Design of a Typical LNG Plant for South-Pars Gas Field

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ABSTRACT

Based on a low case scenario, a LNG plant with 7.5 million tons per annum capacity for transporting liquefied natural gas is proposed. It is shown that for a given gas composition and condition, 208 tons of sulfur per annum is also produced. A total number of 7 ships are required for transporting the LNG produced.

INTRODUCTION

Nowadays, by increasing energy demand in the world, transporting liquefied natural gas (LNG) as a source of energy is gaining more attention. Since transporting natural gas using pipeline (PNG) is not cost effective for long distances \cite{1}, and other modes of transporting natural gas such as natural gas hydrate (NGH) or compressed natural gas (CNG) are in the stage of development, the LNG transportation is commonly adapted.

Common energy demand in the form of LNG is approximately 80 million tons per annum (mtpa) \cite{2}. About two-thirds of this amount is imported by Japan. However, it is expected that the LNG demand in Asia increases due to economic growth, notably in India, South Korea and China. The emergence of new LNG markets in these countries has justified the development of new projects in Qatar and Oman and Indonesia. South Pars gas field in Persian Gulf has brought hope to transport natural gas to potential markets. One possible mode of transporting natural gas is conventional pipeline. The other mode might be LNG transportation. This works concerns with an elementary design of transporting natural gas from Asseluyeh in South of Iran to India as a potential market. The results can be used in feasibility study of transporting natural gas to India, knowing that pipeline transporting would not be cost effective for long distances \cite{1}.

ADAPTING A SUITABLE SCENARIO

Three scenarios can be followed. The first is low case. Based on this scenario, the potential market is a near country with limited energy demand, e.g. India. The second case is base case, in which Far East countries can also be considered as potential markets. The third case is high case. In this case Europe and U.S. can also be considered as potential markets in addition to Far East countries and India. Since LNG plants are capital cost intensive and countries importing LNG are limited, it seems likely to consider a low case which can be the least risky project. Evidently, the designed plant can be extended in future by emergence of new markets.

ASSELUYEH TO INDIA

Table 1 presents some India ports capable of receiving LNG. Also presented in Table 1 is the distance of these ports from Asseluyeh. It seems that three of the ports are nearer to Asseluyeh than the others. These ports have nearly the same distance from Asseluyeh; i.e. about 1270 nm (nautical mile). Hence, we take the distance from Asseluyeh to India as 1270 nm (2352 km).

NATURAL GAS FEED SPECIFICATION

South-Par gas field is a super giant field. The natural gas specification is different from a part to others. A typical specification can be similar to the one given in Table 2. This feed is used in the design.
TWO-TRAIN LNG PLANT

The natural gas feed rate (1100 MMSCF/d) is a large quantity. To be consistent with vessel size and device standards, two parallel LNG trains are used for LNG transportation. Figure 1 shows the two-train LNG plant with some specifications that will be explained shortly. The gas feed in each train (550 MMSCF/d) enters a sweetening absorber unit which takes the advantage of DEA as absorbent [3]. In this unit the sour gases (H₂S and CO₂) are removed; volumetrically 550 MMSCF/d × (0.021 + 0.005) = 14.3 MMSCF/d.

The sour gas stream roughly contains 81% CO₂ and 19% H₂S. This stream is directed to sulfur recovery unit that uses Claus process [3] to catalytically convert H₂S to Sulfur. The prevailing reactions are

\[
2H_2S + 3O_2 \rightarrow 2H_2O + 2SO_2
\]  
\[
2H_2S + SO_2 \rightarrow 2H_2O + 3S
\]

As a result, 104 tons of sulfur per day is produced per each train; totally 208 tons per day.

The sweetened stream leaving the DEA absorber is saturated with water. It needs to be dehydrated to bone dry before introducing to the liquefaction unit. For this purpose 4A type molecular sieve is used as adsorbent [3]. The feed entering to the adsorption unit contains 61 lbs water per MMSCF/d of gas [4]. Thus 14.835 tons of water should be removed per each train. The sweetened and dehydrated gas stream (primarily containing methane) is directed to liquefaction unit where a three-stage mixed refrigerant process is used [2]. The product will be 3.75 mtpa LNG. The two trains produce 7.5 mtpa.

LNG SHIPS

LNG ships are standard. They are usually constructed as big LNG ships and small LNG ships. The size of big ships is approximately 138,000 m³ and the small ships 70,000 m³. If big ships are to be used, then each ship can carry 138,000 m³ × 423 kg/m³ = 58,374,000 kg (or 58,374 tons) LNG. Based on 7.5 mtpa LNG and considering a round-trip traveling to India takes 2540 nm, the number of ships required is easily calculated. Assuming the ships speed to be 20 knots, then each round-trip would take 2540/20 = 127 h = 5.3 days. Assuming 7 days ballast duration and 7 days laden duration, a complete journey would take 5.3 + 7 + 7 ~ 20 days. Therefore each ship will travel 365/20 ~ 18 times per annum to India. Hence the amount of LNG exported to India per annum per ship would be 18 × 58,375 = 1,050,732 tons/annum/ship. Thereby, for 7.5 mtpa (7.5 × 10⁶ tons/annum) LNG production, 7 ships are required.

LNG TANKS

Assuming 7 days uncertainty for arriving ships to the LNG port, we should have a storage capacity of 7 days working of the plant without any shut down. In other words, 7.5×10⁹ kg LNG/annum × 1annum/365 days × 7 days = 14,383,561 kg LNG storage is required. If the density of LNG is 423 kg/m³ [4], thus 14,383,561 kg LNG / 423 kg/m³ = 340,037 m³ storage capacity is required. If each tank has a capacity of 85,000 m³ (this is a standard capacity in LNG plants), then 340,037/85,000 = 4 tanks are required.
CONCLUSION
Based on the above calculations, for a feed rate of 1100 MMSCF/d and a two-train LNG plant can be constructed to produce 7.5 mtpa LNG, 208 tons/d sulfur and 29.6 tons/d water.
To transport this amount of LNG to India, 7 ships each 138,000 m³ capacity is required.
Also 4 storage tanks, each has 85,000 m³ storage capacity is required.

AKNOWLEDGEMENT

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REFERENCES


Table 1
Ports of India and their distances from Asseluyeh

<table>
<thead>
<tr>
<th>Port</th>
<th>Distance (nautical mile)¹</th>
<th>Volume (tpa)²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dabhol</td>
<td>1260</td>
<td>2,570,000</td>
</tr>
<tr>
<td>Kakinada</td>
<td>2810</td>
<td>1,430,000</td>
</tr>
<tr>
<td>Chennai</td>
<td>2590</td>
<td>1,530,000</td>
</tr>
<tr>
<td>Cochin</td>
<td>1730</td>
<td>2,070,000</td>
</tr>
<tr>
<td>Hazira</td>
<td>1270</td>
<td>2,560,000</td>
</tr>
<tr>
<td>Pipavav</td>
<td>1210</td>
<td>2,640,000</td>
</tr>
</tbody>
</table>

¹ 1 nautical mile = 1852 m, ² tones/annum

Table 2
Feed specifications

<table>
<thead>
<tr>
<th>Feed Rate (MMSCF/d)</th>
<th>1100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (F)</td>
<td>100</td>
</tr>
<tr>
<td>Pressure (psia)</td>
<td>1000</td>
</tr>
<tr>
<td>CH₄</td>
<td>97.4%</td>
</tr>
<tr>
<td>H₂S</td>
<td>0.5%</td>
</tr>
<tr>
<td>CO₂</td>
<td>2.1%</td>
</tr>
</tbody>
</table>
Figure 1. The proposed two-train LNG plant with 7.5 mtpa capacity