Technology Insight 4

TNO’s Miniplant & onsite CO_2 capture services

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TNO, The Netherlands

Providing onsite CO_2 capture services for industry

TNO is the largest independent research, development and consultancy organisation in The Netherlands. Its research teams include experts in carbon capture research and development, while its onsite, state-of-the-art equipment and facilities provide the opportunity for companies – including waste-to-energy operators – to explore process optimisation possibilities for production processes. TNO provides knowledge and advice that enable companies to strike a balance between what is technically feasible and economically viable.

The TNO Miniplant – for capture solvent development & testing

TNO built its unique mobile CO_2 Capture Miniplant, below, at its Delft research facility several years ago to conduct onsite testing of post-combustion carbon capture from different types of industrial flue gases. To date, the Miniplant has conducted more than 10,000 hours of capture operations. It has been so successful that a second mobile Miniplant has now been built, which complies with ATEX regulations on explosion safety.

Putting it to the test

The Miniplant was designed to test solvents, degradation effects, novel degradation mitigation technologies and other developments in a pilot-scale carbon capture set-up.

It is equipped with the latest technologies regarding process monitoring and measurement, and is fully automated to allow for operation 24/7.

The plant has good accessibility, a user-friendly software interface and a smart process data collection system. It can also be used for R&D into biogas e.g. for feed gas composition with CO_2 concentrations of up to 60%.

A huge variety of solvent and flue gases and their interactions can be tested and analysed, with the knowledge gained used as the basis for designing CO_2 capture installations.

Miniplant set-up

The Miniplant, left, consists of three skids with process equipment: quench, absorber, desorber, water washes, heat exchangers, pumps, pipes, CO_2 analysers, flow meters and controller, an automatic data logging/operation system and computer unit.

Located at TNO's lab in Delft, the plant can be moved to other locations, as required. In late 2021, for example, it was transported to RWE's Niederaussem facility in Germany to conduct solvent testing alongside RWE's larger scale CO_2 capture plant.

The Miniplant supports initial steps in capture design, such as solvent development and process optimisation. It can be used to determine the absorption and desorption capacity of CO_2 capture solvents and is set up for continuous operation. It also allows for testing solvent stability when exposed to real flue gases (and their impurities).

Absorbing activities

The absorber column is divided into six sections: sump, four packed sections and top with the possibility of gas and liquid sampling in every section. Each packed section has a height of 510mm so three packing elements can be accommodated. Each section is connected using flanges. It is easy to modify the column height and, for example, include a dedicated glass section for visual inspection.

The top section of the absorber has been modified to be able to take isokinetic sampling for aerosol measurements. The gas can be analysed with an impactor or an FTIR for particle size distribution or composition, respectively, to evaluate the level of emissions and design suitable counter-measures.

The CO_2, amine and water content of absorption solvents is analysed offline using an ATR-FTIR, which is calibrated to each specific solvent and has a response time of less than a minute. TNO is currently developing an automated online measurement system based on the same principle, which would avoid the need to take samples.

The Microplant

TNO also has a "Microplant", a smaller scale version of the Miniplant with similar functionality but smaller dimensions and lower flow rates. The choice of plant size used depends on the operations required. While the smaller absorber height of the microplant (ca. 1m) limits the capture rate, it can be used to test the operability of solvents, which includes aspects such as identifying the maximum and minimum CO_2 loadings under varying conditions, foaming tendency and corrosivity potential.

Combatting oxidative degradation

The mini and micro plants offer several modular testing opportunities for carbon capture facilities, such as DORA (an oxygen removal membrane), activated carbon bed and a solvent reclaimer to maintain solvent quality. Some of these can be coupled to the Miniplant and others are stand-alone equipment. Knowledge from such systems is being applied to several international projects, such as LAUNCH-CCUS, where various solvent degradation experiments were done with the Miniplant using different fresh and degraded solvents; these experiments used open solvents and results will be shared publicly to increase knowledge of solvent degradation and management strategies. This way, the mini and micro plants help to close knowledge gaps relating to solvent degradation.

Designing CO_2 capture for the waste-to-energy sector

For companies operating in various sectors, it is important to understand the composition of flue gases resulting from their industrial processes and which contaminants or impurities they contain. By measuring and analysing the flue gases with advanced equipment, an optimal, economical and viable design of CO_2 capture process can be determined.

In the NEWEST CCUS project, TNO's Miniplant was used to test a novel solvent. The solvent, a blend of ammonia and taurine, was capable of releasing CO_2 at pressures above 8 barg, which could be demonstrated due to the flexible design of the Miniplant, which allows for stripper operation up to 10 barg. State-of-the-art solvent systems normally release CO_2 between atmospheric pressure and 2 barg. Developing solvents that have the ability to work with higher pressures on the stripper side will bring cost savings in the subsequent compression unit (CO_2 needs to be compressed before it is transported – either as a liquid or a compressed gas).

The Miniplant's specifications

Miniplant details

- Solvent circulation flow rate: 5 to 50 l/hour
- Input gas flow rate: 1 to 5 Nm^3/hour
- Stripper pressure: max 10 barg
- Reboiler temperature: max 150°C
- Footprint: 1.5 m × 4 m = 6 m^2
- Maximum height: 7.5 m

Its advantages

- Analysis of solvent-flue gas interactions helps reduce scale up risks
- Permit acquisition process is facilitated by determining base emissions as well as emissions in dynamic operations
- Future operators gain first-hand experience of a full-scale CO_2 capture plant

Meet TNO's team & test facilities

CLICK ON FRAME TO PLAY VIDEO

The NEWEST-CCUS project (Project No. 299683) is co-funded by the ERA-NET Accelerating CCS Technologies initiative. The governments of each participating country have contributed funding through the ACT2 initiative.