



Hot Gas Clean-Up for Gasification Process



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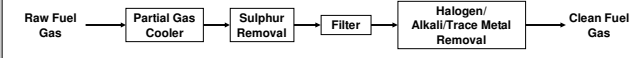
Introduction

- Gas cleaning systems for gasification-based power generation are needed to remove dust, S-species, N-species (e.g. ammonia, cyanides, etc), halides and trace metals from the gasifier fuel gases prior to their passage through the gas turbine and their subsequent release.
- Hot fuel gas cleaning generally refers to the removal of fuel gas impurities at temperatures above 250°C (Mitchell 1998) before the gas stream enters the gas turbine. The integration of hot gas clean-up (HGCU) technology to remove pollutants from coal-derived fuel gas offers the prospect of increasing thermal efficiency whilst simultaneously reducing the capital and operating cost of IGCC systems without compromising the environmental performance.
- Why Hot Gas Cleaning
 - Avoid the high capital cost, energy losses & complexity of totally cooling the hot raw syngas.
 - Avoids waste water & black/gray water slurry processing.
 - Increases IGCC efficiency & capacity by increasing the mass flow & sensible energy into the gas turbine.
- Objective: To investigate a novel hot flue clean-up system using molten tin as the scrubbing medium for the removal of solid particulates and H₂S.

Hot Fuel Gas Cleaning

- Hot Fuel Gas Cleaning (HGCU) vs Cold Fuel Gas Cleaning (CGCU)
 - HGCU increases the overall energy efficiency (by 2-3%) by reducing heat loss as latent heat
- Fuel Gas Cleaning versus Flue Gas Cleaning
 - Better control system, low capital and operating costs
- Gas Turbine Protection
 - Particulate Matter: Fly Ash, trace components and metals
 - Particulates: 2 ppmw (< 10 mm)
 - Sulphur (H₂S, COS, CS₂): 20 ppmw

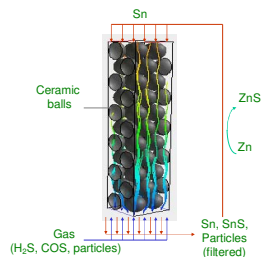
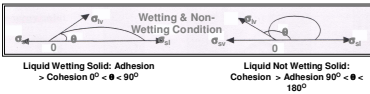
Hot Gas Cleaning (Above 550°C)



Hot Gas Scrubber – Using Molten Tin

Tin (Sn) - Melting Point: 232°C

- Not pose a health impact
- Low viscosity 1.41 cP at 400°C
- Non wetting, easy dispersion into small droplets on the packing surface
- Molten tin as the scrubbing medium for the removal of H₂S and solid particulates.



Desulphurisation by Molten Tin

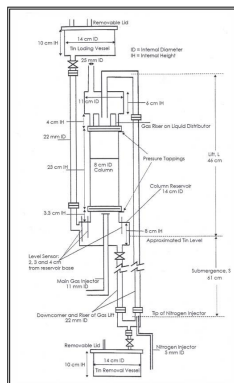
- H₂S + Sn → SnS + H₂
- COS + Sn → SnS + CO
- Recovery of Tin: Zn + SnS → ZnS + Sn

Particle Removal by Molten Tin

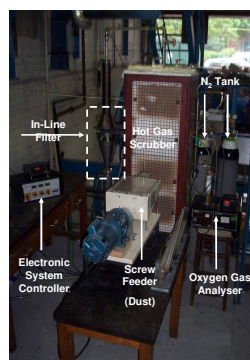
- Discrete molten tin droplets and rivulets on the packing surface act as solid particulate collectors.

Lab-scale Packed Bed Scrubber

- Size of packed bed: 8 cm - internal diameter and 23 cm - length
- Ceramic balls: 9.53 mm high-purity ceramic alumina spheres
- 316 Stainless Steel for resistance to corrosion.
- Countercurrent flows of tin and gas.
- Minimum operating temperature: 350°C
- Glass powder as simulated particles



Schematic of packed bed scrubber

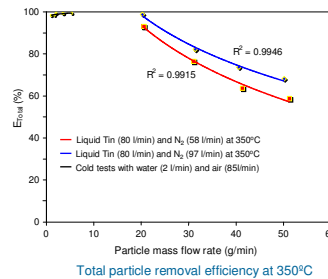


Setup for particle removal tests

Experiments: Particulate Removal & Desulphurisation

- Key parameters: Dust loading, flow rates of H₂S, N₂ and tin, and bed temperature
- Particle removal tests

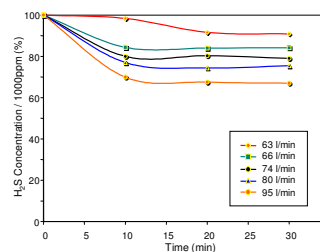
- The low capture of particles was due to the limitations of lab-scale scrubbers such as low temperature of particles at the inlet causing Si (glass powder)-Sn agglomeration.



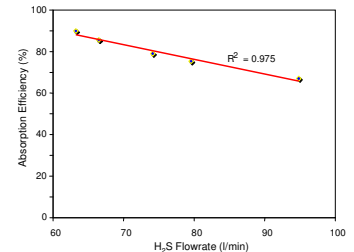
Accumulation of particles and tin

Desulphurisation Tests

- Absorption in the scrubbing solution (molten tin) was rapid as indicated by the high removal rate



Absorption of H₂S with inlet concentration of 1000 ppm

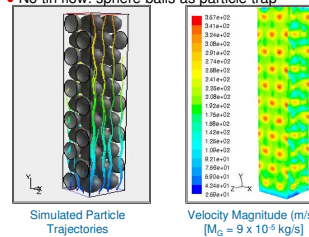


Absorption efficiency of H₂S

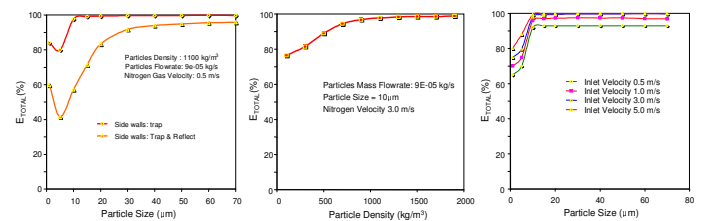
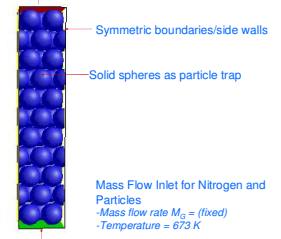
Computational Fluid Dynamics – Particle Removal

FLUENT code used for simulation of particle removal

- No tin flow: sphere balls as particle trap



Outflow: particle escapes



Total particle removal efficiency predicted for different particle sizes, particle density and inlet velocity

Conclusions and Future Work

- Total separation efficiencies were obtained, ranging from 60 to 95 % for particle removal.
- An increase in the H₂S gas flowrate will decrease the efficiency of the gas absorption.
- Desulphurisation efficiencies ranging from 67 – 95 % for H₂S cleaning
- Future Work
 - Investigation H₂S removal by molten tin.
 - Investigate the reactivity of the molten tin with others chemicals.
 - Further CFD modelling work incorporating chemical reactions of H₂S in the packed bed.
 - Validate the model using experimental data.

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