THE FEASIBILITY OF MICRO-CRYOGENIC TECHNOLOGY APPLICATION FOR ENHANCING DOMESTIC NATURAL GAS UTILIZATION, CASE STUDY : NATURAL GAS PROVISION AT R & D CENTRE FOR OIL AND GAS TECHNOLOGY "LEMIGAS"

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ABSTRACT

Indonesia with a huge natural gas reserves distributed in various islands and separated by sea has utilized the gas for domestic energy source and petrochemical feedstock purposes. Transportation of the gas to its consumers can be in the form of either pipeline gas or Liquefied Natural Gas (LNG) schemes. Selection of the scheme chosen is determined based on its economic evaluation and technical reliability.

The distribution of gas reserves in various islands segmented by sea in Indonesia in combination with economic activity concentration especially in Java island bring about difficulties in gas development due to the up-front massive investment required on gas pipe laying or LNG plant construction.

It is therefore required to find a cheaper alternative to the scheme with an established safety standard application, in order that the domestic gas utilization will be able to be enhanced and thus reducing petroleum liquid import.

An alternative that can be significantly considered is micro-cryogenic technology development in Indonesia for constructing a low capacity LNG plant so that a small scale of LNG can be economically produced. The LNG is then distributed to gas consumers at regions which has no existing and will not be viable for new gas network installation.

Micro-cryogenic technology application is thought to be developed considering a preliminary feasibility study results. The study found that micro-cryogenic technology is around US $ 0,75 million (68.2 %) cheaper than gas pipeline technology to provide natural gas for Gas Demonstration Plant operation at R & D Centre for Oil and Gas Technology "Lemigas".

I. INTRODUCTION

Liquefied Natural Gas or LNG is natural gas which is stored in the form of liquid. The gas is liquefied at the temperature, at least, of -120 ΥC and atmospheric pressure. LNG technology is now established for the purposes of storing and transporting the gas. To meet peak demand of the gas during winter session, most subtropical countries stored the gas in the form of LNG, during summer session, at an LNG peak shaving plant and Indonesia exports the gas in the form of LNG to very long disance importer countries including Japan and Korea. LNG is the only powerful technic for storing natural gas since this can stored of around 600 volumes of the gas.

Historically, Natural gas was first liquefied on a practical scale by the United States Bureau of Mines in 1917. In this instance the purpose of the liquefaction was to separate helium from natural gas to obtain helium for airships and not to liquefy natural gas per se. The world's first commercial liquefaction plant was an LNG Peakshaving facility built in Cleveland, Ohio in 1941. It operated succesfully until 1944 when a tank containing LNG failed. Although this accident was a set back for the LNG industry, it at least ensured that major improvements in materials, design, construction and operating techniques were perfected and introduced.

II. OPERATIONAL BASE-LOAD LNG PLANT

The design of an LNG plant is unique reflecting technological developments over time as well as different feed gas compositions, local site conditions and the design and process preferences of the plant owners. In addition, design and process selection have been and will continue to be inluenced by differences and trade-offs between capital, operating and maintenance costs, fuel efficiency consideration and the like. However, a base load LNG plant wil generally comprise the following components or units which is collectively called as a ' train ' :

- Gas receiving and metering
- Acid gas removal and / or sulphur recovery
- Dehydration
- Mercury removal, if necessary
- Heavy hydrocarbon separation
- Fractionation
- Liquefaction
- NGL treatment
- LNG and NGL storage
- Loading facilities
- Main utilities.

Gas receiving and metering

In this unit the feed gas for the plant is regulated at a satisfactory pressure for the later removal of heavy hydrocarbons which would be otherwise cause problems in the liquefaction, storage and transport of LNG. Metering the quantity of gas supplied to the plant is obviously necessary, especialy if the gas suppliers are not the same as the owner of the plant which is often the case.

Acid gas removal

Any carbondioxide, hydrogen sulphide and other sulphur compounds present in the feed gas are removed at this stage to levels which are sufficiently low to avoid them freezing out in the liquefaction unit. Typically this means reducing the carbon dioxide content to about 50 ppm by volume and sulphur compounds to less than 3 ppm.

Mercury removal

In some instances natural gas can contain very small amounts of mercury, of around 300 micrograms / Nm^3 or even higher, usually in the form of elemental mercury vapour. All this mercury has to be removed which means in practice down to about 0.1 micrograms / Nm^3 to prevent corrosion of pipework and equipment made of alumunium or alumunium alloys.

Dehydration

The treated sweet gas leaving the acid gas removal unit is saturated with water vapour as the swetening solvents are generally aqueous solutions. Before cooling the gas below zero degrees centigrade it must be dried in order to avoid icing up in the heavy hydrocarbon separation unit, liquefaction units, storage and ships.

Heavy hydrocarbon separation

The design of this unit will rely on the quantities of ethane and other heavier hydrocarbons present in the natural gas, by the need to extract any heavy hydrocarbons that would otherwise freeze out in the very low temperatures of the liquefaction unit, and by the need to meet the LNG specifications as agreed with the LNG buyer.

Fractionation

The liquid mix from the heavy hydrocarbon separation unit is fed typically to a succession of distillation columns including the de-methanizer, de-ethanizer, de-propanizer and de-butanizer, each stripping out one component from its top end. The bottom stream of each column is fed into the next one so that from the last column flows a de-butanised stream of pentanes and heavier hydrocarbons, sometimes referred to as 'gasoline' or more usually as natural gas liquids (NGL).

NGL treatment

If despite the acid gas removal phase the products of the fractionation unit do not satisfy market specifications, the gas should be 'sweetened' in an NGL treatment unit to remove residual hydrogen sulphide, carbonyl sulphide (COS) and mercaptants which may have become concentrated in these products.

Liquefaction

There are three main processes currently in use in liquefaction cycles of a base-load plants. These include :

1. **Pure refrigerant cascade process**

   The process, diagramatically shown in Figure 1, consists of a combination of three cooling systems each comprising a compressor, a condenser, an expansion valve and an evaporator (or heat exchanger). Typically, propane, ethylene and methane are used in three cooling cycles to provide at progressively lower temperature.

   In the first cycle, the propane refrigerant is condensed at high pressure by cooling water (or air). Then the

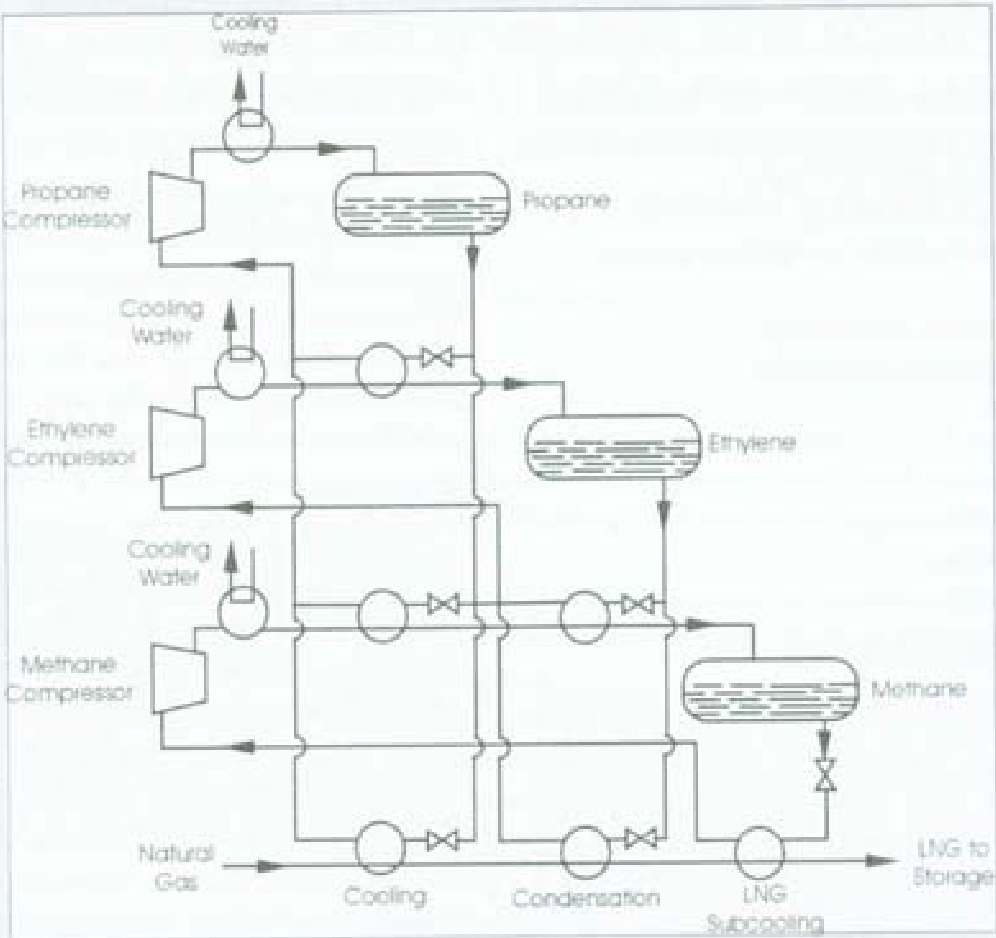

Figure 1
Schematic pure refrigerant cascade process[5]

pressure of the liquid propane is let-down through the expansion valve, and it can vaporise at a lower temperature by condensing the ethylene of the second cycle, as well as cooling the natural gas down to some -30 YC, all in a series of evaporators. Finally, the propane vapours are recompressed to the initial high pressure at which they can be condensed at ambient temperature. Cycle two and three work on the same pattern. Ethylene is condensed under pressure by the propane of cycle one and, once depressured, vaporises by cooling the natural gas down to about -100 YC. In the last cycle, methane is condensed by the ethylene and, after pressure let-down, is allowed to vaporise by cooling the natural gas to its complete liquefaction temperature of about-160 YC.

2. Mixed refrigerant process.

The process, schemed in Figure 2, is extremely simple but power consumption is substantially greater than for the cascade process. Whereas with pure refrigerants a series of separate cycles are involved, with mixed refrigerants i.e. methane, ethane, propane and nitrogen, sometimes butane and pentane as well. Condensation and evaporation take place in one cycle over a wide temperature range down to around -160 YC.

After compression, the mixed refrigerant is partially condensed againts cooling water and sent to a gas-liquid separator. The liquid and vapour are distributed over the tubes in the heat exchanger are condensed completely. After pressure reduction, gradual

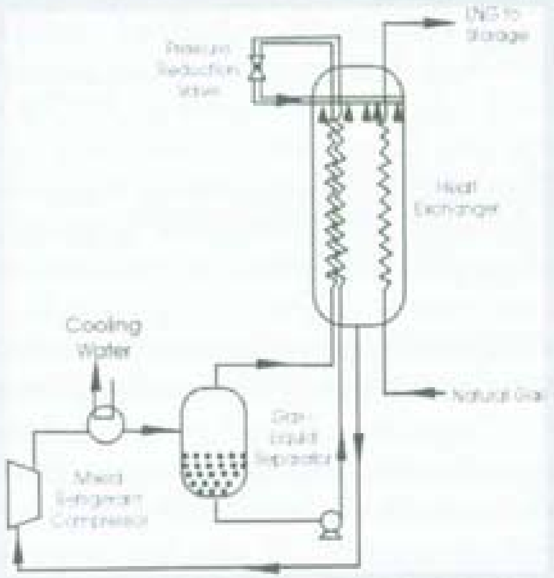

Figure 2
Schematic mixed refrigerant process[4]

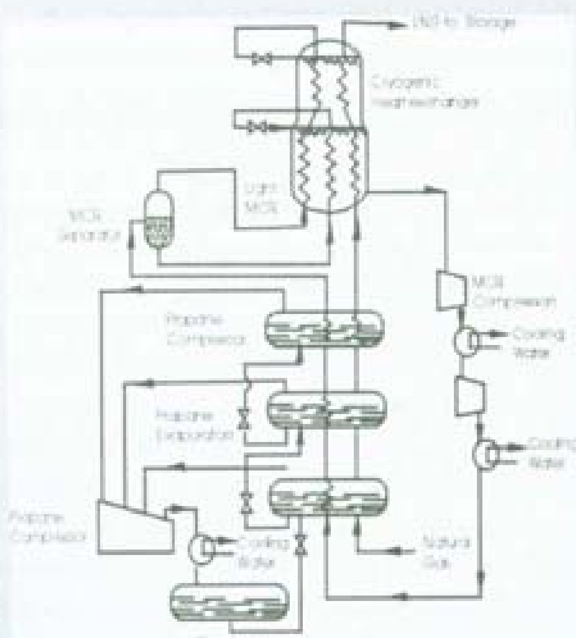

Figure 3
Schematic pre-cooled mixed refrigerant process[4]

evaporation provides refrigeration to liquefy the natural gas.

3. Pre-cooled mixed refrigerant process

The schematic of this cycle is outlined in Figure 3. The process is a combination of The Pure Refrigerant Cascade Process and The Mixed Refrigerant Cycle. This proses also merges several discrete cycles into one cycle, and although propane pre-cooling is added. This is well justified by increased efficiency.

Propane is first condensed by cooling water and then with heat exchangers in three or four stages, cooling the feed gas stream and mixed refrigerant to about -30 YC. After compression, the mixed refrigerant, which is Multi-Component Refigerant (MCR), is likewise first cooled by water and by propane.

At this stage, and before the MCR is fed into the cryogenic heat exchanger, it is separated into two fractions, a light MCR and a heavy MCR. Natural gas, already cooled to around -30 YC , is fed into the bottom of the cryogenic heat exchanger with both MCR fractions and distributed through spirally-wound tube bundles.

In the top part of the heat exchanger, the light MCR fractions and natural gas are cooled to around -160 YC by spraying light MCR after pressure let-down over the remaining bundles. At this point the natural gas is liquefied and fed to storage. Low pressure of MCR vapours are collected at the bottom of the heat exchanger, compressed and recycled.

LNG and NGL storage

Natural gas can be stored in the form of LNG in above-ground or in-ground tanks. However, only above-ground tanks meet pressure vessel regulation in Indonesia.

There are various types or design of above-ground prestressed concrete tanks for LNG. Briefly, the principles concept are as follows :

- An outer prestressed concrete wall with an inner 'stand alone' metal tank with the annular space filled with an insulation material. The roof can be either carbon steel or prestressed concrete supported by the outer concrete wall, with a suspended insulated inner deck.

the gas by decreasing its pressure.

- Cold separator which will separate liquid formed from the gas.
- LNG storage to collect LNG produced.
- Intensifier, optionally, to increase the inlet gas pressure. This is installed before the heat exchanger if the LNG plant will be fed from low pressure system.

5. Micro-cryogenic technology is around US $ 0,75 million (68.2 %) cheaper than gas pipeline technology to provide natural gas for Gas Demonstration Plant operation at R & D Centre for Oil and Gas Technology "Lemigas".
6. A design of moveable low capacity LNG plant is requiered for the gas provision at R & D Centre for Oil and Gas Technology "Lemigas".
7. Micro-cryogenic technology is feasible to be developed to enhance domestic natural gas utilization particularly at regions which has no existing and will not be viable for new gas network installation.

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