CHEMSYSTEMS
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Report Abstract

NGL Extraction Technologies
PERP06/07S10

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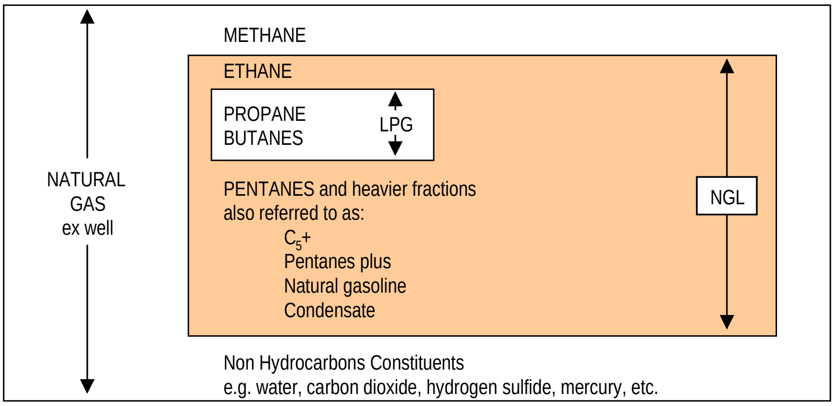
For further information about these reports contact Dr. Jeffrey S. Plotkin, Vice President and Global Director, PERP Program, phone: 1-914-609-0315; fax: 1-914-609-0399; e-mail: jplotkin@nexant.com; or Heidi Junker Coleman, phone: 1-914-609-0381, e-mail address: hcoleman@nexant.com, Website: http://www.chemsystems.com.

INTRODUCTION

In the early years of the petroleum industry, most of the natural gas production was flared or simply vented into the atmosphere due to a lack of economical technologies for its transport to the market. Over the years, pipeline welding techniques were developed such that natural gas could be transported across longer distances to the consumer's site. This coincided with the development of the plastics industry, which since the 1950s has boosted demand for natural gas as an industrial feedstock and fuel. Residential and commercial demand has also developed as gas pipeline networks became more extensive and efficient.

Natural gas is a naturally occurring hydrocarbon mixture of mainly methane, heavier hydrocarbon components such as ethane, propane and butane, and other components such as nitrogen, carbon dioxide, mercury, etc. The hydrocarbon components of natural gas, other than methane, are collectively referred to as natural gas liquids or NGL as they are easily transported as liquid, either as refrigerated or pressurized liquids. Natural gas liquids - see Figure below - are widely used in the petrochemical industry and are also widely used as fuel for commercial or domestic applications, particularly in areas where natural gas networks do not exist.

Natural Gas Liquids



LPG = Liquefied Petroleum Gas NGL = Natural Gas Liquids

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NGL can be recovered from natural gas via a process called NGL extraction. However, there is a wide degree of choice on the depth of extraction of hydrocarbon liquids chosen in process design, with the decision dependent on feed gas composition, temperature, pressure, sales gas specification and also other factors such as the project economics, environmental regulations and the target market. For example, NGL may not need to be extracted to meet sales gas specification in the case of a very lean feed gas. On-purpose ethane extraction is generally considered to be economically viable only if it can then be used as feedstock for ethylene production in steam crackers. In general terms, ethane extraction will be economically viable if the generation of its derivatives is more attractive than its fuel value (as a sales gas component). The same applies for the extraction of other NGL fractions such as liquefied petroleum gases (LPG).

Consequently, depending on the gas composition exiting the separator, sales gas specification and overall project economics, the recovery of natural gas liquids from natural gas streams can range from simple hydrocarbon dew pointing (aimed primarily at gas transportation rather than NGL recovery) to complex NGL recovery including deep ethane extraction. The desired degree of liquid recovery has a profound effect on process selection, complexity, and cost of the processing facility. Consequently, natural gas liquid (NGL) extraction schemes are generally custom-chosen, and the unit size can vary from relatively small-scale packaged units to very large installations.

In addition, it is important to note that the type of NGL recovery process employed has a significant effect on the level of pre-treatment required. The major options available for hydrocarbon dew pointing and NGL extraction are cooling of the feed gas, absorption of hydrocarbon in a solvent, and adsorption of heavy hydrocarbon onto a solid desiccant. These various technologies can also be combined for improved hydrocarbon recovery, where for example, a cryogenic process can use absorption in the de-methanizer or another column, and enhanced absorption processes can also incorporate a refrigeration step.

This report provides a review of the commercially available technology options that are available for the extraction of natural gas liquids from natural gas streams (Section 3 and Section 4), while also looking at the future trends in technology development (Section 5). Section 6 explores the economics of NGL extraction, while Section 7 gives an overview of the markets for NGL.

NGL EXTRACTION TECHNOLOGIES

Natural gas liquids have three main industrial uses. They can be used as fuels, petrochemical feedstocks or as refinery blends that can be further processed and sold as straight run cuts, such as naphtha, kerosene and gas oil. Alternatively NGL can be left with the methane, where they add thermal value to the sales gas, or subsequently extracted for petrochemical uses.

NGL extraction is not a chemical reaction. It involves separation of heavier hydrocarbons from the main gas stream through pressure and temperature reduction, which depending on the degree of NGL extraction may involve a cryogenic process. The process design is based on vapor/liquid phase behavior, hydrocarbon mixture phase envelope, thermodynamic data, correlations, and well-developed computer simulation packages.

Following offshore or onshore production, the well fluid is typically routed to a gas separation facility. Gas separation, which involves the separation of free hydrocarbon liquids and water from the gas stream, can be accomplished onshore or offshore, whereas, gas treating and processing is typically performed onshore.

Pre-treatment of the feed gas from a typical well stream - a high velocity, turbulent, constantly expanding mixture of gases and hydrocarbon liquids, mixed with water, solids and other contaminants; and factors determining the degree of NGL Extraction from a natural gas stream are also important and briefly outlined in the report.

The NGL extraction technologies that are the focus of this section are categorized as follows:

- Cooling based processes:
  - Low temperature separation (LTS)
  - Mechanical refrigeration
  - Turbo expansion
- Other Processes:
  - Lean oil absorption
  - Solvent absorption
  - Solid bed adsorption

Cooling Based Processes

NGL extraction to meet sales gas specifications is typically achieved using low temperature separation and mechanical refrigeration systems, which are typically intended for applications where moderate to high propane recoveries are desired, whereas, high propane and deep ethane extraction would often require cooling the gas down to cryogenic temperatures. Cryogenic temperatures (lower than -42ºC, boiling point of propane at atmospheric pressure) would typically be achieved using a combination of pressure expansion and refrigeration. The three main methods used for NGL extraction via cooling of the feed gas discussed in this report are:

- Low Temperature Separation (LTS), Joule-Thomson based processes with or without glycol injection
- Turbo expansion
- Mechanical refrigeration.

Other Processes

Non-cooling processes have not typically been the preferred option after the development of the turbo-expander processes for propane and ethane extraction in the 1980s. However, these non-cooling processes should still be considered at the conceptual design stage of project implementation as they may prove to provide the optimal solution in certain applications.

The non-cooling processes described in this section are as follows:

- absorption in a heavier hydrocarbon liquid, known as the Lean Oil Absorption process
- absorption processes that use a physical solvent for the selective recovery of desirable hydrocarbons from a gas stream, known as the Solvent Absorption process
- adsorption processes that use a solid desiccant for the adsorption of heavy hydrocarbons.

Main Considerations in Process Choice and Design

As previously discussed, several processes exist for the extraction of NGL from a gaseous hydrocarbon stream, all of which have different design characteristics and optimum performance criteria. The comparison of various processes is only possible under a specific set of criteria which include: inlet conditions such as feed gas composition and pressure; downstream conditions such as the level of NGL recovery desired; product specification; residue gas pressure; and overall conditions such as ambient conditions, availability of utilities, plant location and market conditions.

A widely accepted means of comparing process design is the total compression power required by the process. This provides a rough measure of the plant's capital and operating costs because compression makes up a large percentage of capital and operating (fuel and maintenance) costs. The process power requirements are typically expressed in terms of MW per MMSCFD and are typically evaluated for each process option under consideration based on the plant owner specifications.

The impact of feed gas pressure, feed gas pressure decline, inlet composition, and level of NGL recovery on the process performance, compression power requirement, and process choice and design are described in further details in this section.

Natural Gas Liquids Fractionation

Once recovered, an NGL stream can be further treated and fractionated to take full advantage of the potential value of its individual constituents, which include ethane, propane, normal and isobutane and a heavier components stream, often referred to as natural gasoline. Fractionation may either be undertaken at the same location as the NGL extraction plant or the recovered NGL mixture can be transported to a separate site for fractionation. The decision to fractionate the NGL stream at a particular location will be based on economic factors such as the location of the main market for the products, the price of individual components, the volume produced, and the transportation costs.

This topic is discussed further in this section.

LICENSED TECHNOLOGIES

As a general rule, a gas processing plant will be a combination of several units, all of which can be either "Open Art Design" or licensed technologies. A gas plant can, for example, be split into an acid gas removal unit, a dehydration unit, a condensate recovery unit, a natural gas liquids (NGL) recovery unit, and an LNG liquefaction train (where applicable). Each unit can then be design independently using the various technologies available or using proprietary designs, patents and/or licenses processes.

Over 30 NGL recovery processes have been identified as part of this study, and all are available either as a licensed process or in the general public domain. The number of processes continues to proliferate as evidenced by the number of patents issued in the past few years.

It is important to note that the selection of which NGL extraction process to use is very project specific and will depend on the feed gas conditions and composition, the availability and cost of fuel and energy, product specifications, and the relative product values and markets. This section discusses the available technology options that are considered at the forefront for new and retrofitted NGL extraction plants.

EMERGING TECHNOLOGIES

Traditional technologies such as mechanical refrigeration, turbo-expenders and specialty solvent methods for NGL extraction are being developed to reduce equipment size, improve process intensification, reduce energy requirements and lower capital expenditure. Focus has been on the development of supersonic separation, membranes technologies, and new generations of integrated cryogenic plants.

The integration of commercially proven and efficient processes to optimize production and reduce costs is in itself a technological innovation that is being driven by the expanding global gas market and the need to satisfy widely different consumer specifications.

In this section a discussion of emerging technologies and applications in the field of NGL extraction from a natural gas stream is given and focuses on the following developments:

- Supersonic Technologies
- Membrane Technologies, and finally
- The integration of NGL extraction with Liquefied Natural Gas (LNG) production.

ECONOMIC ANALYSIS

Gas processing project economics are dependent on the sale of recovered NGL products from the gas in cases where hydrocarbons are more valuable as liquids than they are as gas, but also where removal of heavier hydrocarbons is necessary to make the residue gas marketable, i.e. meet pipeline specifications.

Thus the economic evaluation of gas processing can be a complex matter, and a number of possibilities exist for comparing and contrasting the costs associated with natural gas processing to meet sales gas (pipeline) specification. This is due to the variety of process technology available and the number of applications to which each technology may be applied (i.e. various degree of treatment possible). The feed gas or wellhead gas composition, pressure and temperature as well as the level of treatment required will greatly influence the choice of technology to be used and typically more than one method may be technically appropriate for a given feed gas composition and sales gas specification.

In Sections 3 and 4, several different processes for NGL extraction have been discussed in detail, which would achieve a defined sales gas specification based on the chosen feed gas composition, temperature and pressure. The capital and operating costs for two of these processes has been analyzed in depth in this Section. Specifically, ChemSystems has analyzed the cost of NGL production for new build gas processing facilities:

- using dew point control to meet sales gas specification (**mechanical refrigeration**), and
- involving deeper extraction of NGL together with ethane removal, to monetize the heat content of the feed gas and to meet sales gas specification (**turbo expansion**).

The cost of production analysis presented uses a U.S. $ per ton of NGL basis and therefore seeks to identify the price of the NGL product at which its production becomes feasible for the given gas composition, and other assumptions such as plant locations, NGL recoveries, rates of return etc.

Since the main contributor to the relative economics of these two processes is the variable cost, ChemSystems investigated the effect of varying ethane prices on the costs of NGL production.

Another contributor to the variable costs of NGL production is shrinkage and thus the price of sales gas. The effect of varying sales gas prices on the economics of the two NGL extraction processes has therefore been investigated as well.

COMMERCIAL ANALYSIS

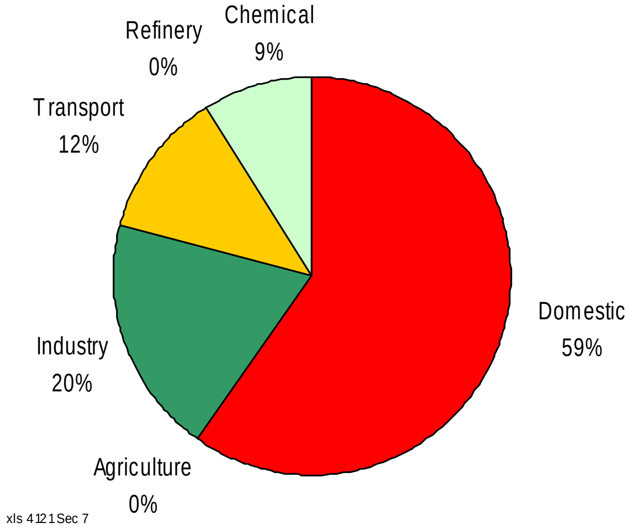
This section provides a review of the markets of Natural Gas Liquids (NGL), and is preceded by a presentation of the general market characteristics.

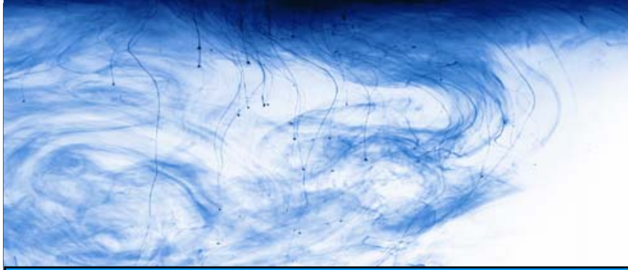
Nearly all ethane that is produced comes from natural gas. Small amounts are also produced from steam cracking of naphtha and gas oil and from refinery operations. Ethane is sometimes sold as a component of sales (pipeline) gas, but where there exist sufficient quantities, it is usually desirable to extract the ethane for sale as a cracker feedstock. There is very little global trade in ethane.

General market characteristics for LPG and Natural Gasoline/Condensate are outlined. The figure below shows a breakdown of the LPG demand by end-use in Asia Pacific

- supply and demand for the United States, Western Europe and Asia Pacific are discussed
- supply, demand and trade data for the United States, Western Europe and Asia Pacific are given.

Asia Pacific LPG End-Use Pattern





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