Improving efficiency of CO_2 compression for CCS and EOR with reciprocating compressors and diaphragm pumps

Case study for 30 t/h CO_2 vs. 200 bar

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Today the main priority for the development and wide spread deployment of CO_2 capture and storage technology is to reduce the cost for capture, compression and transport.

In all Carbon Capture and Storage schemes the compression represents an important process step. It requires significant compression power to boost the pressure of the CO_2 after capture to typical pipeline levels. Reduction of the cost and power requirements for compression will encourage injection of CO2 both for existing and future power plants and other large CO_2 producing processes. Therefore current R&D activities are focused on developing and improving the energy- and cost-intensive sub processes of separation and compression.
In low pressure (< 150 bar) applications, the compression can be performed by multistage reciprocating or turbo compressors.
For high pressure applications depending on the specific characteristics of the injection process, it can be reasonable to utilize new concepts with part compression followed by liquefaction and pumping. Significant power savings in the compression step can be achieved with this tandem approach.

The poster presents the power saving of this combined solution, illustrated by an example for compressing 30t/h CO_2 from 2 bara to 200 bara.
The conventional way of compression, that is compression by compressor only, requires five compression stages for this application and results in a power demand of 3 MW. The approach of combining a reciprocating compressor with a high pressure pump consists of a reciprocating compressor with three stages, liquefaction of the CO_2 and a triplex diaphragm pump. The CO_2 is compressed to 70 bar in the compressor, subcooled to 25℃ and boosted to the final pressure of 200 bar by the pump in a single step. This combined path of compression reduces the power demand by 0,5 MW.
Depending on the ambient conditions, the overall power saving can therefore be up to 15% if cooling water is available. If active cooling is required, the power saving is still in the range of 5-8%.

Beside the efficiency improvement also the corrosion behaviour of CO_2 has to be considered at a pressure level around and above the critical point. To prevent liquid building during decompression (e.g. sealing elements and packing of the compressor) the temperature level shall be above 90℃. More severe is the risk of corrosion if the CO_2 is saturated with water. To avoid this corrosion problem, for the present process it is necessary to increase the suction temperature for stage 4, which, as a result, increases the number of stages and the power demand. As a consequence, the combination of reciprocating compressors and pumps for CO_2 compression also reduces corrosion issues for processes with discharge pressures above 100 bar.

Additionally, reciprocating machines offer advantages where process flexibility is an important criterion. Varying mass flows can be achieved by speed control in combination with valve unloading for reciprocating compressors, and by speed control for diaphragm pumps. Varying gas compositions, occurring in Enhanced Oil Recovery and Acid Gas Injection, can be handled easily by reciprocating compressors and pumps. And finally, a variation in discharge pressure does not require any adaption of the installation since the final pressure is accomplished by the pump in one single stage.

The combination of semi isothermal compression with reciprocating compressors, cooling, liquefaction and pumping with diaphragm pumps offers a high overall efficiency for compressing CO2 for mass flow rates up to 150 t/h and discharge pressure up to 500 bar.