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Covering the international oil and gas industry from field to forecourt – exploration, production, refining and marketing
Cracking carbon capture from oil refineries

Fluid catalytic cracking (FCC) units are one of the highest carbon dioxide (CO₂) emitting areas of an oil refinery. As a result, they are a major focus for those taking on the challenge of developing next generation carbon capture technologies for use by the oil and gas industry. Ivan Miracca, head of the CO₂ Capture Project (CCP) Capture Team provides an overview of one such project that aims to capture up to 95% of FCC CO₂ emissions - potentially equating to some 20% to 30% of total CO₂ emissions from a typical refinery.

The oil and gas industry has been using carbon dioxide (CO₂) sequestration techniques for many years, with the resulting CO₂ streams used for a variety of purposes, including enhanced oil recovery. However, as the world looks for ways to tackle climate change, the industry needs to identify and develop next generation capture technologies that will allow this sector to economically capture and store CO₂ on an industrial scale.

The CO₂ Capture Project (CCP) - a partnership of seven major energy companies: BP, Chevron, ConocoPhillips, Eni, Petrobras, Shell, Suncor and associate member EPRI - was formed in 2000 in a bid to advance the technologies that will underpin the deployment of industrial-scale CO₂ capture and storage (CCS). The CCP Capture Team, comprised of research and development experts from the member companies, has been working to develop a suite of economically viable next generation technologies. Much of this work has focused on applications in three critical areas for the oil and gas industry - refining operations, steam production for heavy oil extraction and natural gas power generation. This has involved conducting research into reducing cost uncertainties and identifying the best options to take forward for field demonstration.

This work is now entering the critical phase of field demonstrations and it is the oil and gas industry's view that this is the most important phase of these taking place. The target for this work is to get the highest emitting processes in a refinery - the fluid catalytic cracking (FCC) unit, which converts crude oil into valuable carbon feedstock - into lighter, more valuable products. The demonstration, led by Petrobras, began in March 2011 at a pilot-scale FCC unit at the company's refinery complex in Paraná state, Brazil. The demonstration is expected to continue for five years, with the aim of verifying the technical, economic viability of retrofitting such a unit to enable CO₂ capture through oxy-combustion. As a result, it is expected to bring closer to reality a cost-effective technology capable of capturing up to 95% of FCC CO₂ emissions, potentially equating to some 20% to 30% of total CO₂ emissions from a typical refinery.

Refinery emissions

Refineries are responsible for some 8% of total emissions of CO₂ from stationary sources worldwide (power stations account for more than 80%), amounting to 0.81bn t/y. The level of emissions from a single refinery depend on the specific process configuration and the mix of fuels used, but are broadly in the same range as emissions from a power station. For example, a world scale refinery processing 250,000 bbl/day of crude oil may emit between 44mn and 55mn t/y of CO₂ (35 to 43 t/y/tonne of crude oil). A small 3,5mn t/day refinery generating a 350 MW coal-fired power station. The carbon footprint of refineries is set to increase further as increasingly heavier oils are used as feedstock.

A typical refinery has a wide range of CO₂ emissions sources, including fired heaters, boilers and process units, as well as several stacks emitting flue gas to the atmosphere. In this multi-source environment, two major emitters are identified depending on the specific process scheme:

- The regenerator of the FCC unit.
- The hydrogen production unit (usually a steam reformer).

The CO₂ capture technologies for these two processes may account for up to 30% of CO₂ emissions. These are the main targets for a substantial reduction of greenhouse gas (GHG) emissions. Generally, both pre-combustion and oxyfiring are better candidates than post-combustion to capture CO₂ from the regenerator. While post-combustion would at least need one capture unit per plant, both pre-combustion and oxyfiring in theory would allow centralised capture, minimising concerns regarding pilot space availability that are typical in a space-constrained refinery application. However, in the FCC unit of a refinery, pre-combustion is not applicable (see details of CCP techno-economic evaluation below).

Capture in the FCC unit

In the FCC unit, CO₂ is generated by combustion of the coke formed as a by-product in the reactor and adiabated by the catalyst. This operation is necessary to restore catalyst activity and oxy-combustion is the only alternative to post-combustion, which is not possible under current conditions in the regenerator. The retro-fit of the unit for oxy-combustion involved the design, construction, and installation of an oxygen-blown oxy-combustion pilot plant, which would be in operation in the regenerator and allows simulation of a commercial FCC unit, including the energy balance. The retrofit of the unit for oxy-combustion operation involved the design, construction, and installation of an oxygen-blown oxy-combustion pilot plant, which would be in operation in the regenerator and allows simulation of a commercial FCC unit, including the energy balance.

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 CCS guidance and training at the EI

The Energy Institute (EI), together with the UK Health and Safety Executive, the Global CCS Institute and the Carbon Capture and Storage Association, has been working with industry to develop good practice for implementing CCS technology.

Coordinated as part of the EI Technical Work Programme, this project involved a wide range of participants from across the oil and gas, power and industrial sectors, including leading and emerging engineering industries. To date, two guidance documents have been produced as a result of this cooperation: Technical guidance on hazard analysis for oxy-combustion capture installations and onshore pipelines and Good plant design and operation, environmental and safety considerations, transport, selection of storage sites and reservoirs, leak management, monitoring and performance targets.

Future technical research

Further EI CCS technical guidance is currently in development and the EI CCS Working Group has begun work on two key projects: ‘Hazard analysis for oxy-combustion capture installations and offshore pipelines’ and ‘Failure rate data collection for CCS service equipment installation capture installations’. The first project covers hazard and risk analysis, modelling techniques and applications, as well as emergency procedures and requirements and practical examples. Only minimal research has been completed regarding failure of equipment

If you would like to be involved in any future EI CCS technical projects, contact Martin Macnab, EI Technical Director, m.macnab@energypublishing.org

The next EI CCS course is planned for 4-5 October 2011. For more information about EI Training, contact on: m.macnab@energypublishing.org.

EI CCS technical guidance documents are freely available to download at: www.energypublishing.org