

Author:

Jorge Foglietta, ABB Randall Corporation
Tel (713) 821-4313, Fax (713) 821-3544

Mailing Address:

Randall Division
ABB Lummus Global Inc.
P.O. Box 420087
Houston, Texas 77242-0087

NEW PROCESS SCHEME FOR HIGH NGL RECOVERY

Abstract

The competitive scenario of the oil and gas market is a challenge for today's plant designers to achieve designs that meet client expectations with shrinking budgets, safety requirements and operating flexibility.

A new process scheme for the recovery of NGL has been developed and patented (US Pat 5,890.377).

This paper describes the process fundamentals of this development, different options of its use, flexibility of operation in ethane rejection or recovery, process controls, and how existing units could be easily revamped to this scheme.

The innovation of this process is that it does not use the typical inlet gas feed split type of flow arrangement to reboil the demethanizer or deethanizer column, but instead uses an open heat pump scheme to that effect. The residue gas compressor provides the heat pump effect. The heat pump stream is then further cooled and entered in the top section of the column as a cold reflux. Product recoveries are above 95% for ethane plus product, or 99% for LPG production. Because of the nature of this design, this process offers the opportunity to operate at full ethane rejection or recovery. The scheme is also very adaptable to revamp existing facilities.

NEW RECYCLE PROCESS SCHEME FOR HIGH ETHANE RECOVERY

Jorge H. Foglietta
Randall Division of ABB Lummus Global Inc.
Houston, Texas

INTRODUCTION

The gas processing industry's dynamic climate is a challenge for today's plant designers. Aggressive design solutions have to meet competitive scenarios and operating flexibility.

A new process scheme for the recovery of NGL has been developed to provide an alternative processing scheme for high ethane recovery (U.S. Pat 5,890,377). This process uses a recycle stream to reboil the cryogenic column and provide a reflux to achieve product recoveries above 95% for ethane plus product, or 99% for propane plus production. The scheme is especially well suited for semi-rich to lean gas streams. In combination with the traditional processing scheme, it provides flexibility for application with rich gas streams.

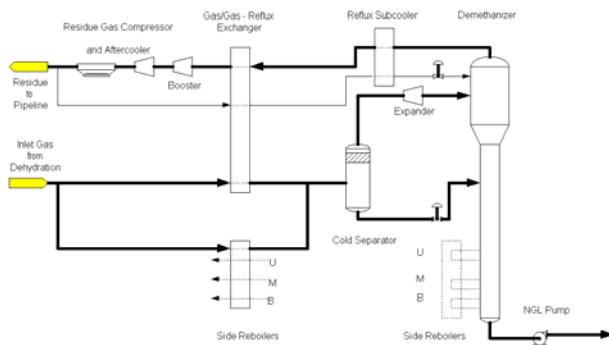
This paper describes the process fundamentals of this development and the different options of application. It also describes the flexibility of operation in ethane rejection or recovery mode, the required process controls, and the simplicity to retrofit or revamp old units.

PROCESS FUNDAMENTALS

Traditionally, cryogenic plants provide reboiling to demethanizers by using part of inlet feed gas, or **inlet feed split** (see fig. 1). If the two stream temperatures are not similar, there is lost work in the mixing operation

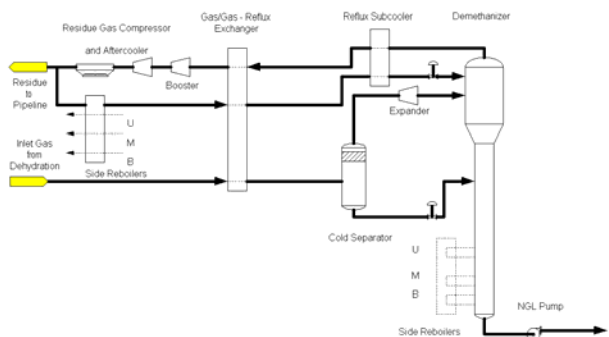
unless the designer has access to some proprietary design.

Figure 1
Classic Reflux Scheme



The concept introduced in this process consists of reboiling the demethanizer with the residue gas, or **residue gas split**.

Figure 2
Post-Split Recycle Reflux Scheme



In the new process scheme, the entire inlet gas stream is sent to the main gas-gas exchanger, while the recycle-reflux stream circulates through the reboilers. After providing the necessary heat to reboil the column, the recycle-reflux stream is further cooled and “liquefied” in the reflux subcooler, becoming a dense phase fluid. The recycle-reflux stream is then expanded isenthalpically in a valve and sent to the top of the demethanizer column as reflux (see fig. 2). This scheme is also known as open heat pump.

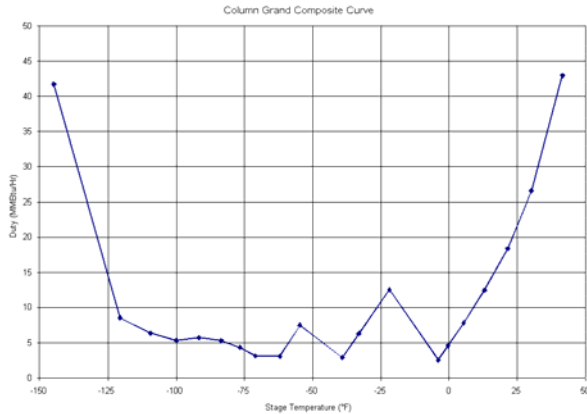
Product recoveries are typically above 95% for ethane plus product, or 99% for propane production.

It can be observed that this process offers simpler opportunities to integrate the heat efficiently into the process.

By using distillation pinch techniques, it will be possible to recover refrigeration from the column in a more efficient way. Today, high-speed computers, robust simulators and a better understanding of the distillation process enables us to conveniently generate quality information for design. One of these techniques is the **Column Grand Composite Curve, (CGCC)** (see fig. 3). The **CGCC** is an excellent tool to identify the minimum reflux/stripping conditions, the controlling feed and the opportunities for feed preheat. It also identifies the temperature-heat distribution in the column should side exchangers be added. Such a tool is invaluable to the designer since every demethanizer has a minimum of two side reboilers. The determination or optimization of the refrigeration recovery using side reboilers is key to efficient NGL plant design.

The demethanizer column provides refrigeration to the process via the cold side reboilers. This step eliminates or minimizes external propane refrigeration requirements. Propane refrigeration is used only when the side reboilers are insufficient to satisfy the plant heat balance.

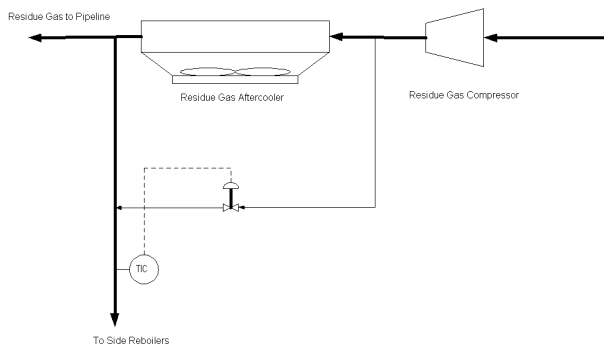
Figure 3



One design benefit from this concept is the ability to control the temperature of the gas to reboil the column. This results in a process independent of the inlet gas temperature. This provides an advantage when processing offshore gas that typically is too cold to reboil the demethanizer (see fig. 4). Conventional schemes need a heat source in this case. There is a temperature limitation for aluminum plate fins set usually at 150 F, which must be taken into account.

Figure 4

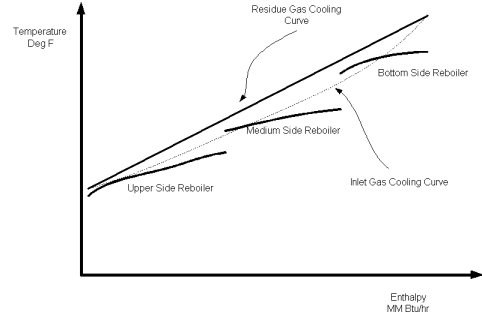
Reflux Temperature Control



Since the residue gas is leaner than the feed gas, the cooling curves have a better shape in the reboiling service than when using inlet gas. This is due the elimination of the condensation of heavy components. This represents an advantage when operating in conditions where the possibility of compositional change could occur. This design has flexibility for this case (see fig. 5).

Figure 5

Side Reboilers Temperature-Enthalpy Curves



Those experienced in the design of cryogenic gas plants will recognize that this new processing scheme can be very attractive for feed gases with a liquid content up to 3.5 gallons per thousand cubic feet of ethane plus content.

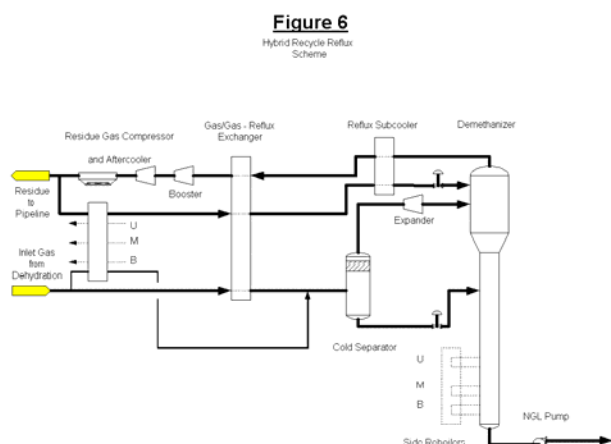
For every gas composition (on plants with residue pressure equal to the inlet pressure, i.e. straddle plants), there will be a unique economical and practical level of recovery dictated by the energy required to cool the recycle stream, reboil the column and recompress the residue gas. There can be a special incentive to use a residue recycle scheme when the pipeline pressure has to be higher than the plant inlet pressure. This is because the energy requirements to cool the reflux are lower.

The design of the recycle process can be developed from basic distillation design principles. The designer determines, according to the project requirements, the reflux requirements to achieve the desired separation and recovery. This can be accomplished even with a short-cut method, like Fenske-Underwood, to determine the minimum reflux and number of stages. The recycle rate is then set by the ratio L/D , where L is the reflux rate and D is the residue gas rate at the desired gas recovery.

Thus the reboiler duty is determined. The next step is to calculate how much gas is required to

satisfy this duty. Three things can occur at this stage:

1. The recycle flow is within the same reflux flow requirement. (This is the ideal case.)
2. The recycle is less than the required reflux. (A by-pass is required.)
3. The recycle is much more than the required reflux. (This is very typical of rich gas streams. A hybrid design could be used for this purpose; see fig. 6.)

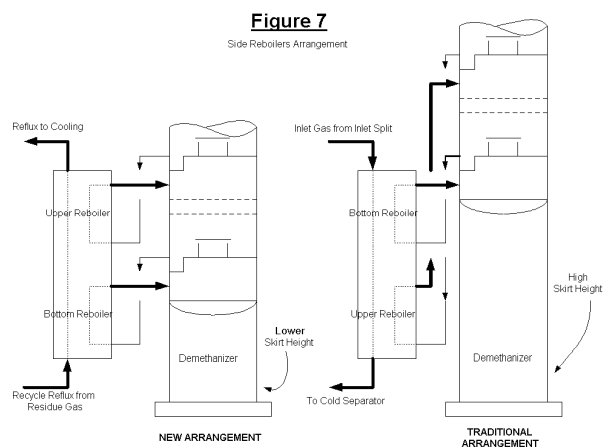


Several heat integration techniques may be used to optimize the use of the energy of the streams, including the addition of refrigeration and the adjustment of the demethanizer pressure to satisfy the process requirements.

CONSTRUCTION BENEFITS

Using this scheme may result in lower equipment cost and greater constructability. Since the residue gas does not condense any liquids during the cooling process, this stream can be configured flowing upwards in the plate fin instead of downwards. This eliminates the necessity for high demethanizer skirt for elevation to satisfy the reboiler hydraulics, and reduces the cost of the exchanger.

When using inlet gas split, condensation occurs and the flow needs to be downward for drainage. This requires the gas to enter the exchanger from the top of the plate fin. This new configuration reduces the elevation; thus costs in the vessel and foundation should be covered and the amount of stainless steel piping should be reduced (see fig. 7).



FLEXIBILITY OF OPERATION (RECOVERY/REJECTION)

One of the most desirable features of an NGL extraction facility is its adaptability to the market requirements. This is to produce ethane as liquid or to deliver it in the residue gas stream as fuel.

The earlier turboexpander facilities had none or limited flexibility built in for this operating mode. As the ethane market for ethylene plants feedstock plunged in several occasions in the last three decades, gas plant operators pressed the plant designers to come up with a solution for this issue.

Several design features are normally included, i.e., re-routing of streams, utilization of cold liquid to obtain refrigeration, etc.

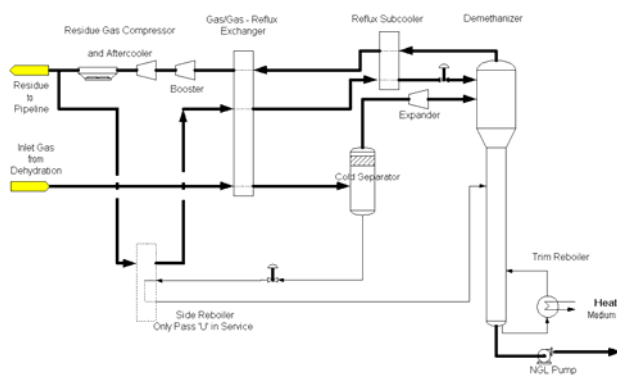
This new process offers the opportunity to operate at full or partial ethane recovery.

Figure 8 shows the process in ethane rejection mode or propane recovery. Recycle gas is cooled using the liquid coming from the cold separator. This is done using one of the plate fin passes with the flow arrangement redirected to this purpose. The stream then goes to the final cooling stage prior to entering in the column.

For the reboiling service, the preferred option is to provide an additional conventional reboiler assisted with a heat medium system. This method is an excellent design option for plant sizes of 150 MMscfd and larger. For smaller, modularized plants, the piping can be arranged such that the recycle gas stream is heated by means of exhaust gas from the gas turbine or a heater. This hot gas provides heat to the column.

When ethane rejection capability is required, it is preferable to use a kettle reboiler as the bottom reboiler for both services. Ethane recovery and rejection, due to the thermal limitations of the plate fin to temperatures below 150 F, requires an additional exchanger for the hotter service.

Figure 8
Ethane Rejection /
Propane Recovery
Operation



PROCESS CONTROLS

Under the original process scheme as shown in Fig. 1, the difficulties to achieve a stable process control situation are, at best,

challenging. The split of the inlet stream results often in pressure imbalances and it requires complex and difficult tuning of the control loops.

As an example of the complex control loop, the split requires a flow control for the side reboiler to send the necessary amount of gas to satisfy the column-heating requirement. This is a cascade loop of a flow with the temperature acting as a reset signal. Alternately, use of temperature with flow as a reset signal has been applied. Both schemes are difficult to tune and operate.

Also, in order to have good control action for the valves, an adequate pressure drop must be taken. This action in stable operating conditions results in a smooth flow and quiet control loop. However, when the pressure or flow fluctuates, the resultant action of the controls results in the swinging or oscillation of the control system. This is not desirable for either the operator or the process under control.

Under the new process control scheme, the point of control is downstream of the residue compressor. This offers a more stable and robust point to physically control the process, because the compressor discharge pressure floats on the pipeline pressure which is a more stable variable.

The heat requirement of the column can be satisfied by the use of a hot gas injection or "hot gas bypass". This should allow the temperature to be controlled in a simple manner, which is more stable.

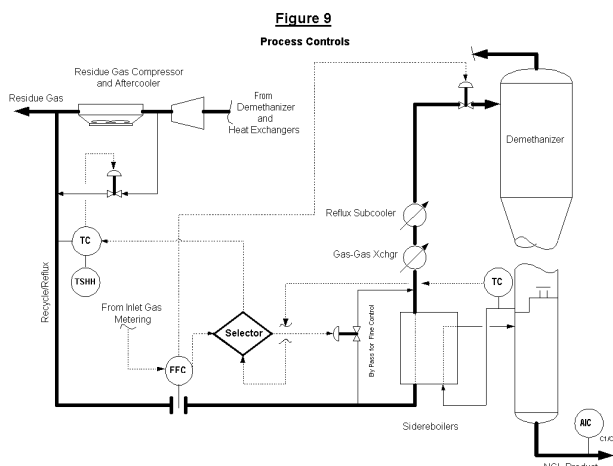
For a cryogenic column, the objective is to control temperature as a function of the liquid product specifications, e.g., the ratio of methane to ethane.

We have maintained this concept, as it is basic to the industry. However, the method used to

achieve this is a departure from the traditional control methodology.

The algorithm built into the control computer or platform of the control system achieves the temperature of the bottom of the cryogenic column. The major variables used and monitored are demethanizer bottom temperature, the residue gas temperature, and the residue gas flow. These variables are constantly monitored, and are the input used to determine the setpoints and controlled actions required.

Simplistically, the flow controller is used to maintain the plant recovery and the temperature controller is used to maintain the tower temperature. An additional feature of the algorithm is the flow is adjusted to maintain column heat balance without the potential to “over reflux” the tower.



This flow arrangement and control method is convenient for operation on total recycle, which is encountered frequently during plant start-up or restarts.

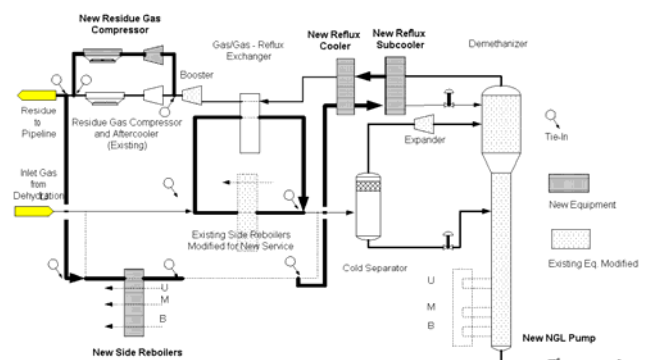
REVAMP OF EXISTING UNITS

The retrofit of existing plants offers an attractive area of opportunities to use this novel process. While keeping in mind that each case will have its own specific considerations, the

following list indicates the most probable changes to retrofit a typical facility (see fig. 10):

- New compressor with aftercooler
- New recycle gas gas-gas exchanger
- New inlet gas-gas exchanger
- New side reboilers
- Re-wheel turboexpander/booster
- Column internals
- Piping and valving

Figure 10
Typical Retrofit Scheme



The new process scheme, when applied to the retrofit of existing units, can introduce some savings by:

- Re-using the existing side reboilers as additional inlet gas coolers. This exchanger has to be replaced due to the new duty requirements.
- The high-pressure side of this exchanger is adequate for the condensing service, while the low-pressure side is re-serviced for the cold residue stream.
- Re-using the existing piping loop to the side reboilers.

“BACK TO THE FUTURE”

We believe that this new process scheme could offer an opportunity to materialize some

innovations in the area of simultaneous mass and heat transfer and high efficiency separation and expansion.

Current technology has achieved up to 3 to 4 theoretical stages. If this concept could be applied to this process scheme, this could lead to a demethanizer column 48 feet shorter than the most current designs.

CONCLUSIONS

We have introduced a new gas processing scheme that:

- Changes the classical inlet split gas arrangement to a residue gas split, simplifying the front end of the plant and the process design of it.
- Introduces an alternative recycle reflux scheme to achieve higher NGL recoveries.
- Provides operation flexibility.
- Optimizes the heat exchange.
- Introduces equipment cost reduction.
- Simplifies the piping design around the side reboilers.
- Improves the constructability around the demethanizer and side reboiler.
- Is easier to control.
- Introduces savings in the retrofit of existing low recovery units.
- Opens a future of innovative designs, while keeping execution costs low.

This process scheme not only provides benefits from the pure process perspective, but

contributes also to reduce the overall cost of the unit.

ACKNOWLEDGEMENTS

Hazem Haddad, Donald Murrile, Lisa Edwards Tinsley and Chrissa Sandlin, of the Randall Division of ABB Lummus Global Inc. for their contribution in the preparation of this paper.

REFERENCES CITED

- [1] U.S. Patent 5,890,377