaling of CLC technology for gaseous fuels to a demonstration step have been identified together by the industrial and university/research partners. It is the objective of the project to establish and validate solutions to these topics, thereby enabling a future demonstration phase. These topics include:

1) Identify process suitability of raw materials commercially available at competitive prices.
2) Establish best commercial particle production technique for up-scaling from laboratory freeze-granulation method so far applied.
3) Adapt alternate particle production paths with potentially lower production costs.
4) Investigate possible effects of gas impurities on particles, primarily sulphur.
5) Long term testing in an existing 10 kW_{th} CLC prototype unit to confirm mechanical and chemical integrity of particles.
6) Modification of existing CFB rig to intermediate CLC demonstration unit at 100-200 kW_{th} scale.
7) Extend and verify modelling capability for process performance optimisation and scale-up.
8) Process and technology scale-up to prepare for industrial 20-50 MW_e demonstration unit.

Project partners

Chalmers University of Technology (Chalmers), Sweden
Consejo Superior de Investigaciones Cientificas (CSIC), Spain
Vienna University of Technology (TUV), Austria
ALSTOM Power Boilers (APB), France
Shell Global Solutions International BV, Netherlands
Tallinn University of Technology (TUT), Estonia

- The project is also part of phase II of CCP (CO2 Capture Project) via Shell.

Detailed objectives:

1. Identify process suitability of raw materials commercially available at competitive prices. The particles produced in the previous GRACE project were based on expensive so called pro-analysi chemicals of the highest possible purity, in order to avoid any uncertainties regarding effects of impurities. For cost reduction reasons, it has to be verified that raw or semi-finished materials commercially available are equally effective.

2. Establish best commercial particle production technique for up-scaling from laboratory freeze-granulation method so far applied. The laboratory production method used, freeze-granulation, is suitable for smaller batches, but for large-scale production spray-drying appears to be the best method. Spray-drying is a common industrial practice for producing large amounts of particles at low cost. The two methods have large similarities, and it is expected that spray-drying can produce particles of equal quality, nevertheless this should be verified.

3. Adapt alternate particle production paths with potentially lower production costs. The use of commercial techniques for catalyst preparation can be adapted to achieve lower costs, since the fraction of nickel oxide needed may be significantly decreased. Furthermore, the sintering can be achieved at lower temperatures resulting in cost reduction.

4. Investigate possible effects of gas impurities on particles, primarily sulphur. It is important to safely assess the effect of the presence of impurities in the gas feed (sulphur and higher hydrocarbons) on the process and analyse possible implications for the process design. Firstly it is necessary to assess whether there are process conditions under which particles can be damaged by the presence of sulphur. Secondly it is important to find out whether any sulphur is transported to the air reactor and released there, and if it is important to assess the fraction of sulphur released in the air reactor in view of the possible need of flue gas cleaning. No detrimental effects are expected from the presence of higher hydrocarbons, in effect the 100 h testing in the GRACE project was made with natural gas including higher hydrocarbons. Approximately one fourth of the carbon was in the form of hydrocarbons heavier than methane. Nevertheless, the reactivity of particles towards higher hydrocarbons should be assessed for better understanding of the process and emissions compliance.

5. Long term testing in an existing 10 kWth CLC prototype unit to confirm mechanical and chemical integrity of particles. Although the GRACE tests clearly suggest that the lifetime of the particles should be very long, this needs to be verified in long-term operation of the process. In view of the operational costs this long term testing needs to be made in the smaller 10 kW existing CLC unit available. This unit is adequate for this, except that it needs to be equipped for unmanned operation. The target lifetime of particles is minimum 4000 hours. The target is based on a cost of particles below 1 € /ton CO_2 captured in combination with present assumptions on particle inventory and particle production cost.

6. Design and testing in intermediate CLC demonstration unit at 100-200 kWth scale. The scale up from 10 to 100-200 kW has been identified as an appropriate step, given that this is a completely new combustion technology. The unit will include a number of features not available in the smaller 10 kW unit, and provide vital information on scaling-up, operational control principles to simulate part-load operation and upset conditions, particle behaviour and emissions. Steam fluidized particle locks will avoid the dilution of product gas with inert gas. Direct control of fuel reactor bed inventory will provide data for model validation giving safer assessments of needed inventories in larger units. Larger power will mean smaller relative heat losses, i.e. more realistic and relevant particle circulation rates. Furthermore the impact of fuel impurities will be tested by using a range of commercially available natural gases. Special provisions should be considered for integrated CO_2 purification, which is necessary because of thermodynamic limitations inherent when using NiO.

7. Extend and verify modelling capability for process performance optimisation and scale-up. Reliable models and process simulation are key scale-up tools for performance mapping and for executing the development of a well-engineered integrated CLC Process layout. Detailed modelling studies, based on GRACE achievements, are required for air and fuel reactor and will be benchmarked by experimental results of the 100/200 kW pilot reactor. A global simulation model will be set-up for process optimization, which is essential for analysis of process integration options, part-load behaviour, off-design operation. The model will integrate an economic module forming the basis for analysis of investment and through-life economics of the process.

8. Process and technology scale-up to prepare for industrial 20-50 MWe demonstration unit. Environmental assessment is needed to ensure the process meets high standards of environmental performance and workplace safety. In order to fully understand the commercial viability of the process to a large-scale unit it is vital to use information from WPs 1-7 to develop an integrated design. This information will allow selection of design criteria, including process control aspects, and finalization of process integrated concept for a future industrial demonstration unit.