TEG Contactor for Gas Dehydration

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1. Introduction

Water vapor is the most common undesirable impurity in gas streams. Usually, water vapor and hydrate formation, i.e. solid phase that may precipitate from the gas when it is compressed or cooled. Liquid water accelerates corrosion and ice (or solid hydrates) can plug valves, fittings, and even gas lines. To prevent such difficulties, essentially gas stream, which is to be transported in transmission lines, must be dehydrated as per pipeline specifications.

The processing of natural gas to the pipeline specifications usually involves four main processes;

- Oil and condensate removal
- Water removal
- Separation of natural gas liquids
- Sulfur and carbon dioxide removal

Most of the liquid free water associated with extracted natural gas is removed by simple separation methods at or near the wellhead. However, the removal of the water vapor requires more complex treatment, which usually involves one of the two process, either absorption or adsorption.

In absorption, dehydrating agent (e.g. glycols) is employed to remove water vapors and in adsorption, solid desiccants like alumina, silica gel, and molecular sieves can be used. The absorption process has gain wide acceptance because of proven technology and simplicity in design and operation.

2. Glycol Dehydration

Glycols are extremely stable to thermal and chemical decomposition, readily available at moderate cost, useful for continuous operation and are easy to regenerate. These properties make glycols as obvious choice as dehydrating agents.

In the liquid state, water molecules are highly associated because of hydrogen bonding. The hydroxyl and ether groups in glycols form similar associations with water molecules. This liquid –phase hydrogen bonding with glycols provides higher affinity for absorption of water in glycol. Four glycols have been successfully used to dry natural gas: ethylene glycol (EG), Diethylene glycol (DEG), Triethylene glycol (TEG) and Tetraethylene glycol (TREG).

TEG has gained universal acceptance as the most cost effective choice because:

- TEG is more easily regenerated to a concentration of 98-99.95% in an atmospheric stripper because of its high boiling point and decomposition temperature.
- Vaporization temperature losses are lower than EG or DEG
- Capital and operating cost are lower

Diethylene glycol is preferred for applications below about 10^{o}C because of the high viscosity of TEG in this temperature range.

3. Process Description

As shown in Figure 1, wet natural gas is first flashed in an inlet separator to remove liquid and solid content. The gas stream from separator is dried in contactor using counter current glycol stream with temperature difference of around 5 ^{o}C with that of gas stream. The dry gas passes through a gas/ glycol heat exchangers to cool lean glycol. The rich glycol, from the bottom of the contactor, is flashed at reduced pressure in flash tank where dissolved hydrocarbon gases are recovered and further it is preheated with lean glycol in a glycol/ glycol heat exchanger. After exchanging heat, the rich glycol is further fed to the stripping column where TEG gets concentrated only upto 98.5%. Further purity in stripper is not recommended due to limitation of maximum reboiler temperature of about 204^{o}C. Higher temperature in reboiler can lead to undesirable process of decomposition of glycol. The purity of 99.9% (wt) is achieved in a regeneration column where TEG is stripped by using some part of dried gas, processed in contactor. The regenerated TEG is recycled back to the contactor.

4. Contactors

Contactor is most important mass transfer equipment in TEG dehydration since its performance has crucial impact on downstream processes. The typical contactor is provided with internals like Vane Inlet Device (VID) for gas distribution, Chimney tray for collection of liquid, trays/packings for mass transfer and demister to minimize TEG losses. Mass transfer in contactor can be achieved by using Bubble cap, Valve trays, Sieve trays or Structured packings. In earlier days, bubble cap trays were commonly used in contactor. But in recent decade, due to proven performance of the structured packing, TEG contactors are now designed or revamped with high capacity structured packing. Typical contactor for structured packing with all required internals is shown in Figure 2.

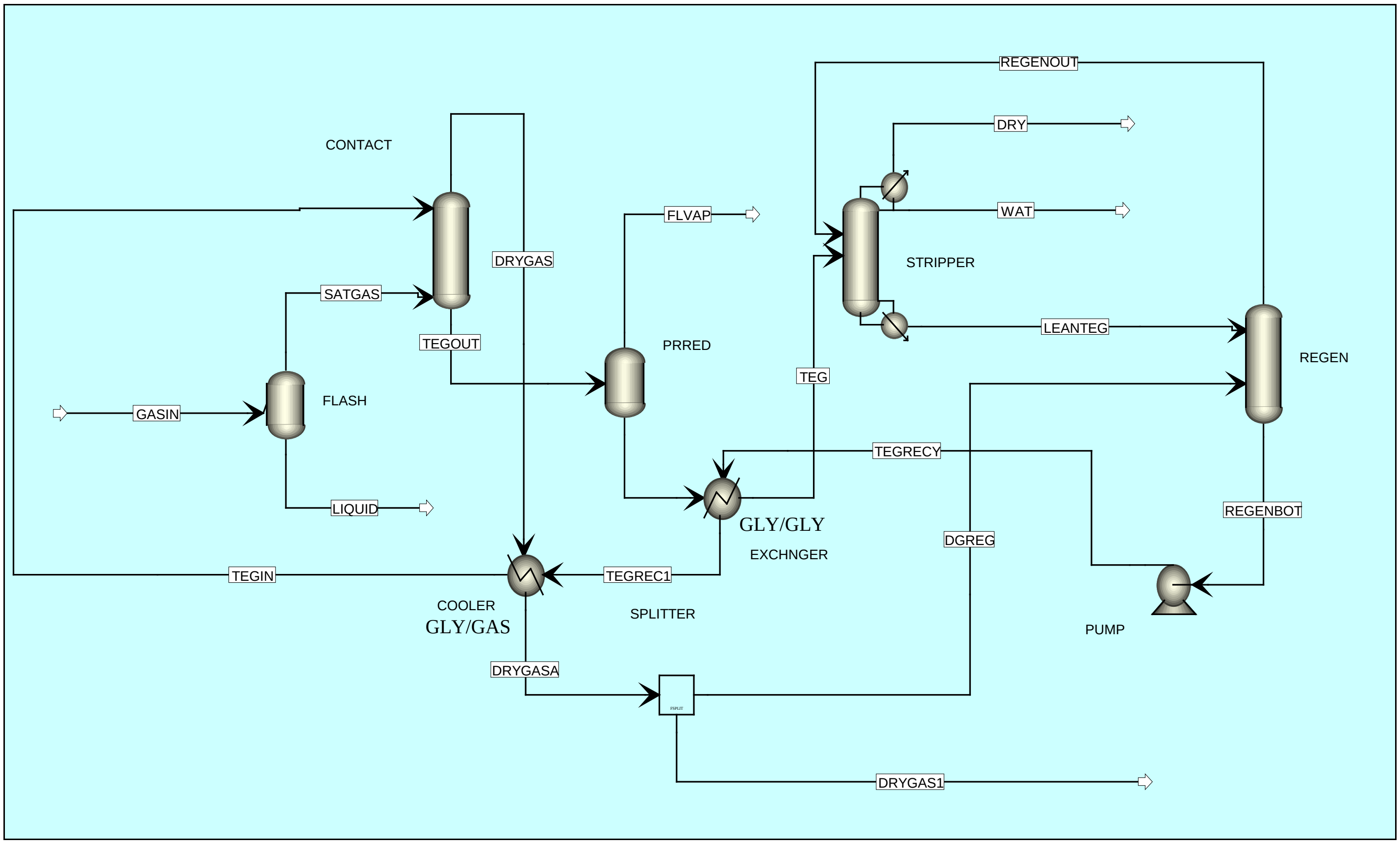

Figure 1: Flow diagram for TEG dehydration

5. Hardware required for contactor

5.1 Vane Inlet Device (VID)

VID is commonly used for introducing gas/liquid mixtures into the column . It mainly consists of series flat blades which evenly distribute inlet gas. The purpose of VID is to

- reduce momentum of the feed.
- performs separation of solids and liquid,if any, from the gas .
- achieve an even gas distribution across the column cross section by splitting the feed mixture into a series of flat jets.
- The inlet device allows for considerable reductions of the vessel height and inlet nozzle size.

5.2 Packing Support

Packing Support is use to support structured packing and allow easy passage for gas and liquid traffic. Finepac^{TM} INT-SP-01 is open flat grid type packing support plate designed for use with structured packing in columns lesser than 900 mm internal diameter. The minimum width of the support ring is 60mm. The standard design has grid bars spaced on 75mm centres but variations with closer grid spacings.

Finepac^{TM} INT-SP-02 is open flat grid type Packing Support Plate designed for use with structured packing in columns larger than 900mm internal diameter. The plate is made up in 375mm wide segmental sections which can be installed through column manways (minimum manway size 450mm NB) and bolted together inside the column. The standard design has grid bars spaced on 75mm centres but variations with closer grid spacings can be manufactured to support packings where the support plate capacity is not critical.A full annular support ring needs to be welded to the wall of the column to hold the support plate. The minimum width of the support ring is 60mm. Variations to the standard design with increased grid height may be specified to increase load capacity if required.

5.3 Liquid Distributor

The performance of structred packing depends on wetting of packing which needs excellent liquid distribution. Liquid distrubutors are designed to operate wide range of turndown and turnup as per process requirement. The design of liquid distributor depends on the liquid flowrates, column diameter and turndown required. Finepac™ designs and supplies distributors suitable for various applications, few of them which are commonly used in this application are listed below;

5.3.1 Channel Type Distributor (INT-SP-03)

Finepac™ INT-SP-03 This is a single stange distibutor having assembly of main channel and arm channels. Depending on liquid loads and fouling serivice distribution is done through either ground holes or drip tubes.

5.3.2 Trough Type Distributor (INT-SP-04)

Finepac™ INT-SP-04 Liquid Distributor is suited to high liquid rates. Trough type distributor is similar to the channel type distributor with additional trough provided for calming of inlet liquid.

5.4 Chimney Tray (INT-SP-10)

Finepac™ INT-SP-10 chimeny tray is used to collect liquid at the bottom of the column. For gas flow chimenys are provided which normally occupies 20-40% column area . Liquid is collected on the tray and removed as bottom product.

5.5 Tray columns

The bubble caps are widely used for this application. Bubble cap are preferred over valve trays as they do not weep or drain at low gas flowrate, which gives higher turn down ratio. They are also suitable for viscous liquids. Most of the glycol dehydration contactors have 4 to 10 bubble- cap trays with standard 24-inch tray spacing. Finepac™ has designed and supplied bubble cap trays for few of such installation.

5.6 Structured Packing

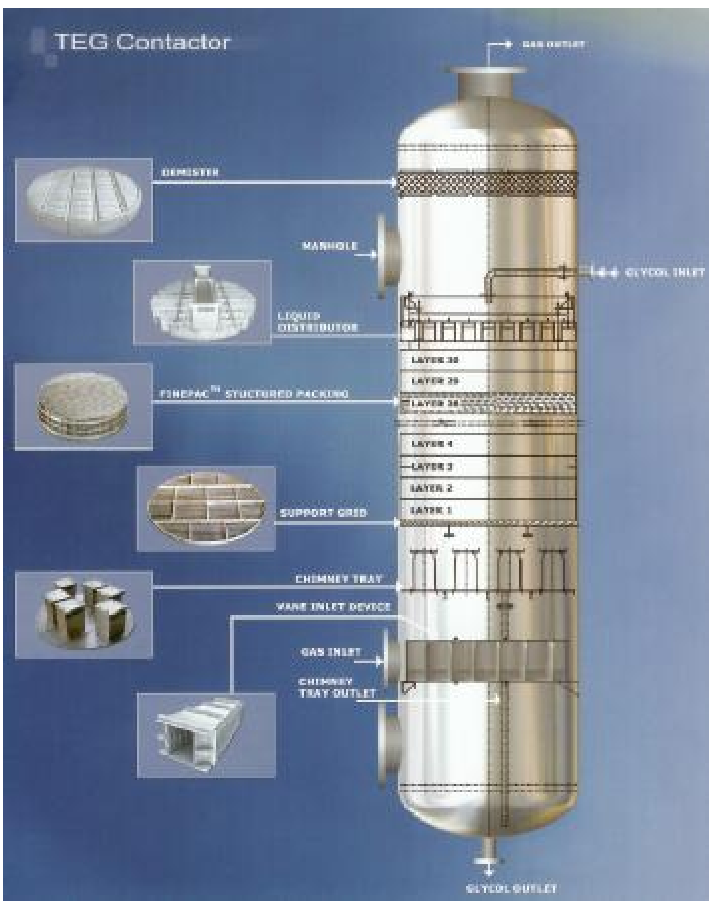

Figure 2: Typical TEG contactor with internal assembly

Structured packing

The recent trend toward extremely low dew point requirements (-40°F and below) has resulted in re-examination of contactor designs to attain more theoretical stages at a reasonable cost. Structured packing is claimed to offer greatly increased throughput, lower pressure drop and lower column height than the bubble cap trays for same service.

Structured packing has edge over trays in following aspects

- The design gas velocity in a structured packing tower is approximately twice the normal velocity in a tray tower, hence gives more capacity with the existing column.
- Turndown capability of the structured packing is excellent.
- Lower Capital cost

Some important consideration for structured packing;

- A high efficiency drip point liquid distributor should be used
- Because of high gas velocity a high efficiency mist eliminator is required (10 to 12" mesh pad)

6. Stripping column

It is a reboiled stripper where absorbed water from TEG is removed. The stripping gas column is distillation column usually randomly packed with pall ring. Four theoretical stages are used to regenerate the TEG to 98%(wt)

7. Regeneration column

The regeneration column is a gas-stripping column, randomly packed column with pall ring. We need atleast three theoretical stages to achieve TEG of 99.9%.

8. Case Study

Process Simulation

ASPENPLUS V12.1 process simulator is used to simulate complete TEG dehydration flowsheet so as to optimize the glycol required which in turn will optimize heat exchanger area and the utility required. This process is modeled using Glycol package available with Aspen Plus. For this application, it uses Schwartzentruber-Renon equation-of-state (SR-POLAR) as it is well suited for high-pressure non-ideal systems. Radfrac is used to model contactor, stripper and regenerator. The inlet temperature of TEG is generally kept at 25^{o}C to 40^{o}C as higher temperature lowers the absorption capacity of the TEG. The contactor is simulated with four theoretical stages and the sizing is carried out using ASPENPLUS V12.1. This model is validated with plant data provided by clients and the results generated are as follows;

Input to the contactor

	WETGAS	LEAN TEG
Temperature C	25	25
Pressure bar	59.013	60
Vapor Frac	1	0
Mole Flow kmol/hr	11065.55	10.588
Mass Flow kg/hr	215815.739	1590
Volume Flow cum/hr	4200.683	1.414
Mass Frac		
C1	0.684	0
C2	0.037	0
C3	0.021	0
IC4	0.006	0
NC4	0.009	0
IC5	0.005	0
NC5	0.005	0
C6	0.007	0
C7	0.007	0
C8	0	0
CO2	0.112	0
N2	0.106	0
H2S	4PPM	0
H2O	0.002	0
TEG	0	0.999

Column Details

Dry gas specification is dew point of -12 ^{o} C at operating condition

Simulation Results

- TEG required to achieve dry gas specification is 1590 kg/hr.

Comparative study of structured packing and the bubble column

1. Structured packing
   - Column Diameter : 2m
   - Packing Height : 4.2 m
   - Packing type : Finepac structured packing (type 2.5L)
2. Bubble cap tray column
   - Column Diameter : 2.4 m
   - No. of trays : 10 (considering overall efficiency 25%)
   - Tray spacing : 610mm

Conclusion

The process described above is commonly used for dehydration of natural gas using TEG as dehydrating agent. Above studies shows that structure packing is more economical than the bubble cap column. Finepac^{TM} has developed comprehensive expertise in designing and commissioning of complete TEG dehydration package.

References

1. A. Kohl and R. Neilson, Gas purification (Fifth Edition)
2. S. Francis, Manning and R. E. Thompson, Oilfield Processing of Petroleum- Volume one- Natural Gas
3. J. A. Kean, H.M. Turner and B. C. Price, (1991) Hydro. Process. Vol.70, No.4, April, p.55.

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