

Profiles

Post-combustion carbon capture from coal fired plants – solvent scrubbing

‘The major drawback of solvent scrubbing is the cost due to the high energy requirements’

Carbon dioxide can be removed from post-combustion flue gas using regenerable solvents. The solvent most frequently encountered for CO₂ capture is monoethanolamine (MEA), an amine solvent.

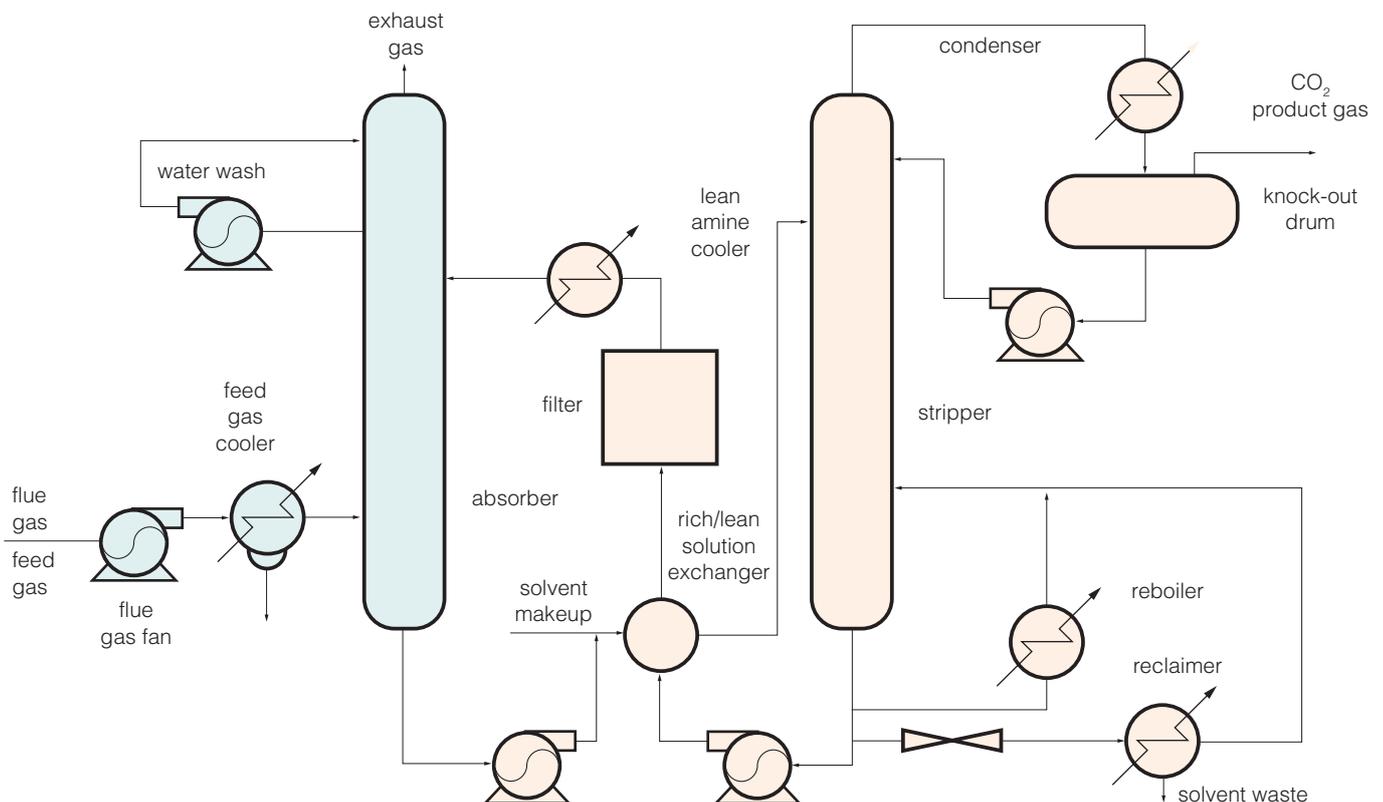
In the solvent scrubbing process, the cooled flue gas is brought into contact with the solvent in the absorber at temperatures typically between 40 and 60°C, CO₂ is bound by the chemical solvent in the absorber. The flue gas is then water washed to balance water in

‘There is little point in retrofitting plants of low thermal efficiency’

the system and to remove any solvent droplets or solvent vapour carried over, and then it leaves the absorber. It is possible to reduce CO₂ concentration in the exit gas down to very low values, as a result of the chemical reaction in the solvent, but lower exit concentrations tend to increase the height of the absorption vessel. The ‘rich’ solvent, which contains the chemically bound CO₂ is then pumped to the top of a stripper (or regeneration vessel), via a heat exchanger. The regeneration of the

‘A full-scale demonstration plant for CO₂ capture by amine solvents should be commissioned’

chemical solvent is carried out in the stripper at elevated temperatures (100–140°C) and pressures not very much higher than atmospheric pressure. Heat is supplied to the reboiler to maintain the regeneration conditions. This leads to a thermal energy penalty as a result of heating up the solvent, providing the required desorption heat for removing the chemically bound CO₂ and for steam production which acts as a stripping gas. Steam is recovered in the condenser and fed back to the



Process flow diagram for CO₂ recovery from flue gas by amine absorption

stripper, whereas the CO₂ product gas leaves the stripper. The 'lean' solvent, containing far less CO₂ is then pumped back to the absorber via the lean-rich heat exchanger and a cooler to bring it down to the absorber temperature level. The flow diagram of the process is shown in the figure.

MEA has several advantages as a solvent such as its high reactivity, low cost, high absorbing capacity on a mass basis, reasonable thermal stability and thermal degradation rate. However it also has some disadvantages such as its corrosive effects. Much research has been devoted to finding or developing solvents that are superior to MEA. A better solvent would not degrade, it would work under normal flue gas outlet conditions, and it would require less energy for regeneration. Some of the ways in which alternative solvents might perform better than MEA include:

- higher capacity for CO₂ capture;
- lower energy for regeneration;
- higher absorption/desorption rates and regeneration at lower temperatures;
- lower volatility and better stability;
- less degradation and lower corrosivity.

The major drawback of solvent scrubbing is the cost due to the high energy requirements of the process. The energy required using MEA as a solvent can cause a 20% reduction of power generation for a pulverised fuel (pf) power plant. A reference example comes from the Ratcliffe power station in the UK. At present the thermal efficiency of this station is 38.9% (LHV). If the plant is retrofitted with Advanced Supercritical Boiler/Turbine (ASC BT) technology the efficiency would rise to 44.9%. Further addition of an amine scrubbing CO₂ capture plant would then reduce the efficiency by 20.9 % to 35.5%. That is a reduction of 9.4 percentage points for a bituminous coal station. Interestingly, adding post-combustion to a brown coal fired plant has been calculated to produce the same net electrical efficiency of 35.5%. Although one of the advantages of amine scrubbing for post-combustion capture is that it can be retrofitted to some existing power plants in suitable locations, the difficulties in retrofitting post-combustion capture must not be underestimated. There is little point in retrofitting plants of low thermal efficiency since the efficiency losses

would render the plant uneconomic.

Although there are several pilot plants in existence, notably the EU CASTOR pilot plant in Esbjerg, Denmark, the IEA Greenhouse Gas R&D Programme (IEA GHG) has suggested that a full-scale demonstration plant for CO₂ capture by amine solvents be commissioned. This would probably be stand-alone but it could be one stream on a large unit. The size would need to be at least 300 MWe to justify supercritical operation and high efficiency SO₂ and NO_x clean-up would also be required. Approximately 6000 t CO₂/day should be captured.

Plans for the construction of 'capture ready' plants have been put forward. The IEA GHG has prepared a definition of a 'capture ready' plant. It is one which can include CO₂ capture when the necessary regulatory or economic drivers are in place. The aim of building plants that are capture ready is to reduce the risk of stranded assets and 'carbon lock-in'. Developers of capture ready plant should take responsibility for ensuring that all known factors in their control that would prevent installation and operation of CO₂ capture have been identified and eliminated. This might include:

- a study of options for CO₂ capture retrofit and potential pre-investments;
- inclusion of sufficient space and access for additional facilities that would be required;
- identification of reasonable route(s) to storage of CO₂.

Each issue of *Profiles* is based on a detailed study undertaken by IEA Clean Coal Centre, the full report of which is available separately. This particular issue of *Profiles* is based on the report:

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