

Imperial College London UNIVERSITY OF CAMBRIDGE 800 YEARS 1209-2009 Cranfield UNIVERSITY The University Of Sheffield.

JOINT UK-CHINA NETWORK TO INVESTIGATE THE PRODUCTION OF CLEAN ENERGY AND HYDROGEN VIA NOVEL PROCESS TECHNOLOGIES (CEH2NET)

UK Partners:
 Cambridge University (CU)
 Imperial College London (ICL)
 Cranfield University (CrU)
 Sheffield University (SU)

PRC Partners:
 Thermal Power Research Institute (TPRI)
 Tsinghua University (TU)
 North China Electric Power University (NCEPU)
 Taiyuan University of Technology (TUT)

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OBJECTIVES OF NETWORK

To investigate the production of clean energy and hydrogen from coal and biomass via a number of thermal chemical routes. These are at the early stage of development and underpinning scientific knowledge is required to facilitate their route towards commercialisation.

Advanced Calcium Looping Cycles

Metal Looping Cycles for fuel reforming

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Collaboration

Develop a sustainable network between the UK and China on this topic and ensure an effective interchange of knowledge

- Building on existing relationships
- Funding to allow Chinese Investigators to visit UK
- Funding to allow UK PI's and research workers to visit China
- Possible joint supervision of PhD's
- Workshop in China

Two way transfer of knowledge between world leading groups in China and in the UK

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PROJECT WORK PACKAGES

Work package 1: Production of hydrogen using oxidation/reduction looping cycles

Work package 2: Advanced gasification processes using the calcination/carbonation cycle

Work package 3: Underpinning studies

Work package 4: Scale up and engineering issues

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Work package 1: Lab scale production of hydrogen using oxidation/reduction looping cycles

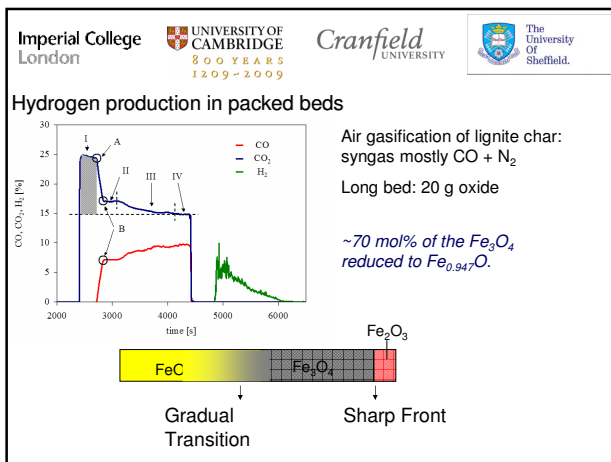
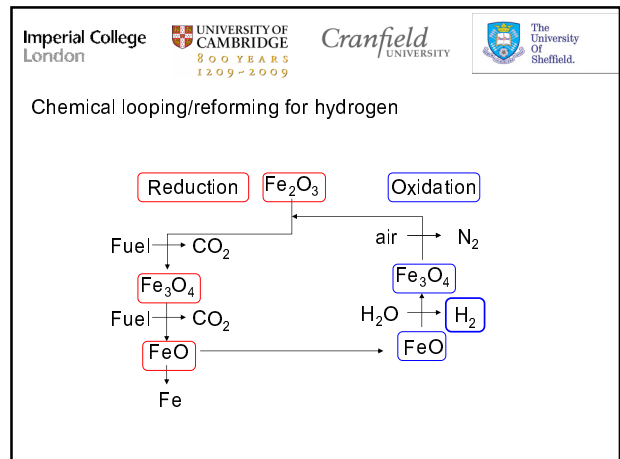
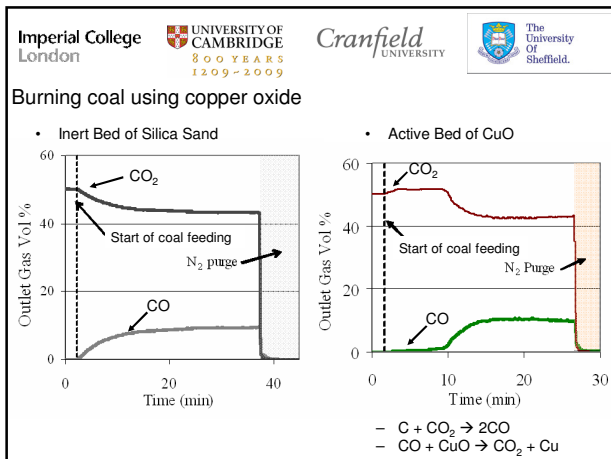
- Previous projects in Cambridge looking at
 - Chemical looping combustion and solid fuels
 - Metal redox cycles for hydrogen production
- Use the oxygen on a SOLID metal oxide to "burn" the fuel
- Re-oxidise with air to produce heat OR steam to produce hydrogen
- Solid fuel must be gasified to syngas before being combusted by metal oxide.

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Basic chemical looping combustion

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    graph TD
      subgraph Cycle1 [Reduction/Oxidation]
        direction LR
        R1[Reduction] --> CuO[CuO]
        CuO --> O1[Oxidation]
      end
      subgraph Cycle2 [Reduction/Oxidation]
        direction LR
        R2[Reduction] --> Cu2O[Cu2O]
        Cu2O --> O2[Oxidation]
      end
      Fuel1[Fuel] --> CO2_1[CO2]
      Fuel2[Fuel] --> CO2_2[CO2]
      Air[air] --> N2[N2]
      CuO --> Cu[Cu]
      Cu --> Cu2O
      Cu2O --> Cu
      Cu --> CuO
      Exo[Exothermic ΔH < 0]
  
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Tasks

1.1- Gasification and reforming of solid fuels in the presence of active metal oxides:

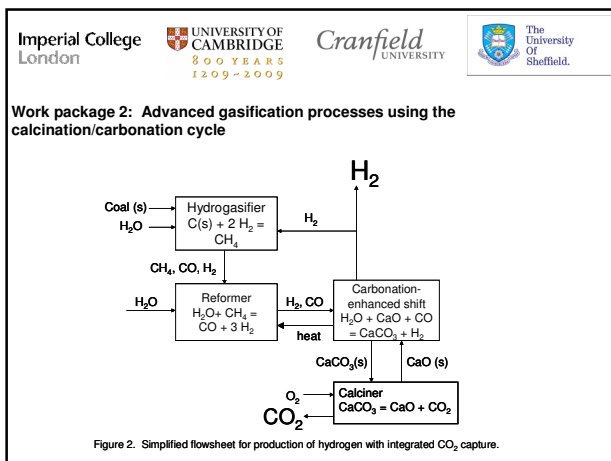
- Pressurised fluidised bed gasifier
- Gasification in beds of active and inactive materials

1.2 Semi batch and continuous hydrogen production using coal:

- Gasifier linked to packed bed of iron oxides (semi-batch)
- Moving bed or interconnected fluidised beds (continuous)

1.3 – Determine the Effect and Fate of Sulphur

- S released from coal will potentially react with the metal looping agent and other additives to form stable sulphides



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Tasks

2.1: Hydrogasification of coal and biomass.

- A laboratory scale fluidised bed, operating with a continuous fuel feed will be used to study aspects of the ZECA concept. Tests will initially be done at 2 Mpa, but this may be increased, once the equipment is fully commissioned and its performance validated.
- Target fuels = lignite and biomass

2.2: Reforming of CH₄/enhanced water gas shift in the presence of H₂S.

- The behaviour of the CO₂ sorbent (e.g. limestone) will be examined in a low pressure fluidised bed reactor. The effect of H₂S on the behaviour will be investigated.

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Work package 3: Underpinning studies

Background:

- Both routes to clean H₂ use a combination of catalysed and non catalysed reactions between solids and gases.
- The key to success with both processes is the development of robust and active solids, which maintain their reactivity during many cycles.

Tasks

3.1: Development of robust natural and artificial sorbents and looping agents:

- Naturally occurring oxides and carbonates and manufactured particles are all candidates.
- Improvements in performance by chemical modification etc..

3.2: Characterisation of looping materials:

- Advanced methods will be used to examine changes in the physical and chemical structure during multiple cycles of reaction.

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Workpackage 4: Scale up, engineering issues and environmental impact

Background: The objective is to investigate issues that may arise when the process concepts are scaled-up.

- Attrition and mechanical stresses
- Continuous operation at pilot scale.
- Thermal integration of the different process stages, and assessment of environmental impact.
- Flowsheeting

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Tasks

4.1 Engineering issues in the CO₂ capture by solid looping cycle processes:

- Pilot scale circulating fluidised bed at Cranfield.
- Long term particle stability

4.2 Feasibility of modifying Cranfield reactor for hydrogen production:

- Design calculations
- Demonstration