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Lacq CCS pilot plant: Operational feedback of the surface facilities one year after start-up

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TOTAL is currently operating its Lacq CCS pilot plant to demonstrate the technical feasibility and reliability of a fully integrated CO_2 capture, compression, transportation, injection and geological storage scheme.

It entails the conversion of an existing steam gas-boiler into an oxy-gas combustion unit, oxygen delivered by an air separation unit being used for combustion rather than air to obtain a more concentrated CO_2 stream easier to capture. The 30 MWth oxy-boiler delivers up to 40 t/h of steam to the HP network of the Total Lacq sour gas production and treatment plant. After a quench of the flue gas steam, the rich CO_2 stream is compressed, dehydrated and transported via pipeline to a depleted gas field, 30 kilometers away, where it is injected. The CCS pilot plant under operation will capture and store up to 100,000 tons of CO_2 over a 2-year period.

After commissioning and fine tuning the individual operation of each piece of equipment, the retrofitted oxy-boiler and the whole pilot plant from oxygen production to CO_2 injection in the depleted gas field were fully operational in January 2010. Globally, the operation of the pilot plant has proven to be very satisfactory. The oxy-boiler start-up in air mode, switching from air to oxy mode and load variations up to full capacity have demonstrated to be robust and in-line with the predicted behaviour. The flue gas treatment, which mainly consists of cooling the stream to withdraw condensed water and thus concentrate CO_2 is also working on design. The molecular sieve dryers properly insure their role which consists of drastically lowering the CO_2 rich stream dew point to protect the carbon steel transportation pipe against corrosion.

The unique equipment in the whole CCS pilot plant which has proven to be more challenging to operate than the other components is the Lacq CO_2 rich stream compressor. All major parts of this three-stage reciprocating compressor are made of corrosion resistant material, apart from the compressor cylinders which are made of moulded cast iron. Because of their large sizes, the manufacturing of such cylinders in stainless steel would have been prohibitive with regards to fabrication constraints and cost. The suction chamber of the 3rd stage cylinder was rapidly and severely attacked by acid corrosion. On the other hand, the Rousse one stage reciprocating compressor

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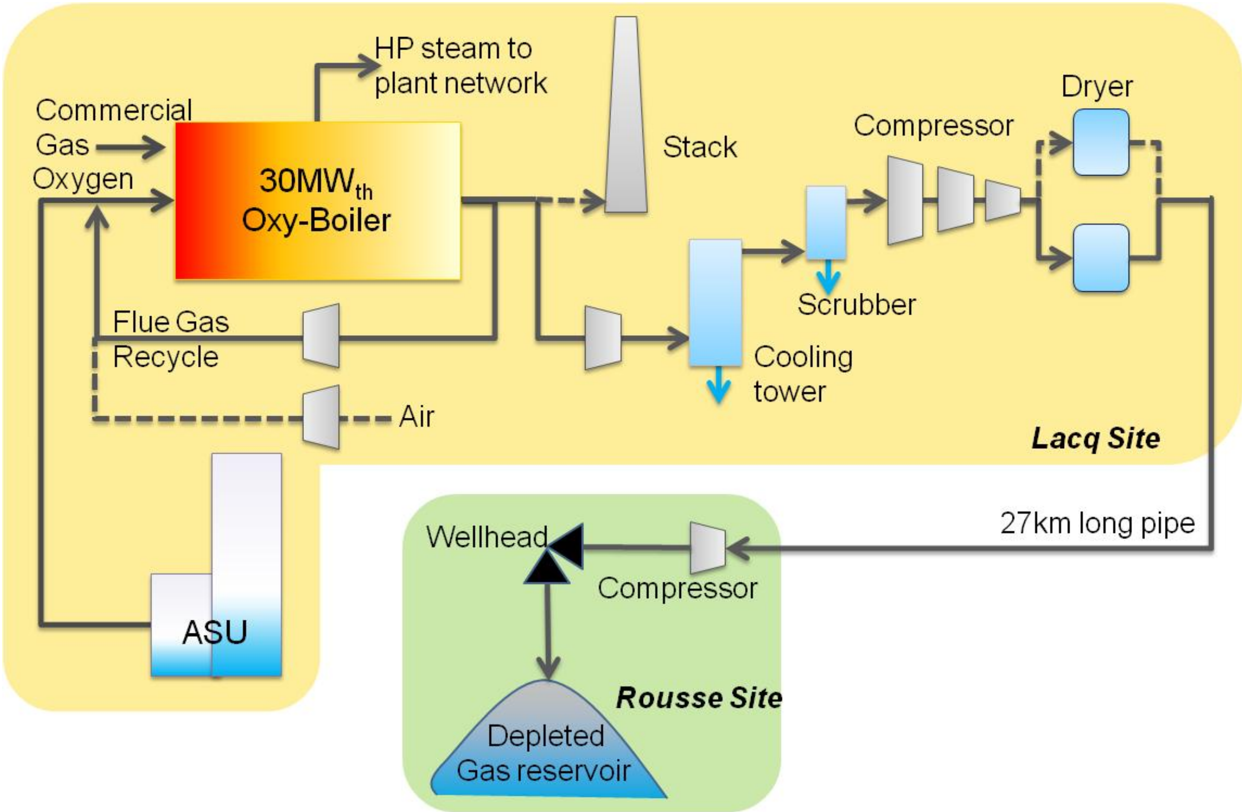
which is built with the same materials does not suffer any corrosion as it is located downstream the dryers and compresses dry CO_2.



The CO_2 rich stream that goes through the Lacq compressor is predominantly composed of CO_2, with second order concentrations of Ar, O_2 and N_2 (when ASU is delivering O_2 at a purity level of 95 or 98.5%), and parts per million of CO and NO_x. Last but not least, it is saturated with water. Therefore, to protect each compression stage from liquid condensation, scrubbers collect the condensed liquids. These scrubbers did not completely avoid liquid carry-over: some micro droplets are carried away with the gas flowing out of the scrubbers. Moreover, because of the small pressure drop and the convective heat losses (in cool climate conditions) between the outlets of the scrubbers and the compressor suction chambers, some condensation can occur. If CO_2 only was present, the dissolved part in the water would have made it slightly acidic (pH ~3.6 to 3.8), but with no major corrosion because of the low amount of water. This would not have led to the very destructive corrosion that occurred in the Lacq compressor. However liquid samples taken in the inter stage scrubbers were extremely acid. The analysis clearly indicated the presence of nitric acid caused by the dissolution of NO_2 in the liquid water from the residual amount of NO_x present in the gas phase.

In that way, the compression of CO_2 enriched flue gases from oxy combustion of gas proved to be very severe regarding corrosion of cast iron, because it contains parts per millions of nitrogen oxides (NO_x) and some residual free water from scrubbers and condensation between scrubbers and suction chambers. Even though no nitrogen is delivered by the air separation when it is operating at very high purity oxygen (99.5%vol.), small sources of nitrogen still enter the boiler: the commercial gas feeding the boiler contains around half a percent of nitrogen, and even though the retrofitted boiler operates slightly over atmospheric pressure, it is very difficult to completely avoid air in-leakages. Therefore, NO_x formation in the furnace is unavoidable, and whenever condensation occurs, the liquids become extremely acid. In the end, the only guarantee to avoid corrosion is to ensure that no condensation occurs in the compressor package, including the scrubbers.

Technical and operational solutions to overcome liquid carry-over and further condensation have been studied. Pros and cons were weighted, and decisions were made to implement the most relevant solutions to our Lacq CCS pilot plant to avoid this destructive corrosion in the compressor. After remediation, the pilot plant was back in operation. At first, the compressor was periodically shut down for inspections which did not reveal any new corrosion.

These past months, the steady operation of the pilot plant has demonstrated the effectiveness of the applied modifications. The Lacq CCS pilot plant is back on track to fulfil its objectives to demonstrate the operability of a fully integrated CCS scheme based on the oxy combustion CO_2 capture process.