CO_2 Capture Project®

PROJECT FACTSHEET

OXY-FIRING FLUID CATALYTIC CRACKING DEMONSTRATION

Results: Field testing of CO_2 Capture Technology for Oil Refineries

Oxy-Firing to Reduce FCC Emissions

As significant emitters of CO_2, oil refineries face unique and considerable challenges in managing their emissions. The major emitting sources from a typical refinery are heaters, boilers, hydrogen plants and fluid catalytic cracking units. This multi-source environment, with wide variation in the characteristics of the sources, requires a multi-faceted development approach for capture technology.

The FCC unit converts heavy, low-value hydrocarbon feedstock into lighter, more valuable products. Traditionally, air is used to regenerate the catalyst by burning off coke deposited on the catalyst during the conversion process. In the oxy-firing mode, air is replaced by pure oxygen, which is diluted with recycled CO_2 to maintain thermal balance and catalyst fluidization.

A techno-economic evaluation of oxy-firing and post-combustion amine absorption for CO_2 capture from the FCC regenerator had found that both processes are able to achieve the required specifications and recovery level. Although the post-combustion option had a lower capital cost, the lower operational costs for oxy-firing delivered a lower overall capture cost. Oxy-firing, though challenging, was chosen as the more promising capture technology to test in an FCC unit.

OVERVIEW

During 2012, the CO_2 Capture Project (CCP) undertook a field demonstration of oxy-firing capture technology on one of the processes in an oil refinery which generates the highest CO_2 emissions – the Fluid Catalytic Cracking (FCC) unit. The test brings closer to reality a cost-effective technology capable of capturing up to 95% of FCC CO_2 emissions, equating to some 20-30% of total CO_2 emissions from a typical refinery.

The demonstration took place in a large pilot scale FCC unit at a Petrobras research facility in Parana state, Brazil. It began in March 2011 and is now complete. The demonstration confirmed the technical viability of retrofitting an FCC unit to enable CO_2 capture through oxy-firing and is thus seen by the CCP as an effective technology for this purpose.

The key results were:

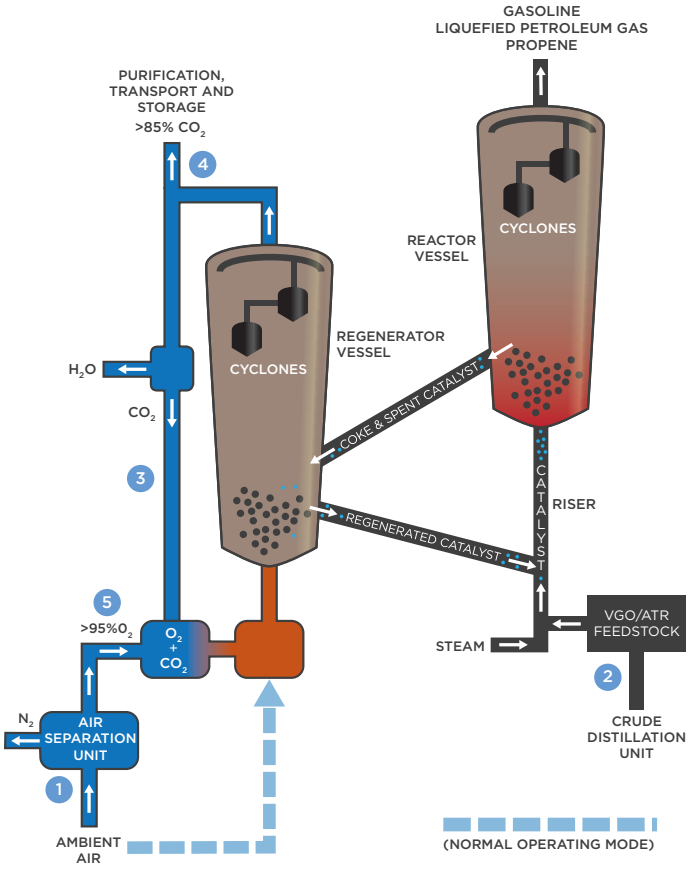
- Fast and smooth switch between air and oxy-firing
- Possible increase in production rate would help mitigate the cost of CO_2 capture
- CO_2 reached 93-95% (dry) concentrations during testing at the Petrobras research facility
- 99.7% O_2 concentrations were achieved at the Petrobras research facility through fine tuning the technology and operating mode
- Corrosion issues in the recycle system were fully understood and solved
- Efficient and stable operation confirmed oxy-firing as viable and economically competitive with post-combustion technology

THE PROJECT

Goals

The main goals of the project were:

- Test start-up and shut-down procedures
- Maintain stable operation of the FCC unit in oxy-firing mode
- Test different operational conditions and process configurations
- Obtain reliable data for scale-up



This diagram is a simplified representation of oxy-firing in an FCC unit. Numbers correspond to results achieved on the right.

Equipment

The pilot FCC unit has the capacity to process up to 33 bpd of hydrocarbon feed (emitting 1 ton/d of CO_2), and it consists of an adiabatic riser, stripper and regenerator, which allows simulation of a commercial FCC unit, including the energy balance.

The retrofit of the unit for oxy-firing operation involved the design, construction and installation of an Oxygen Supply System (OSS) and a CO_2 Recycle System (CRS). There was also a need to develop and design a control strategy for start-up and continuous operation.

The two systems consisted of the following equipment:

Oxygen Supply System (supplied by Linde Gas)

- Liquid O_2 tank
- Vaporizer system
- Flow and pressure control skid
- Gaseous O_2 injector
- Piping

CO_2 Recycle System (supplied by TecnoProject Latina)

- Catalyst fines and SO_x removal unit
- Recycle compressor
- CO_2 storage tank
- Gas analyzers
- Piping

RESULTS

1. Effective monitoring of excess oxygen in the flue gas resulted in a smooth and fast switch between air and oxy-firing
2. The difference in physical properties between nitrogen and CO_2 enabled flexibility of the plant through two methods – allowing either a higher hydrocarbon throughput (e.g. 10% higher flow-rate with the same conversion) or processing heavier feedstock (i.e. lower cost feeds keeping the same product yield). This flexibility of the plant would help mitigate the cost of CO_2 capture
3. Potential corrosion issues were revealed in the recycle system due to the presence of NO_2 and SO_2 impurities in the flue gas. These issues were fully understood and are manageable through proper design
4. CO_2 concentrations reached 93-95% in the tests. Further purification is needed and a dedicated test program may be required for optimization
5. 99.7% O_2 concentrations were achieved at the Petrobras research facility through fine tuning the technology and operating mode

Stable operation was successful in all conditions and the evaluations performed in parallel confirmed that oxy-combustion is viable and economically competitive with state-of-the-art post-combustion technology.

ABOUT THE CO_2 CAPTURE PROJECT

The CO_2 Capture Project (CCP) is an award-winning partnership of major energy companies working to advance the technologies that will underpin the deployment of industrial-scale CO_2 capture and storage. To find out more visit www.co2captureproject.org