SHINING THE LIGHT

Ankur Jariwala, Cameron Process Systems, USA, presents a compact and energy efficient pretreatment option for FLNG projects.

Floating LNG (FLNG) projects are receiving higher visibility due to the overall cost reduction in LNG production compared to traditional onshore LNG. The FLNG concept brings about several challenges, as there are no real FLNG projects currently operating that can provide operating reference to the industry. Overall, the FLNG concept can present great opportunities to monetise stranded and remote gas fields.

In a typical FLNG project, the overall recovery of gas with condensates provides a higher return on investment. The cost of production and processing also plays an important role in the overall project investment and profitability. The processing cost is higher when the amount of impurities that need to be removed are high, which drives an increase in overall capital and operating cost of FLNG topsides. A typical layout of the boat topsides is shown in Figure 1.

Pretreatment typically drives 6 20% of the total processing cost, depending upon the amount of impurities that need to be removed in the feed gas. In the industry, development is usually focused on the liquefaction section, with little emphasis on pretreatment. If pretreatment can be designed and optimised along with the liquefaction section, it can provide significant energy and capital cost savings. The pretreatment strategies should be identified early enough in conceptual or pre FEED stages, so that overall capital and operating cost savings can be incorporated into the overall project.

For FLNG pretreatment, the target is to remove impurities from natural gas so that it can be easily liquefied in the liquefaction section. There is a fine balance between designing pretreatment with excess capacity and designing it too aggressively. The key is to maintain the performance of the pretreatment under slight variable inlet gas feed conditions. It is important to design pretreatment correctly to maintain continuous uptime of LNG liquefaction. The lack of a suitable pretreatment leads to processing bottlenecks and potential downtime.

FLNG pretreatment challenges

Size and weight are extremely important for any topsides design. Because the FLNG topside can typically weigh up to 40 000 t, any reduction in size and weight can assist in additional production. The pretreatment process can be modularised to fit into a more compact space. FLNG requires up to 62 MW of power for the liquefaction section. Adding energy efficiency of even 5% can provide significant savings or additional throughput.

Compact FLNG pretreatment solution

PREMAX is designed to provide a compact pretreatment solution with higher energy efficiency. Figure 2 shows a generic approach for pretreatment.

The pretreatment process is designed to reduce H_2S, Hg, CO_2 and H_2O. Most commonly, CO_2 and H_2S are removed to ppm levels in an amine unit followed by a mol sieve unit to dehydrate gas. In this scheme, the key is to have an integrated solution that can provide process flexibility with the optimised energy requirements for the liquefaction unit. It should be designed to provide a compact solution.

H_2S and Hg can be removed in the same process step if there is a small quantity of H_2S. This H_2S and Hg removal technology consists of a fixed bed system with a metal oxide material and contains non regenerable beads where the beads can absorb H_2S and Hg from the gas. The bed system is in lead lag mode and can be designed for different life cycles, depending upon the H_2S and Hg loading. The non regenerable beads turn out to have improved absorption efficiency and provide a relatively smaller footprint.

Cameron offers two different technologies for removing CO_2 and H_2S. The first is CYNARA CO_2 membranes and the second is an amine unit. Given the CAPEX, OPEX, size and weight criteria for FLNG, the footprint should be as compact as possible. The amine unit cannot be completely eliminated, as membranes only remove bulk CO_2 and H_2S. An amine unit can then achieve lower levels of CO_2, down to 50 ppmv. Also, if there is an

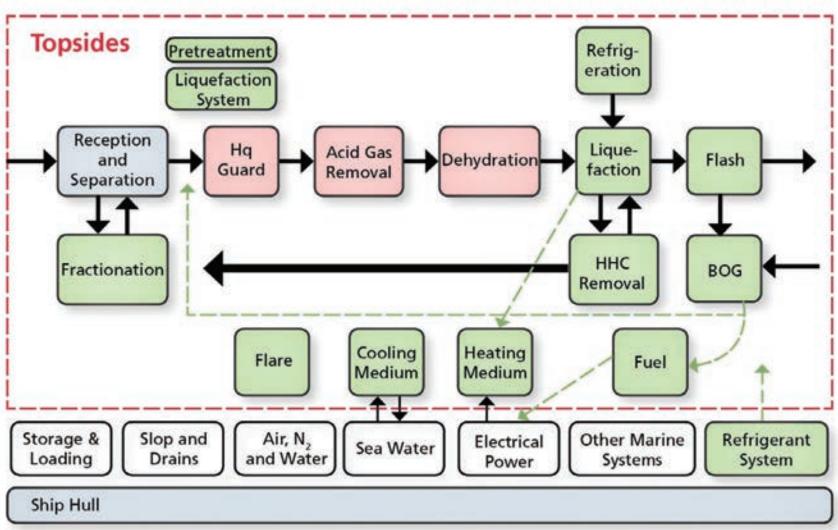

Figure 1. FLNG topsides showing the different components involved in pretreatment and liquefaction.

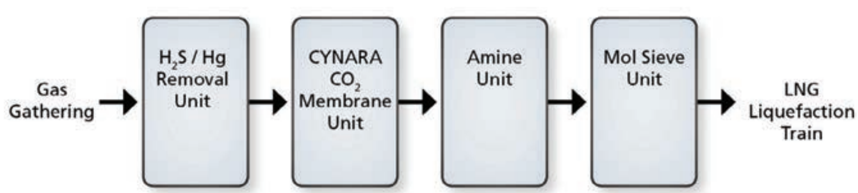

Figure 2. PreMax FLNG pretreatment process.

excess amount of H_2S, amine has to be considered. A membrane unit will provide a great advantage by providing a smaller footprint and removal of CO_2 in bulk quantity.

Membranes

CYNARA CO_2 membranes are asymmetric cellulose triacetate hollow fibre membranes, which preferentially permeate small molecules (e.g. CO_2 and H_2S) and reject large molecules (e.g. CH_4 or heavy hydrocarbons). This results in a low pressure CO_2 and H_2S rich permeate stream on one side, and a methane rich stream on the other side. Several millions of these hollow fibres are packaged into modules packed in the pressure vessels. Feed gas enters from the centre of the membrane module and approaches all of the fibres where CO_2 and H_2S preferentially permeates, and will be collected on the top and bottom of the tube sheet. Methane is rejected and collected in the central perforated tube. It is collected as product gas at high pressure from the bottom.

Cameron s CYNARA 30 in. membrane element provides a compact membrane structure with a high surface area of membranes per square foot. It provides significant cost and space savings by packing more surface area into a 30 in. membrane element. Along with a size and weight advantage, CYNARA membranes have no moving parts, no chemical requirements and the ability to easily adapt to changes in inlet gas conditions. They also provide as high as 99.5%+ system uptime availability.

Typically, the CO_2 coming out of the membranes stream is cooler in temperature than the feed gas. This cooling can be utilised to optimise the cooling loop and therefore reduce the amount of energy required in the overall liquefaction section. This cooling benefit can be realised using CYNARA membranes because of its unique feature of handling condensing hydrocarbons while removing CO_2. Overall, in this scheme, the entire pretreatment package with energy efficiency adds value to the performance of the entire FLNG topside, by saving the required amount of power for the liquefaction section.

Experience is essential when combining several technologies to work well together. The hybrid system with a membrane unit and amine works well offshore. These can be combined and modularised into a single module. However, it will require dehydration downstream as the amine system is a wet process.

Mol sieve units can be designed for offshore applications with FPSO specifications. These units should be integrated with the rest of the pretreatment system. Very little engineering innovation can be done here to reduce size and energy; however, several efforts are underway to make these beds even more compact.

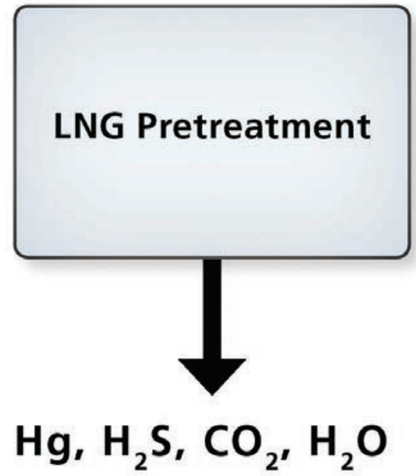

Figure 3. LNG pretreatment focus for removing impurities.

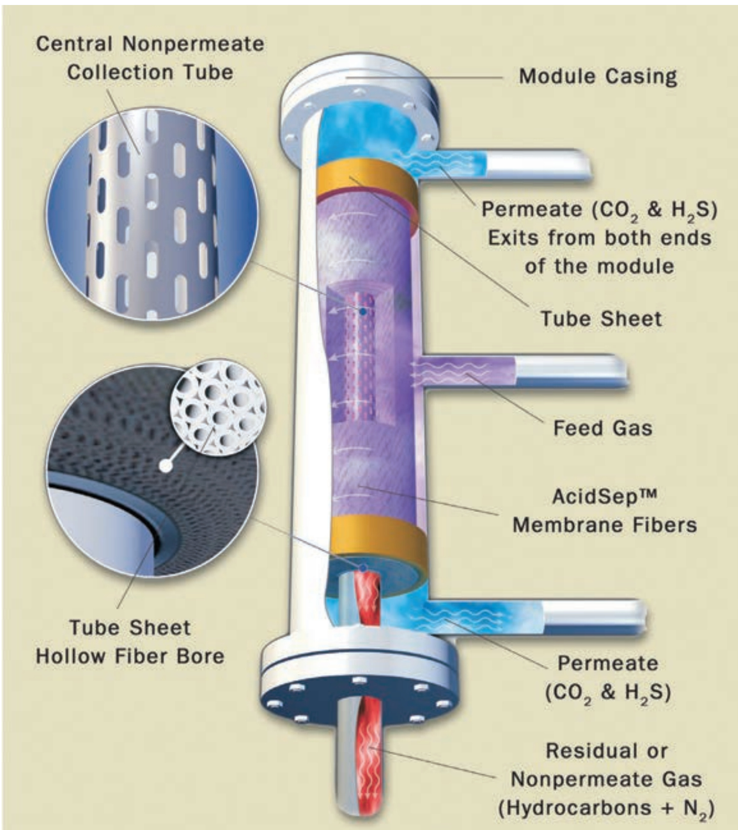

Figure 4. CYNARA CO_2 membranes for removing high CO_2 and H_2S content from natural gas.

In the entire liquefaction chain, there are several large and small pressure vessels that can be further optimised to reduce the overall size by 40%. Cameron evaluated some key gas/liquid separators in one of its conceptual studies. One of these was a gas scrubber, which is downstream of the amine unit where one of the main concerns is carrying over excess amine to the gas dehydration section. Another critical

Table 1. Using high efficiency separator internals can reduce the size and weight for a variety of gas/liquid separators				
	HCC KO separator (cold)	**HCC KO separator (cold)**	**Amine scrubber**	**Amine scrubber**
Internals	Vane inlet + meshpad	IVD + mesh + DC	Vane inlet + meshpad	IVD + mesh + DC
ID	1844 mm	1512 mm	2323 mm	2000 mm
Tantan	2086 mm	2599 mm	2726 mm	3033 mm
Estimated vessel weight	8662 kg	6223 kg	21 256 kg	13 250 kg
Reduction in vessel weight*	2439 kg		8007 kg	
Total reduction in vessel weight*	Approximately 13 t + footprint reduction			
*By choosing Cameron s internals				

separator is located on the fractionation overhead stream, where it is important to remove excess liquid carryover to the cold box. Using high efficiency separator internals, these separators can potentially be reduced in size and weight. Table 1 shows different size and weight savings for this case.

The latest Axial Cyclonic Inlet (ACI) is an inlet device used for higher gas loading. It can provide uniform distribution for gas dominant high pressure/low temperature streams. One of the challenges of cyclones is managing separation efficiency during turndown. The ACI is designed to manage higher turndown and to meet higher gas peaks while addressing smaller pressure drop. These internals are tested and verified by Statoil K laboratory, which has one of the most robust and proven real time fluid separation testing capabilities.

Conclusion

Pretreatment plays an important role in FLNG and should be optimised with the right approach using compact technologies for energy efficiency and improved economics. PREMAX   provides a compact size and weight advantage with a solution that can reduce size by as much as 30   40%. A complete pretreatment solution with CYNARA membranes can potentially reduce the energy requirements in the liquefaction section. Incorporating compact, advanced topside modular units with these technologies will provide a breakthrough for future FLNG projects. **LNG**