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Centre for Energy and Resource Technology

Professor John Oakey

Head, Centre for Energy and Resource Technology

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Resource flow & recovery
(Waste, biofuels, etc.)

Energy processes
(CCS, Gas cleaning, Biomass/Waste to Energy, Built Environment, Offshore

Pollution Management
(Air emissions, residues, GIS, etc.)

Materials and Reliability
(Alloys/coatings, fossil power, risk/maintenance)

M-level programmes
- Offshore & Ocean Technology
- Resource Management

Facilities

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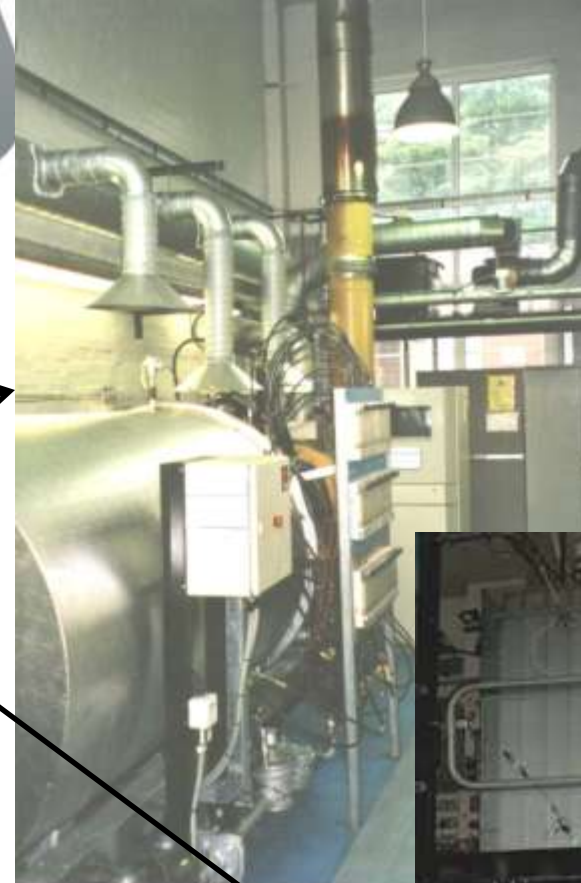
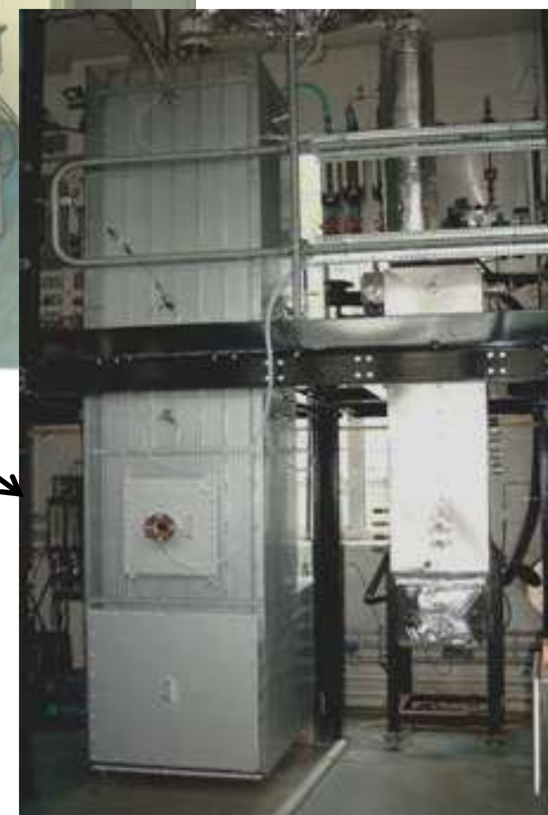
- Gas-fired Burner Rig
- Fluidised Bed/Pulverised Coal Combustor
- Fluidised Bed Gasifier
- Updraft and Downdraft Gasifiers
- Pyrolyser
- Circulating Fluidised Bed Combustor
- Gas Cleaning Rigs – filtration, fixed/fluidised bed reactors, twin-bed system and membrane separation
- Solid Sorbent CO_2 Capture Rig
- Gas Turbine Combustion Rigs
- HP Steam Flow Rig
- Thermal Cycling Rig
- Corrosion and Erosion Rigs
- Process Models
- Metallurgical/Microscopical Equipment
- Coating Facilities - EBPVD, CVD, etc.





http://www.cranfield.ac.uk

Current Research Interests

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Electron beam physical vapour deposition (EB-PVD) coating system

- Boiler Reliability – co-firing and oxy-fuel firing
- CO_2 Capture by Lime Carbonation
- Biomass Co-combustion and Co-gasification
- Advanced Gas Turbine Coatings
- Corrosion Test Method Standardisation
- Residual Life Assessment and Component Life Modelling
- Advanced Bio-energy Systems
- Anaerobic Digestion
- Underground Coal Gasification
- Solid Recovered Fuels and Fuel Preparation
- Biomass/waste Pyrolysis and Gasification
- Waste Resource Assessment
- Environmental Impacts, Regulations and Policy
- Odour Control
- Offshore Wind and Wave/tidal Power
- Low Energy Buildings
- Process Modelling and Life Cycle Analysis
- Oxy-combustion in PF Boilers and Gas Turbines
- CO_2 Transport Pipelines
- H_2 production using chemical looping and CO_2 capture
- H_2/Syngas Gas Turbines
- Next Generation Steam Power Plants
- Multiscale Modelling of CCS
- Protective Coatings

Process Systems Engineering Group

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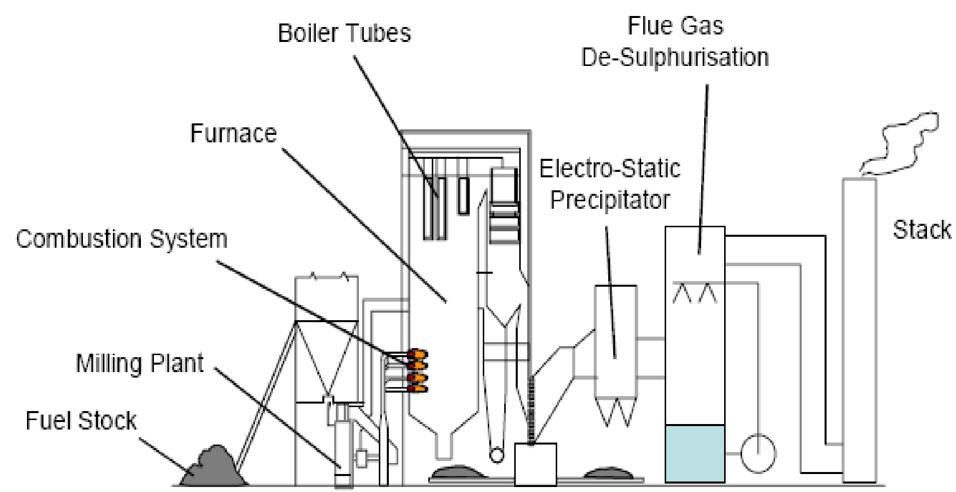
- Multiphase flows (oil and gas focus)
- Flow Measurement
- Advanced Control
- Simulation and optimisation
- Process intensification
- Energy Systems

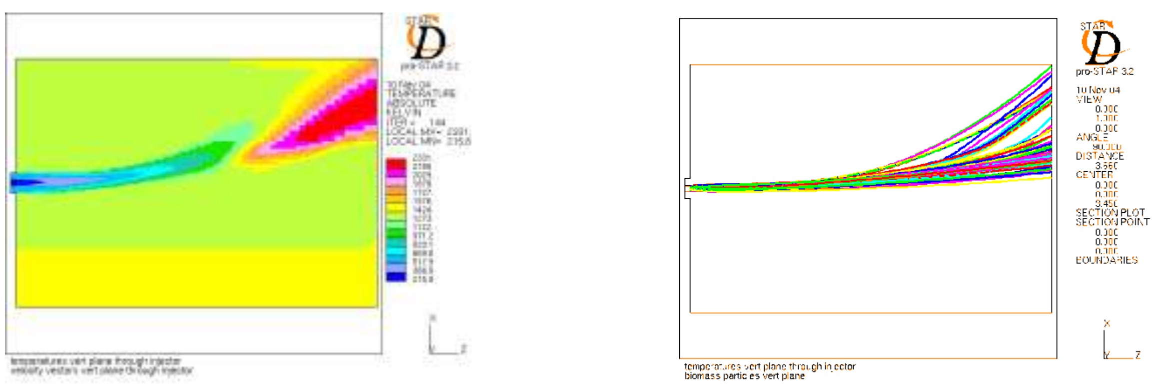
Hoi Yeung
Head, Process Systems Engineering Group

Visiting Prof Colin Ramshaw

Simulation and Optimisation

- Refinery scheduling for uncertainty
- Optimal design of coal and biomass fired boilers





CFD simulation of flame and particle trajectory

Interests in Post-combustion Capture

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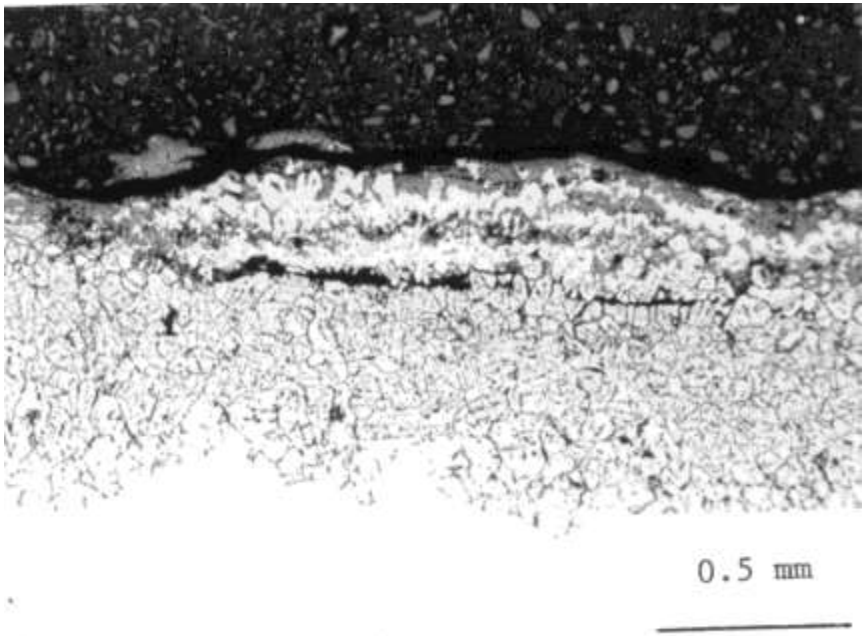
- Durability/materials issues in amine scrubbing systems
- Impact of impurities on amine scrubbing and the CO_2 produced
- Process intensification and process modelling for amine scrubbing
- Solid sorbent capture systems – lime carbonation
  - enhanced calcium carbonate calcination
  - in-bed FBC carbonation

Durability/materials and contaminants



- Long term materials (1000's of hours) data required – including
  - absorption & regeneration
  - possible contaminants
  - operating cycles
  - different solvents
  - likely damage/failure mechanisms – pitting, corrosion fatigue, SCC, weld cracking
  - protective systems
- Automated pilot-scale amine 'flow-loop' unit being designed to generate:-
  - effects of contaminants on capture
  - long-term data life-prediction data
- In-situ corrosion monitoring - e.g. electrochemical

Existing UK-US collaboration on materials in:-

- oxy-combustion
- fireside corrosion
- biomass co-firing
- steam oxidation

Component life modelling

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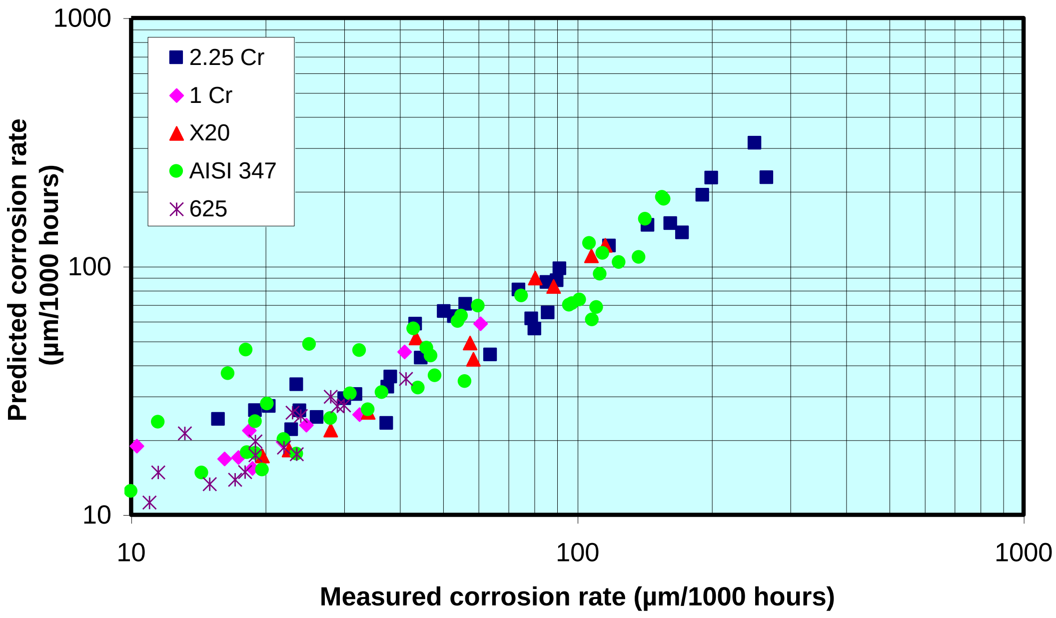
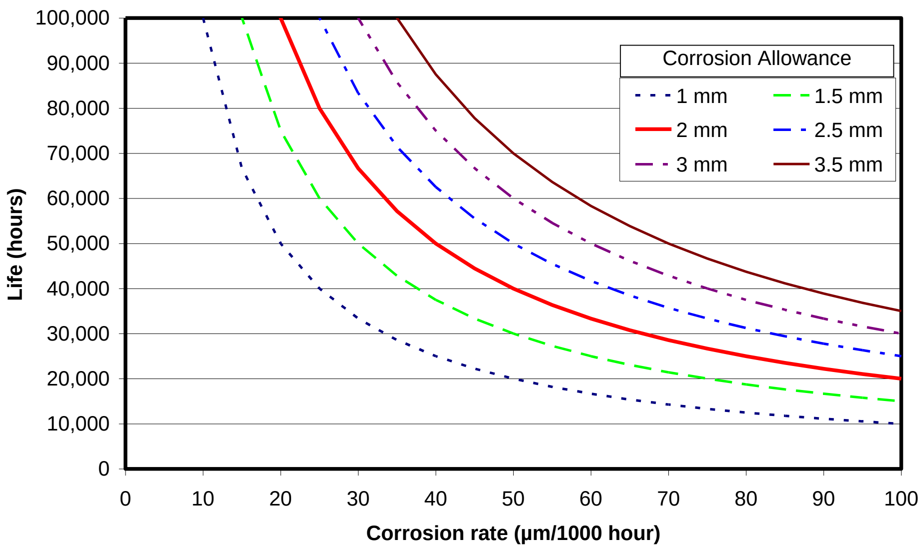
- Lab-scale data from simulated conditions for model development
  - ➢ envelope of ‘safe’ conditions
  - ➢ Effects of independent variables
- Pilot scale data in simulated environments to provide long term data for validation and understanding of kinetics
  - ➢ damage kinetics
  - ➢ model validation
- Need to model the rate of the worst damage for the best material/coating



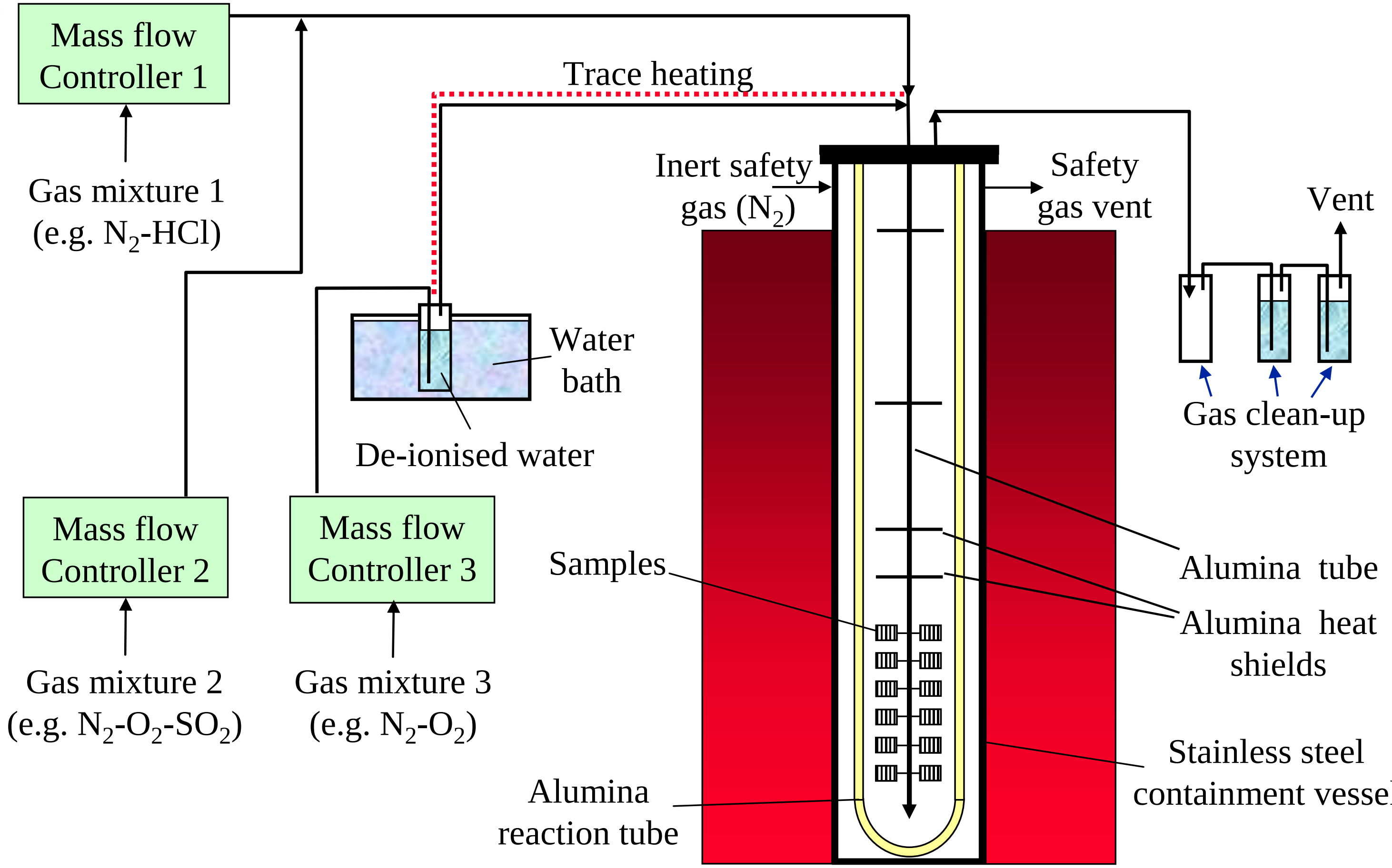
Correlation between Measured Predicted Corrosion Damage Rates
(corrosion damage evaluated at the 10% probability of damage being exceeded)

Corrosion model requirements

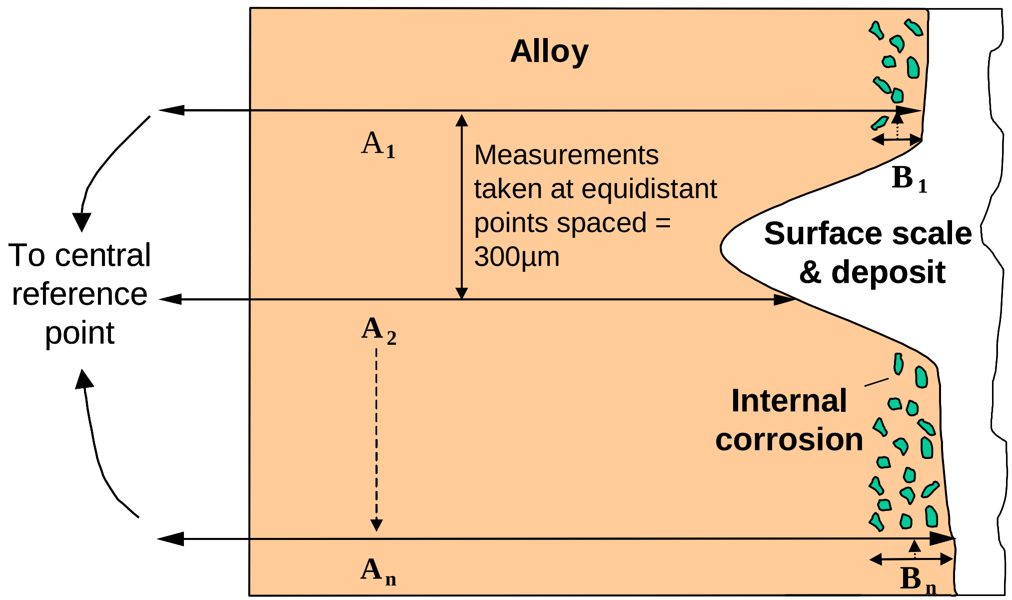
- Specific to:
    - Components, e.g. absorber and stripper parts
    - Identified process environments
- Corrosion damage (in terms of metal loss/ or risk of failure) as function of:
    - Metal temperature
    - Gas composition (e.g. SO_x, HCl, O_2, CO_2, H_2O)
    - Deposit composition – depends on contaminants
    - Time
    - Median vs 'maximum' metal loss
- Component life criteria



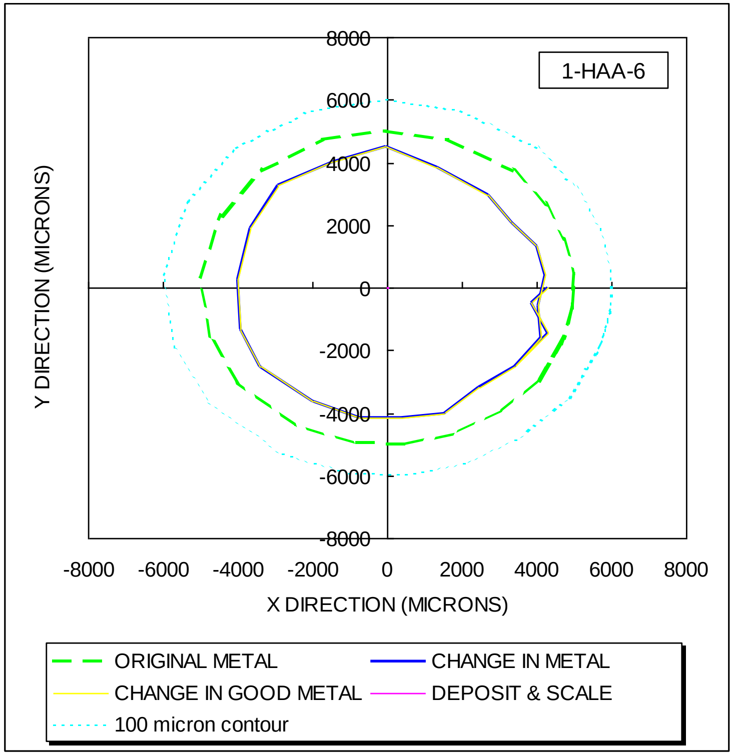
Controlled atmosphere corrosion furnace



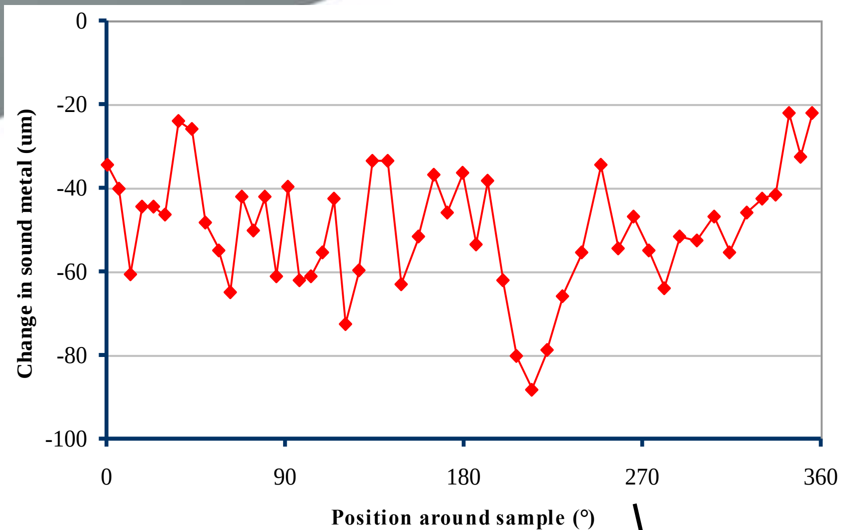
Sample Metrology & Data Analysis (1)



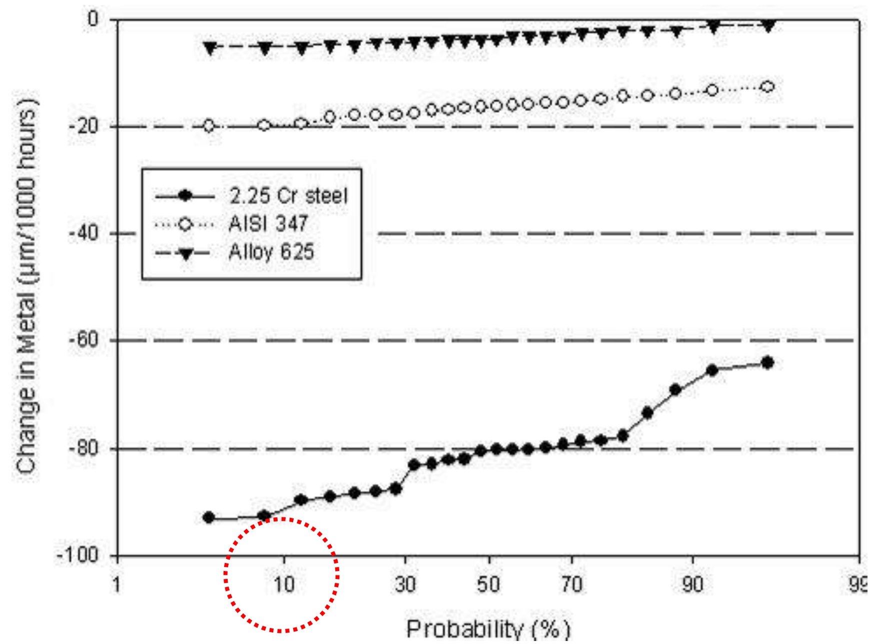
Where n = 24



Sample Metrology & Data Analysis (2)



Data ordered and plotted against probability



Process Intensification for CO_2 capture

Spinning Disc Reactor used to study bubble and mass transfer performance

- CO_2 capture using MEA relies on mass transfer across the liquid film
- Conventional packed column approach results in very large columns with the associated capital and operation issues
- Mass transfer is dramatically increased in the enhance gravity environment created in Rotating Packed Bed Reactor
- An order of magnitude reduction in equipment size is expected for both absorption and regeneration resulting in much reduced capital and operation costs

Process Intensification for CO_2 capture

Operation intensity can be increased dramatically in an enhanced acceleration environment

Possible Work

- Develop demonstration of rotating absorption and regeneration units (300mm diameter)
- Develop process models for scale up to real plant capacity

Contact: Hoi Yeung - h.yeung@cranfield.ac.uk

Process Intensification - Rotating Electrolyser

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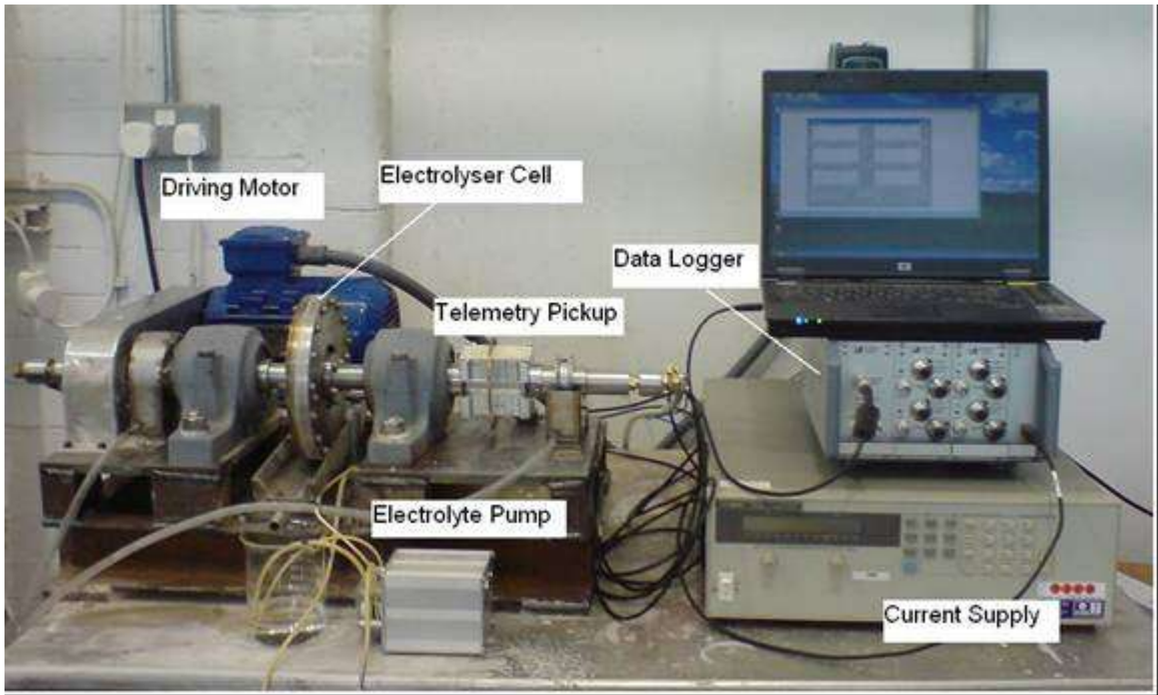
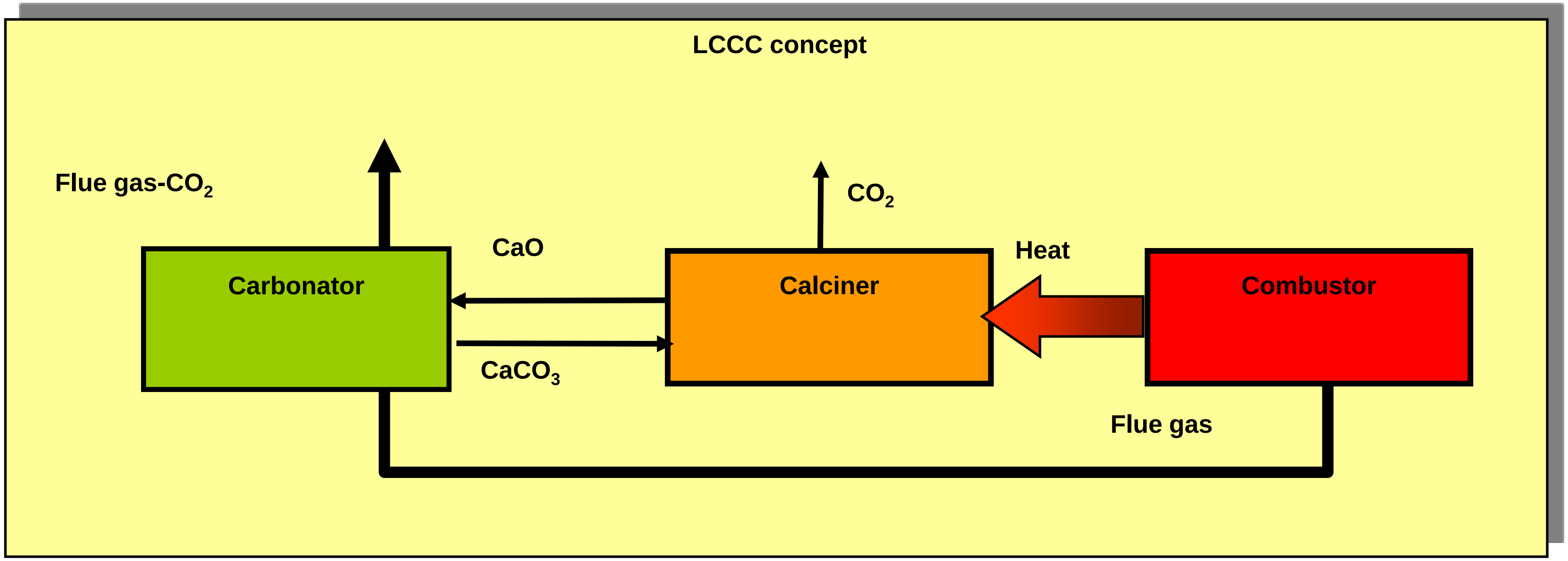
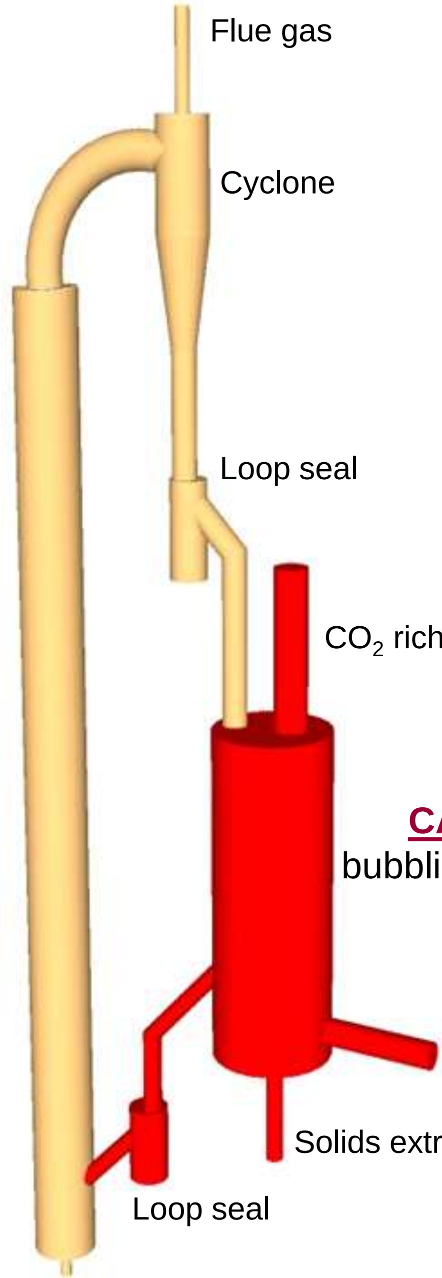


EPSRC funded project to develop a prototype single cell rotating electrolyser for hydrogen production. Current density achieved is over 10 times that of conventional electrolyser for the similar efficiency

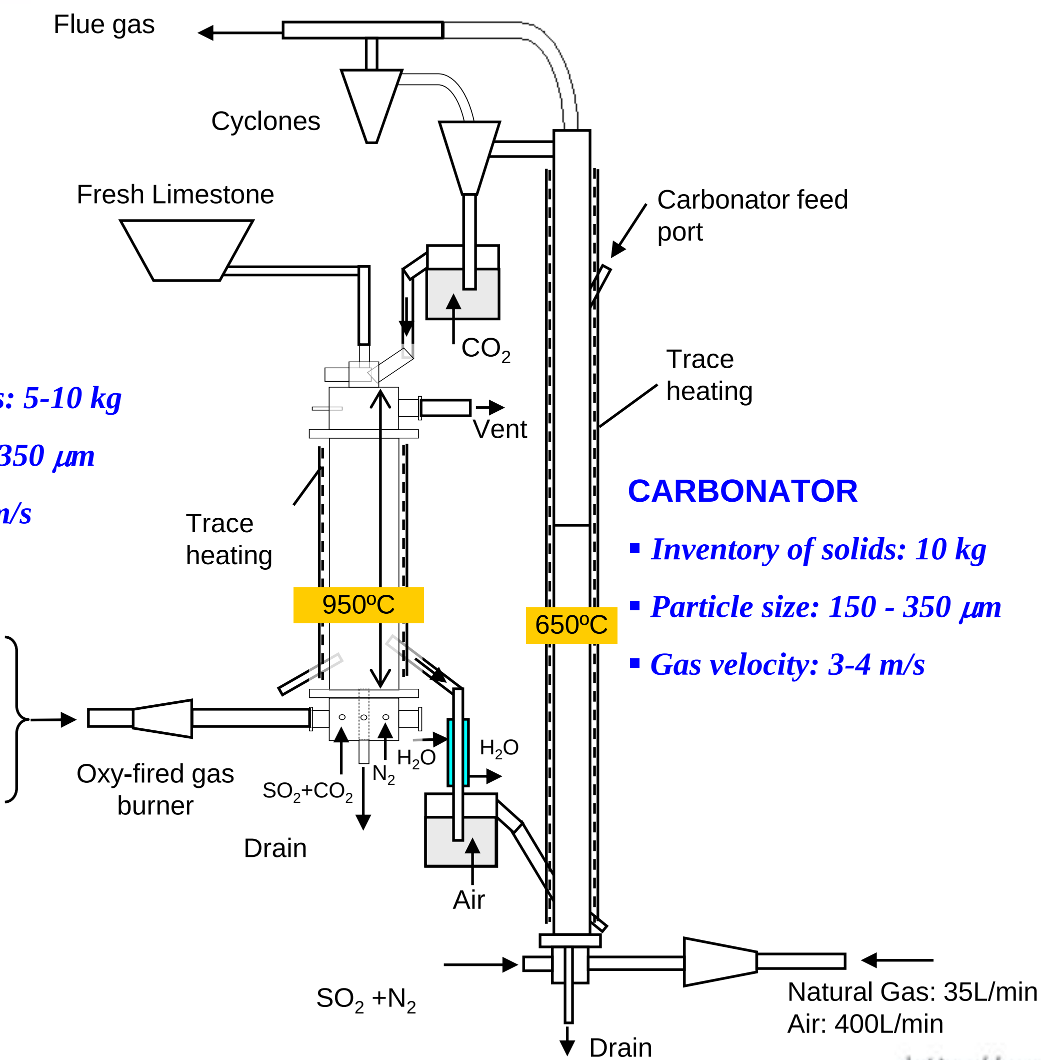
Lime Carbonation / Calcination



Twin Reactor System



Twin Reactor System



CALCINER

- ***Inventory of solids: 5-10 kg***
- ***Particle size: 90 - 350 μm***
- ***Gas velocity: 0.5 m/s***

CARBONATOR

- ***Inventory of solids: 10 kg***
- ***Particle size: 150 - 350 μm***
- ***Gas velocity: 3-4 m/s***

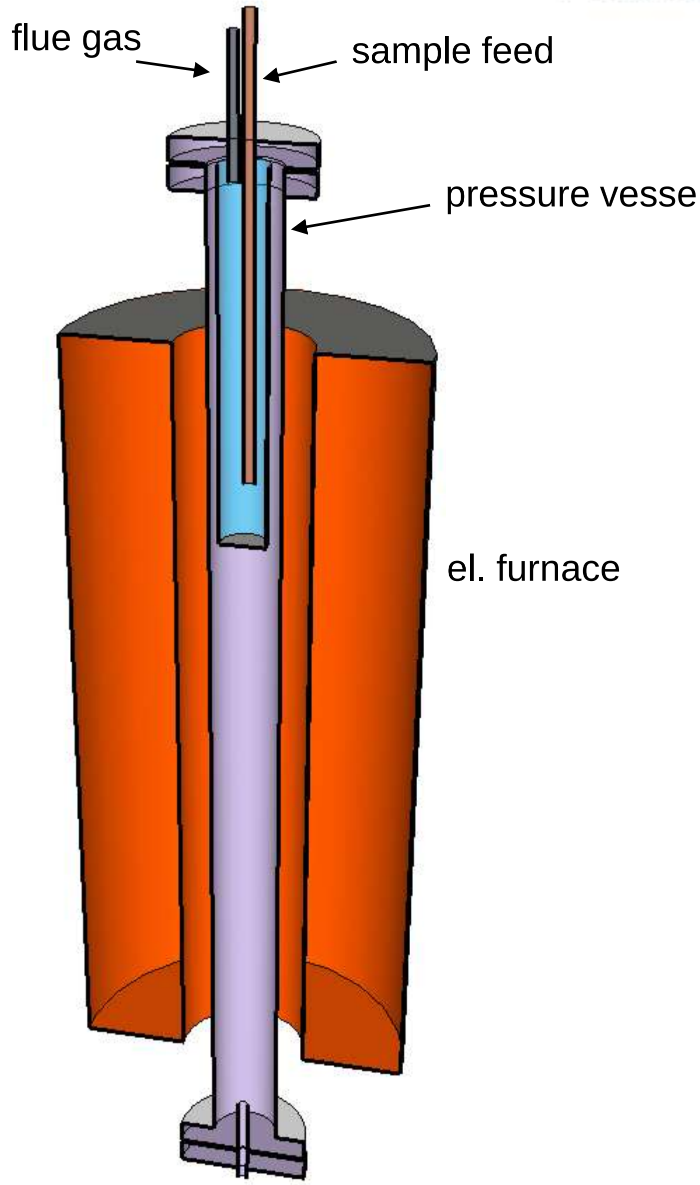
Pressurised fluidised bed reactor

Study of:

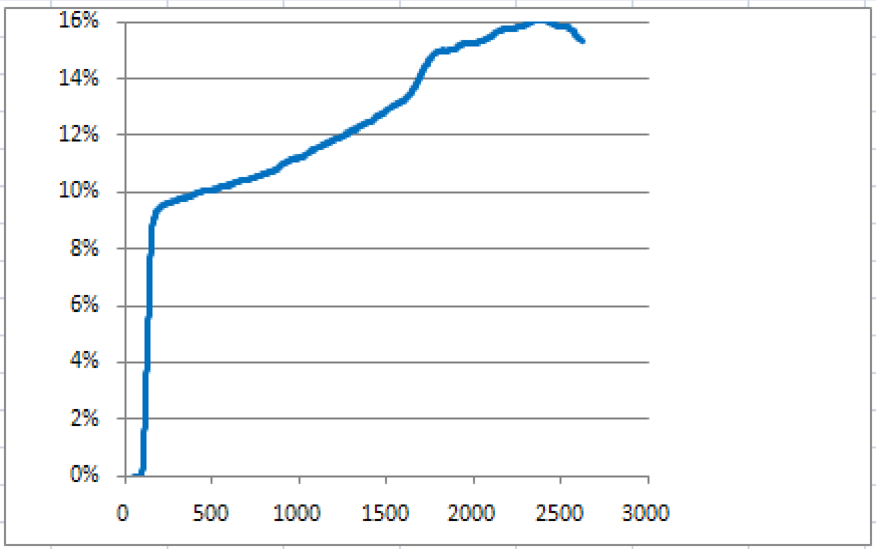
- effects of **pressure** on sorbent performance
- effects of **SO_2** on sorbent degradation
- effects of **steam** on sorbent performance

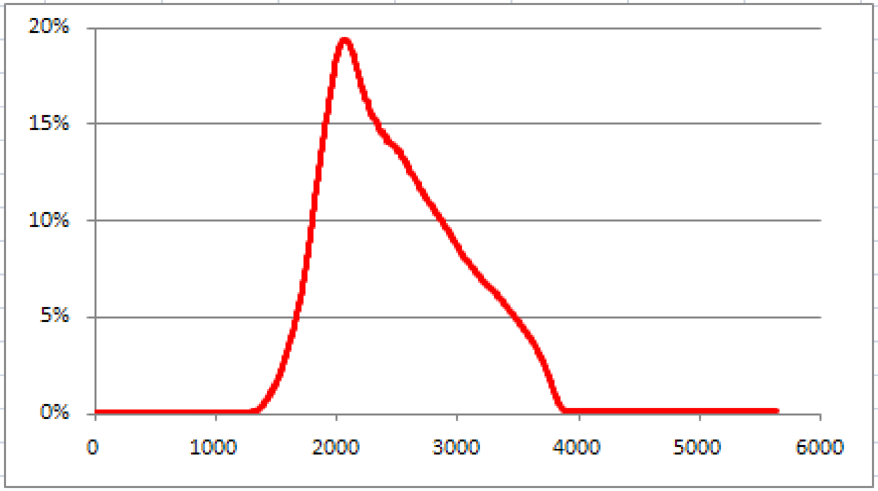
Parameters:

- Maximum operating temperature is **1000 °C**.
- Maximum operating pressure is **15 bar**.



Early data





CO_2 concentration in exhaust versus time (s) during the carbonation phase

CO_2 concentration in exhaust versus time (s) during the calcination phase

Thank You

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