Inventys - CO2 capture for $15 per tonne

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Inventys has developed a gas separation technology that it claims enables carbon dioxide to be captured from industrial flue gas streams for US $15 per tonne of CO2. Called the VeloxoTherm™ process, it has the ability to recover the heat energy evolved during adsorption and use it to help release the CO2.

The VeloxoTherm™ (velox = fast; therm = thermal) gas separation process is a post combustion carbon dioxide capture technology that has been developed by Inventys Thermal Technologies. The breakthrough gas separation technology enables carbon dioxide to be captured from industrial flue gas streams for 15US$ per tonne of CO2. Inventys is in the process of commercializing the technology for the enhanced oil recovery (EOR) market.

The VeloxoTherm™ process is an intensified temperature swing adsorption process that uses a proprietary structured adsorbent to separate CO2 from almost any industrial flue gas stream. Simply put, a structured adsorbent is a sorbent material which is arranged into a monolithic structure. The structured adsorbent used in the VeloxoTherm™ process resembles a honeycomb that preferentially traps CO2 while allowing other gases such as nitrogen and water vapor to pass through it. The favorable balance between hydraulic and transport properties achieved by structured adsorbents significantly increases the gas throughput of the system for a given amount of adsorbent (the specific productivity of the adsorbent). This intensification enables the VeloxoTherm™ TSA process to manage the very large volume of gas that must be processed from industrial flue gas streams encountered in post combustion CO2 capture applications.

How it Works

Fixed bed adsorption processes, like the VeloxoTherm™ process, can be intensified (made to be smaller and to be more efficient) by increasing the feed rate to the process by decreasing the cycle time of the process. The extent to which this approach can be implemented is limited by the pressure drop, mass transfer, and heat transfer characteristics of the adsorbent reactor, all of which are not favorable for a traditional arrangement of adsorbent – packed beds. The shortcomings of packed bed reactors inherently limit the performance of conventional sorbent systems and therefore these systems are not considered to be bona fide alternatives for the post combustion capture of carbon dioxide. Properly designed structured adsorbents can overcome the limitations of conventional sorbent-based separation processes and greatly enhance their performance and economics (Figure 1).

In sorbent separation systems, which use packed bed reactors, the reduction in cycle time decreases the working capacity per cycle, decreasing product recovery, and increasing pressure drop. However, structured adsorbents offer the ability to overcome the challenges encountered when the cycle time of the process is decreased.

Structured adsorbents by their nature are immobilized, so fluidization is nonexistent. Also, correctly designed structured adsorbents provide lower pressure drop per unit length than a packed bed of adsorbent, so for low pressure applications, such as post combustion CO2 capture, they are ideal. In addition, structured adsorbents with high cell densities give proportionally better performance than packed beds because of their higher geometrical surface area. Thus structured adsorbents are among the most efficient methods available to pack high adsorbent surface area into a fixed volume while still maintaining low pressure drop.

Numerous studies have been undertaken to evaluate the mass transfer and pressure drop characteristics of monoliths in adsorption applications. However, the effect of thermal management in adsorptive efficiency has not been investigated to the same extent. The enhancement in performance gained by understanding the thermal effects in adsorbent structures is at the heart of Inventys' expertise.

Adsorption is an exothermic (heat producing) process. When CO2 molecules accumulate on the surface of the structured adsorbent, heat is evolved. When CO2 molecules disperse from the surface during regeneration just the opposite occurs - heat is consumed. As the cycle time of adsorption systems is reduced, management of heat flow during adsorption and desorption becomes increasingly important so that the benefits of superior mass transfer and hydrodynamic benefits offered by structured adsorbents can be realized.

Temperature affects adsorption and desorption detrimentally, reducing capacity on adsorption and decreasing it on desorption. Thus the challenge in designing an effective structured adsorbent is to ensure that heat energy is readily dispersed during adsorption to avoid its accumulation and the resulting increase in temperature. During desorption, the structured adsorbent must rapidly transfer heat energy from the regenerate stream to the sorbent to affect its regeneration.

Monolithic, thin walled structured adsorbents are ideally suited for achieving the required rapid heating and cooling requirement in a rapid thermal swing adsorption processes. The structured adsorbent developed by Inventys for the VeloxoTherm™ process, however, goes one step further – it has the unique ability to recover the heat energy evolved during adsorption and supply this heat energy to the adsorbent during regeneration. This feature is responsible for the low amount of energy required for adsorbent regeneration – less than 1.5 GJ/tonne of CO2 and is an important factor responsible for the very low net energy consumption for the process.

A proven machine for a novel process

The VeloxoTherm process is unlike conventional adsorption processes that have two or more adsorption reactors operating in an adsorption cycle, which is driven by a series of valves. In the VeloxoTherm process the structured adsorbents are fixed in a cylindrical frame which rotates. The frame is divided into at least two zones. In the adsorption zone, flue gas enters and CO2 is captured from the stream. As the frame rotates, the structured adsorbents pass into the regeneration zone where low-pressure steam is used to release the captured CO2 (Figure 2). Because the separation process operates near ambient pressure, a simple sealing mechanism can be used to isolate the adsorption and regeneration zones.

The rotary adsorption machine replaces discrete adsorption vessels and the accompanying complex arrangement of valves and piping. This embodiment has several advantages. The rotary adsorption machine is a simple, inexpensive, and a proven design. Machines of a similar form and function have demonstrated their reliability and simplicity of operation for many years (rotary heat exchangers which have an analogous more of operation are used in the power gen-eration industry for pre-heating combustion air).

Second, the rotary adsorption machine can readily be integrated into new and existing chemical processes (heaters, boilers, crackers, cement kilns, blast furnaces, and gas turbines) because it is not tightly integrated into existing plant operations. Any industrial facility can continue normal operations during the installation, commissioning, and maintenance of the VeloxoTherm plant.

Third, the VeloxoTherm process is readily scalable. Any number of structures can be assembled to construct a VeloxoTherm plant of nearly any capacity; a plant capacity of 100 tonnes per day of CO2, which would be emitted from a typical process heater in a refinery, would be approximately three meters in diameter whereas a 80 meter diameter VeloxoTherm plant would be capable of processing 5 megatonnes of CO2 annually. Having a projected capital cost of US$132-million, a VeloxoTherm plant of this capacity would be suitable for installation on a 500megaWatt pulverized coal fired power plant.

CO2 Enhanced Oil Recovery

After applying primary and secondary extraction techniques, a considerable amount of oil remains trapped in the geological formations of oil reservoirs. In some instances, more than sixty percent of the original oil in place (OOIP) remains stranded at the conclusion of conventional production. Enhanced Oil Recovery (EOR) using CO2 provides a means to extract further oil from otherwise depleted oil assets. CO2 injected into a mature well acts as a solvent that enables the trapped oil to flow to the production well, typically enabling the extraction of an additional 20% of OOIP (Figure 3). In the Unit-ed States alone, CO2-EOR would produce approximately 85-billion barrels incremental oil production.

Natural sources of CO2 are limited both in quantity and geography. The largest natural CO2 sources in the United States are located near the Permian basin whereas opportunities for EOR projects exist in various places across North America. However, there is an abundance CO2 contained in industrial flue gases originating from point sources that are distributed across the North American continent. CO2-EOR offers a compelling opportunity to use the CO2 contained in flue gas streams for enhanced oil extraction while circumventing costly transportation of CO2 from a centralized CO2 source (Figure 4).

The VeloxoTherm process is able to capture CO2 from nearly any industrial flue gas stream for a total cost (operating + capital) of 5 US$ per barrel of oil recovered, which is equivalent to a capture cost of 15 US$/tonne of CO2. The VeloxoTherm™ process presents purified CO2 at low pressure so compression and transportation are required for use in EOR applications. This will translate into a field-delivered price of approximately 35US$/tonne of CO2, depending, on the nature of the EOR project (the cost for compression and transportation are, of course, application and EOR site specific).

More information

Inventys Thermal Technologies is located in Vancouver, British Columbia and the company is working with some of the world's largest energy companies to demonstrate the VeloxoTherm™ process. The company was recently awarded 1.9M$ Sustainable Development Technology Canada (SDTC) to demonstrate the VeloxoTherm™ process with its consortia partners, which include Suncor Energy, Doosan Babcock, and British Petroleum.

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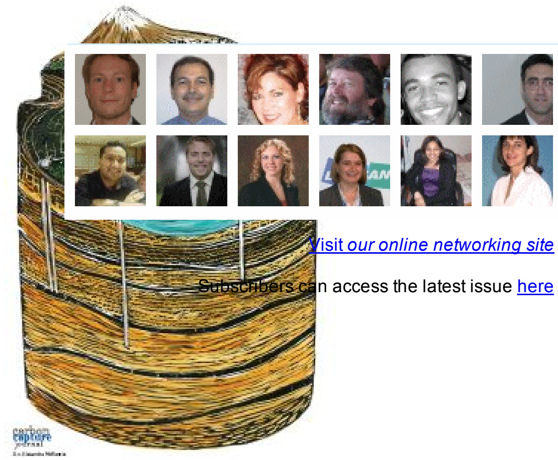

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