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New Process Recovers NGLs From CO_2

By Naomi Baker

HOUSTON–Producers have been utilizing carbon dioxide-enhanced oil recovery since the early 1980s in the Permian Basin, Gulf Coast, Rocky Mountains and elsewhere in the United States. Not only is CO_2 being injected today into oil formations in mature fields, but the emergence of residual oil zones beneath the oil/water contact in areas such as West Texas and Wyoming offers vast potential for CO_2 EOR in the future.

In a CO_2 flood operation, the produced oil and water are separated, and the CO_2 is recompressed and reinjected into the formation. In many cases, however, the reinjected CO_2 contains appreciable amounts of light hydrocarbons–primarily propanes, butanes and pentanes–as well as some methane, ethane and nitrogen. In the past, the processes for capturing these valuable hydrocarbons from the CO_2 stream either have recovered only limited amounts or have been prohibitively expensive.

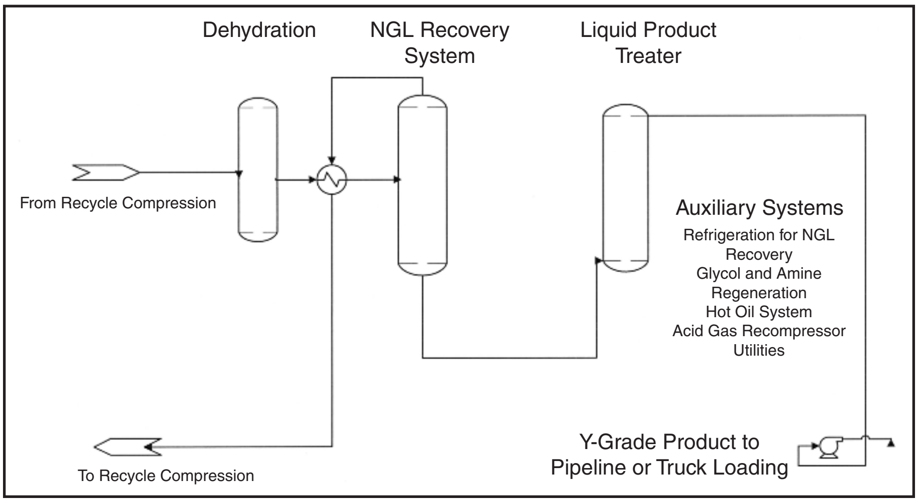
There have been several methods developed for recovering the recycled natural gas liquids, and in some cases also separating the methane and ethane components.

The most common recovery method is simple refrigeration. In this case, the CO_2 reinjection stream is chilled using propane refrigeration. Condensed NGLs are treated for CO_2 (and hydrogen sulfide, if present), utilizing a liquid-amine treater, and are sold. Although easy to operate and relatively inexpensive, this method recovers only 20-50 percent of the hydrocarbons.

An economic benefit of refrigeration systems is that the CO_2 reinjection has a very low pressure drop, eliminating the need for additional recompression, which adds materially to the capital and operating costs.

FIGURE 1

Refrigerated Fractionation Process
Pilot Ceritas CO_2 LLC



Another method frequently employed is a combination of membranes and amine treating. In these hybrid systems, the high-CO_2 stream is compressed and then processed through a permeable membrane, where bulk CO_2 removal results in a low-pressure CO_2 permeate and a higher-pressure, hydrocarbon-rich residual stream that still contains significant CO_2. The hydrocarbon stream is sent to a traditional amine system to treat for further CO_2 removal, which then is sent to sales or to an NGL recovery plant such as a cryogenic unit.

Costs associated with operating a hybrid system include significant pretreating of the feed, in some cases including prechilling, hydrocarbon adsorbents, and dehydration. The CO_2-rich permeate and the amine regeneration still are at low pressure, and must be recompressed at several stages to be used for CO_2 reinjection. These systems are very expensive to build and operate, and only on rare occasions will pay out based on hydrocarbon recovery.

A more elaborate CO_2 removal process is a Ryan-Holmes type system, or a variation of this process. Depending on the desired end products (pure methane, pure CO_2, NGL streams, or CO_2 and NGLs), the Ryan-Holmes process can have up to four distillation columns. The plant uses an additive (lean oil) to break CO_2/ethane azeotropes. Like the hybrid system, these also are very expensive and usually are not economic.

Refrigerated Fractionation

An advanced new solution is available now that has been developed specifically to process nontraditional and niche markets in EOR floods. This proprietary technology was introduced in 2009 to assist companies

A patented refrigerated fractionation system was developed to recover natural gas liquids from the carbon dioxide-reinjection streams in tertiary oil recovery operations. The process plants for the new NGL recovery method typically cost between $500 and $700 an Mcf, depending on location and gas composition.

in building and operating processing facilities to capture recoverable hydrocarbons from the CO_2 reinjection streams.

Several new projects using this patented process are being implemented to recover NGLs from high-CO_2 natural gas streams. The objective is to provide third-party, owner-operated processing services to producers, to allow them to enhance the value of their EOR fields by increasing production volumes and cash flows without incurring any incremental capital costs.

The process utilizes a refrigerated fractionation system to remove the recoverable NGLs from the CO_2 stream, rather than removing the CO_2 from the hydrocarbons (Figure 1). Because the refrigeration horsepower is the largest operating cost, a careful analysis is conducted on each potential project to determine what level of propane recovery will support the increased costs of refrigeration compressor and utility usage.

In some cases, the propane recovery may be slightly lower than what can be achieved with other processes, but such analyses frequently show that the incremental per-gallon cost of recovery is not economical, based on propane prices. In these cases, the optimum propane recovery is targeted, rather than maximum propane recovery.

This NGL recovery process was developed with an economic perspective from the beginning. Typically, independents–especially smaller producers–are not interested in processing and prefer to focus on their core business: producing oil and gas. They are interested in generating additional revenue from recovered NGLs, but are not necessarily interested in operating plants, and certainly do not want to have production disrupted.

The CO_2 reinjection stream is compressed through several stages by the producer, from an inlet of 20-200 psi to a reinjection pressure of 1,500 psi or higher, depending on the reservoir. The NGL recovery plant is situated interstage at a pressure between 300 and 650 psi. Existing compression is not changed; a series of automated bypass valves is installed, which allows the reinjection gas to flow to either the plant or the subsequent stage of compression.

In the plant, the gas is dehydrated first, and then fed to a fractionation column. The column is refluxed through a refrigerated condenser, and is reboiled with a heat medium. The overhead contains essentially all of the original CO_2, methane, ethane, and a portion of the propane. The NGL bottoms contain nearly all of the butanes and heavier hydrocarbon products, the recovered propane, and an equilibrium amount of CO_2 (and H_2S, if present).

The NGLs then are treated with a standard amine-liquid system, and are sent to a pipeline or tanks for truck loading and ultimate sale. The product is an ethane-free liquid petroleum gas mix with a vapor pressure well under 200 psi.

In addition to the fractionation, a tightly integrated system of heat exchangers and separators minimizes utilities and allows propane recovery levels to be customized. The dehydrated overhead is delivered back to the producer at 10-15 degrees Fahrenheit cooler and 10-20 psi lower pressure than it was received at the plant inlet. The amine regeneration overhead can be compressed and returned to the reinjection stream, if necessary. However, because of the very low volumes, this gas frequently is vented or flared. Emissions from the plant are limited to the heat medium heater and volatile organic compounds.

Case Studies

The first plant to use the new process

The refrigerated fractionation system utilizes a tightly integrated system of heat exchangers and separators to minimize utility costs and allow customized propane recovery levels. The first plant to use the new process was located in Sweetwater County, Wy., followed by a plant in Ector County, Tx.

was a 20 million cubic-foot-a-day CO_2 flood located in Sweetwater County, Wy. Installed in 2006, the plant has been running continuously. The CO_2 injection stream has very low hydrocarbon content, but consistently produces 140-180 barrels of natural gas liquids a day.

The second plant is located in the San Andres formation in West Texas. This plant, which is located adjacent to Legado Resources' CO_2 operations in Ector County, began operations in 2012. Based on analyses from Legado's early phased development work, the 30 MMcf/d plant will produce more than 800 bbl/d of NGLs.

An additional stabilizer has been added at this location, which will allow about 60 percent of the NGL product to be blended into the company's crude oil stream, thereby increasing revenue by upgrading the product, and avoiding trucking, transportation and fractionation fees. Plans include building an additional 50 MMcf/d train as Legado expands its EOR acreage.

A "mini" plant with a 1.2 MMcf/d capacity, designed for a one-well CO_2 flood, also has been constructed and is operating in West Texas on an older flood owned by an independent operator.

Cost Comparisons

Generally, amine/membrane hybrids are considerably more expensive and complicated to operate, can require significant preconditioning of the gas–including chilling–and can cost up to $2,000 an Mcf to install. The CO_2 must be recompressed after permeation, and it usually is not cost effective to make the methane saleable. The process plants for the new NGL recovery method have costs between $500 and $700 an Mcf, depending on location and gas composition.

Refrigeration systems have lower installed costs than does an NGL recovery plant, but do not offer the NGL recoveries available with other technologies.

A four-column Ryan-Holmes process is also extremely expensive, complicated, and is rarely built. For sake of analysis, the refrigerated fractionation process has been compared with a one-column Ryan-Holmes facility using online data collected in 2008.

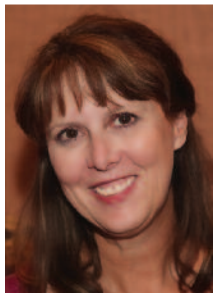
According to the report, the Ryan-Holmes one-column plant (RHOC) processed 35 MMcf/d of gas with an 86 percent CO_2 content. The stated production rate was 511 bbl/d of NGLs, using 3,500 horsepower of refrigeration.

Using the well-tested models for the new NGL recovery process, we determined that 1,400 hp would provide enough refrigeration to produce 848 bbl/d, with a propane recovery of 40 percent, and essentially 100 percent recovery of the heavier components. Based on the publicly available data on the RHOC, including screen shots of the PLC control panel, the tower for the new NGL recovery process has one-third as many trays as the RHOC, and uses a hot oil temperature approximately 100 degrees F lower than the reported temperature at the RHOC.

Significantly, at $0.05 a kilowatt-hour, the electricity to operate the RHOC costs $735,000 more than the plant utilizing the new NGL recovery method (assuming 100 percent utilization year round). The report did state that the RHOC was not operating efficiently at the time, but even if the NGL production was equal to the new plant design, it would require 2.5 times more refrigeration horsepower and more heat in the reboiler.

Many CO_2 EOR floods have recoverable hydrocarbons that are recycled with the CO_2 injection stream, which have not always been economic using older technologies. For producers interested in the bottom line, this proven process offers high recoveries at a low cost. Installations can be structured to have limited operational impact on an EOR flood while adding to production, reserves and cash flow.

With well developed analytical models and operational experience, we can quickly evaluate the applicability of the process to any EOR field and provide the specific incremental benefit that can accrue to it, typically at no cost to the producer. ❒



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Naomi Baker is director of engineering and operations at Pilot Energy Solutions LLC. The company was formed in 2009 to build and operate facilities to capture hydrocarbons from CO2 reinjection streams, utilizing a patented refrigerated fractionation process. Baker has 30 years of experience in natural gas processing, project management and operations with Amoco, Phillips (GPM), and Enbridge Energy. She is co-holder of two patents. Baker earned a B.S. in chemical engineering from Texas Tech University.