CICCS
CENTRE FOR INNOVATION IN CARBON CAPTURE AND STORAGE

HERIOT WATT UNIVERSITY

Microwave desorption of adorbents for CO_2 capture

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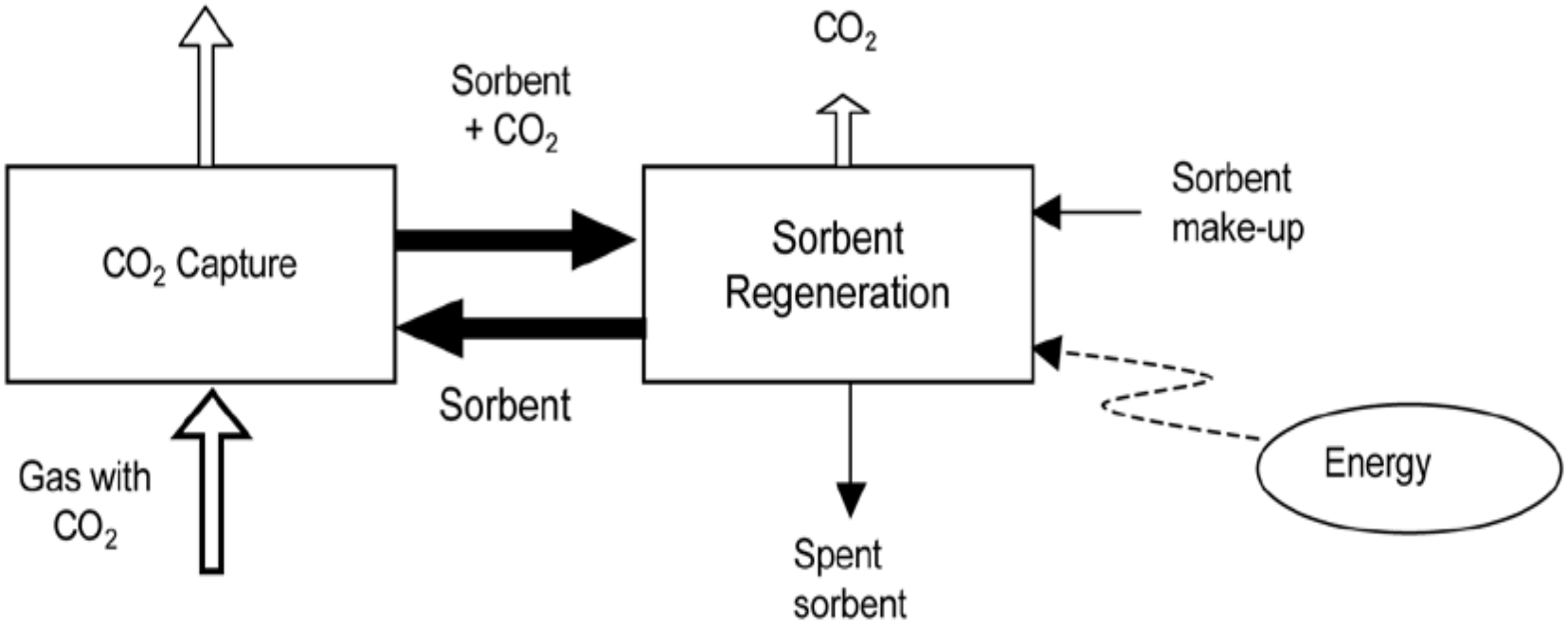
PIN Meeting – Newcastle 2014

Adsorption/Desorption cycles



Source: *2005, Carbon Dioxide Capture and Storage*

Microwave Swing Desorption (MSD)

- Project aim/objectives:

➢ Intensify the process of CO_2 desorption from sorbents by utilising microwave energy, which compared to conventional Temperature Swing Desorption (TSD) will result in:

- ✓ Faster desorption rates;
- ✓ Lower energy consumption;
- ✓ Sorbent preservation leading to more regeneration cycles;
- ✓ Retain higher percentages of pure CO_2 after sorbent regeneration

Microwave Swing Desorption (MSD)

- Experimental setup:
  - ✓ Fixed bed tubular reactor, made from pyrex glass;
    - ❑ length = 250 mm;
    - ❑ outside diameter = 30 mm;
    - ❑ inner diameter = 10 mm;
  - ✓ Granular microporous activated carbon (AC) - NORIT GCN 3070
    - ❑ particle size 210-595µm (30-70 mesh, 93%)
    - ❑ surface area: 1513.9 m^2/g
    - ❑ pore diameter: 1.2 nm
- Conditions:
  - ✓ Flow: 30ml/min He/CO_2 (50:50)
  - ✓ Pressure: ambient (1atm)
  - ✓ Adsorption temperature: 20°C
  - ✓ Desorption temperatures: 70, 90, 110 and 130°C via microwave and conventional heating

Adsorption/Desorption cycle

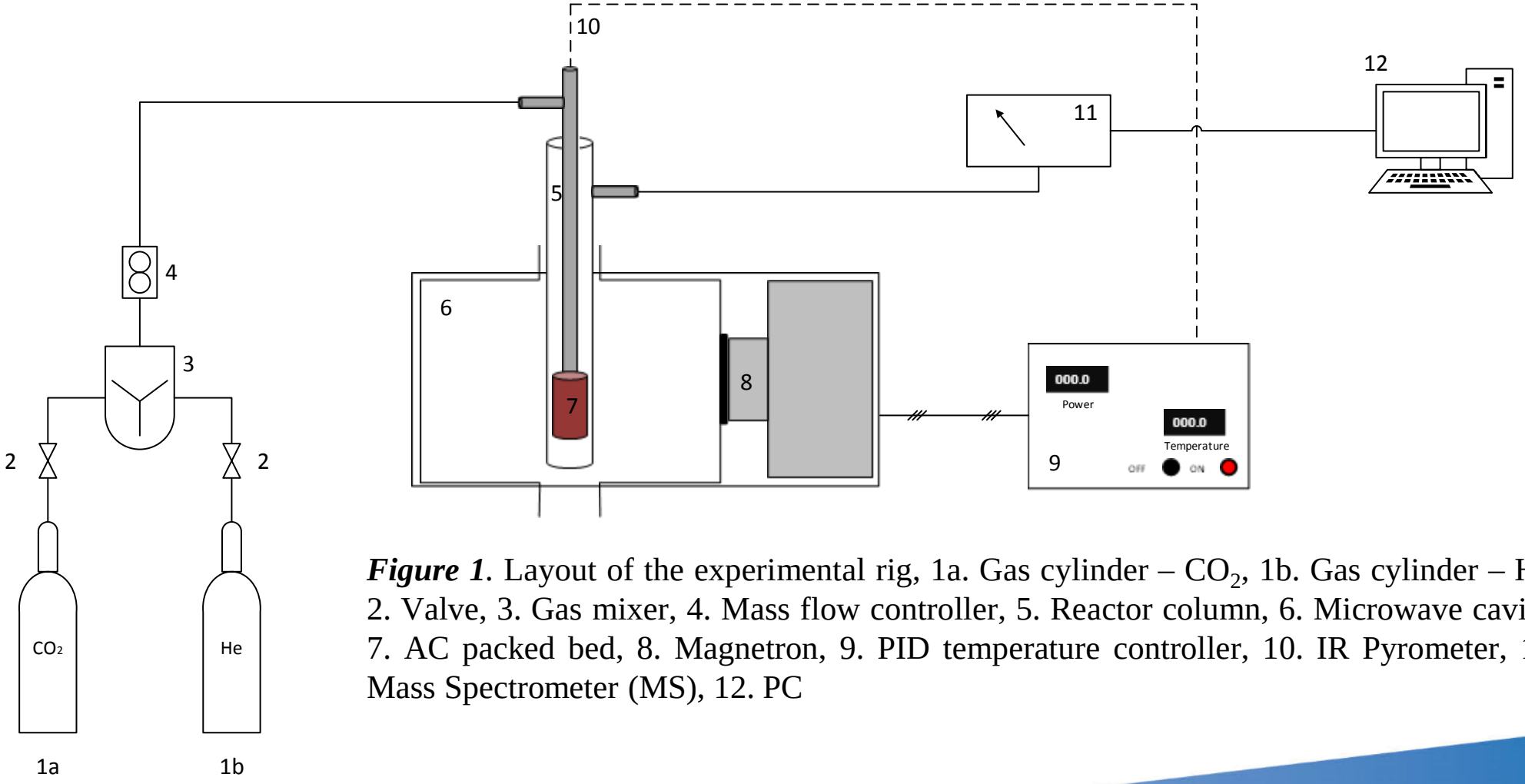


Figure 1. Layout of the experimental rig, 1a. Gas cylinder – CO_2, 1b. Gas cylinder – He, 2. Valve, 3. Gas mixer, 4. Mass flow controller, 5. Reactor column, 6. Microwave cavity, 7. AC packed bed, 8. Magnetron, 9. PID temperature controller, 10. IR Pyrometer, 11. Mass Spectrometer (MS), 12. PC

MSD vs TSD

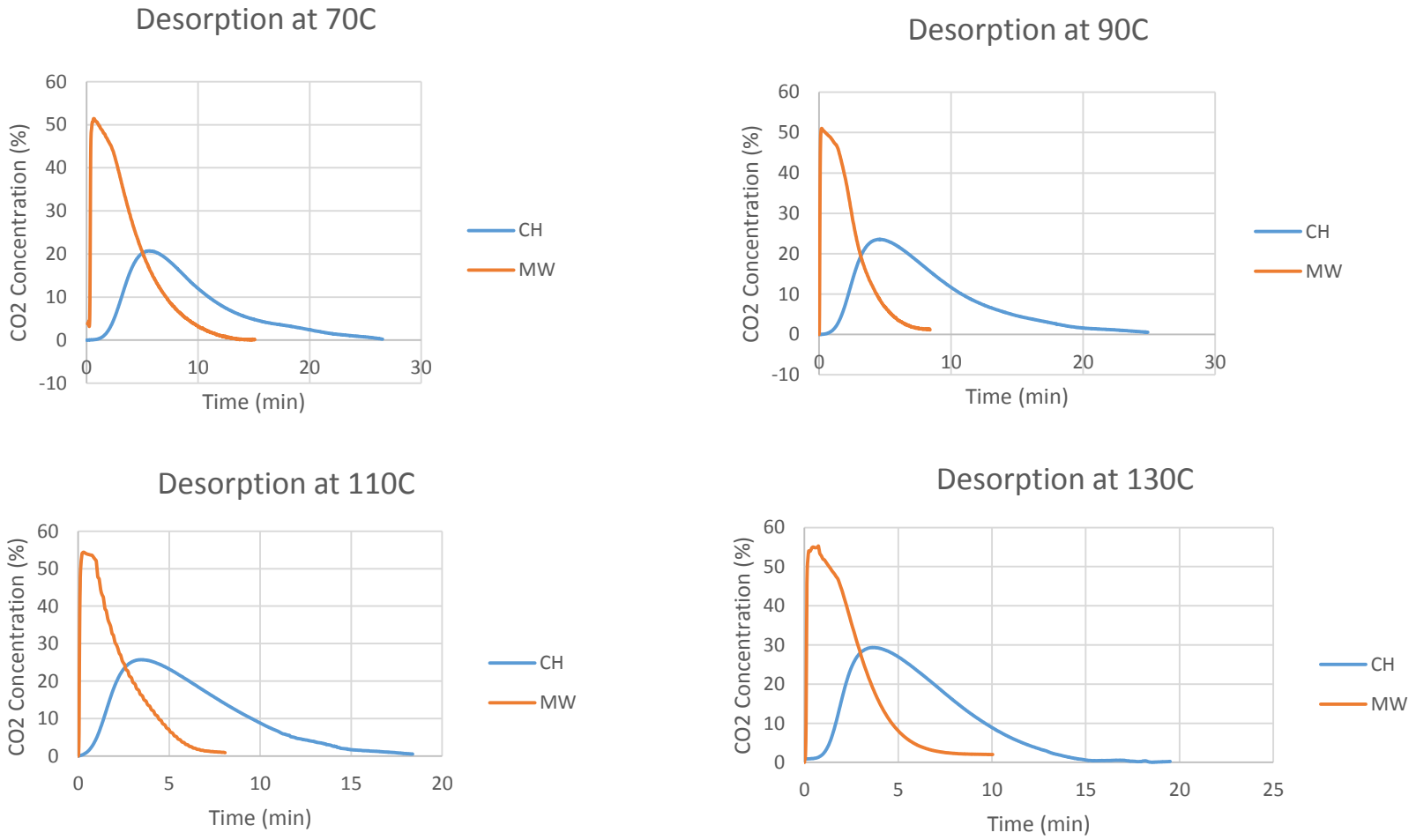


Figure 2. Comparison between microwave and conventional heating desorption at 70, 90, 110 and 130°C

MSD vs TSD

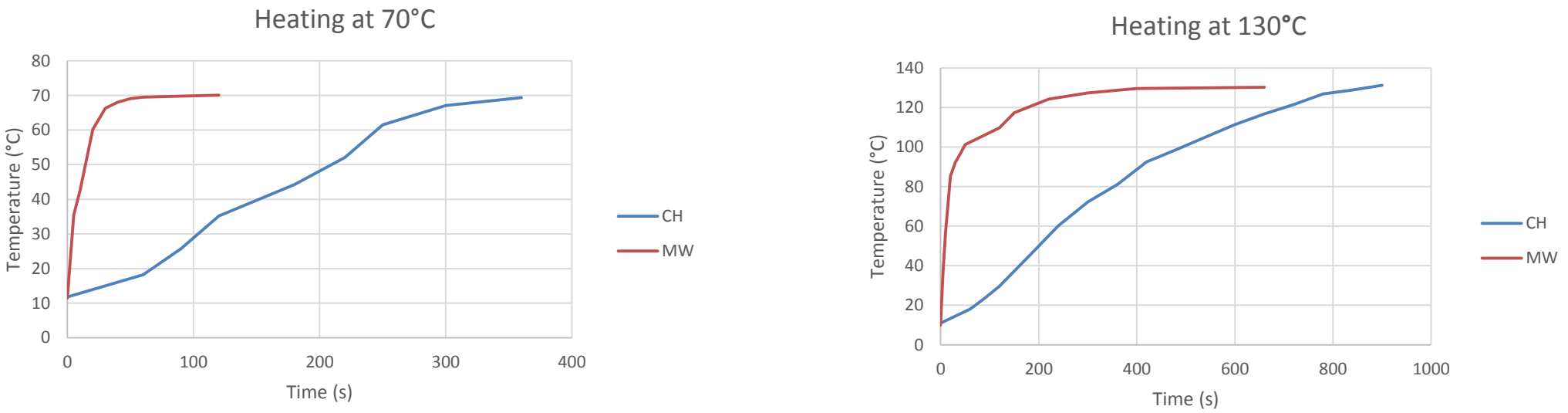


Figure 3. Comparison between microwave and conventional heating of the AC fixed bed heating profile at 70 and 130°C

Microwave Swing Desorption (MSD)

	t_h (min)	q_{des} (ml)	t_{50} (min)	t_{90} (min)	dq/dt_{av} (ml/min)	t_{tot} (min)
CH_{70}	6	25.65	8	16.5	1.54	22.5
MW_{70}	1.5	31.85	2.5	7	4.61	8.5
CH_{130}	15	26.92	5.5	10	2.66	25
MW_{130}	5.5	24.48	1.5	4.5	5.09	10

- $Q_{des} = \int_0^{t_{90}} Q(t)dt$ (1)
- ***Reverse breakthrough time (t_{90}):*** the time needed to achieve 90% desorption after reaching the desired temperature

Table 1. Main parameters obtained from AC regeneration experiments under conventional and microwave heating – t_h: time needed for the AC bed to reach the desired temperature, q_{des}: amount desorbed, t_{50}: time needed for 50% of qdes, t_{90}: reverse breakthrough time, dq/dt_{av}: average desorption rate, t_{tot}= th+t90

Microwave Swing Desorption (MSD)

- Results-Discussion:
  - ✓ Both outlet concentration patterns (MW and CH) follow the log-normal distribution;
  - ✓ Curve peaks are higher with MW;
  - ✓ Shorter tails were observed for MW;
  - ✓ AC bed was heated 4 times faster with MW compared to CH;
  - ✓ Desorption rates were also 4 times higher;
  - ✓ 25% more CO_2 was successfully desorbed at 70°C with MW;

- Future work:
  - ✓ Compare energy efficiency of the two systems;
  - ✓ Compare cyclability of the AC;
  - ✓ Test other materials with MSD (impregnated AC).

Thank you!!

Any Questions??

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Source: www.ecohustler.co.uk