Stranded Natural Gas Utilization by Fisher Tropsch Technology

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1. Introduction

Despite being one of the most abundant energy sources on the planet, more than third of the global natural gas reserves are classified as stranded [1]. Stranded gas refers to the reserve that has been discovered, but remains unusable for either physical or economical reasons. Remote location of gas reserves (where building a pipeline is prohibitively expensive) and low demands in the region are two economical constraints. Associated gas and stranded off shore gases are usually flared or re-injected to the reservoir. These gases can be better utilized by converting it to high value hydrocarbons. Fischer Tropsch technology has proven ability to convert low cost gases to high value hydrocarbon products (gasoline, diesel, oxygenates and wax etc). High capital cost, high operation and maintenance cost were some of the constraints that influenced the popularity and competitiveness of the F-T technology. But recent advancement in reactor and catalyst design and significant reduction in capital requirement has made F-T technology on par with other commercial technologies. Sasol has been operating commercial F-T plants since early 1980s in South Africa to produce a variety of synthetic petroleum products. Shell is operating F-T plant in Bintulu in Malaysia, where it produces low sulfur diesel and food grade wax. In addition, a number of F-T plants and facilities are in advanced stages around the world. Oryx-GTL plant being built by Sasol and Qatar Petroleum, CTL project by Rentech and Peabody Energy, Lube plant in Australia by Syntroleum are some of the upcoming F-T facilities. The impetus of this poster is to demonstrate the features of the F-T technology for production of liquid fuels that strengthens the environmental quality and energy security by cutting the dependence on crude oil.

2. Key Features

Key features have been summarized in two sections. Features of F-T technology, catalyst, rector design and recent advances have been described in first section. Second section focuses on stranded natural gas availability and location, its utilization and information about existing/upcoming commercial F-T plants.

2.1 *Fischer Tropsch technology*

Since its discovery in 1920s, F-T synthesis has undergone period of rapid development and growth. Two main characteristics of the F-T synthesis are production of wide range of hydrocarbon and liberation of large amount of heat. F-T synthesis is either low temperature or high temperature process (LTFT & HTFT). LTFT process mainly produces syncrude with large fraction of heavy, waxy hydrocarbon while HTFT produces light syncrude and olefins. Parameters that need to account for F-T reactor design are process condition for desirable catalytic conversion, properties of feed/product and removal of heat [2]. Over the years, multitubular fixed bed, bubble column/slurry phase, circulating bed and fluidized bed reactors have been commercially used. Fixed bed reactors operate between 180-250°C temperature and 10-15 bar pressure and in three phase gas-liquid-solid trickle bed mode and produces more paraffinic and waxy product spectrum [3]. Theses reactors are commercially used by Sasol in ARGE process (South Africa) and by Shell in Shell middle distillate synthesis (SMDS) process (Malaysia). Slurry phase or bubble column reactor consists of a vessel containing slurry consisting of process derived wax with catalyst dispersed in it [4]. One of significant advantages of the slurry phase reactors are that reactants fully mixed and can be operated virtually isothermally. Commercially, these types of reactors are used by Sasol in Sasol slurry phase distillate (SSPD) process (SA) [4]. High temperature F-T synthesis is carried out in fluidized bed reactors at 300-330 °C temperature and 25 bar pressure. The reactor operates in two phase gas-solid mode and produce predominantly gasoline and lighter olefins. The advantage of Sasol advanced synthol (SAS) reactor includes its simplicity, ease of operation, low operating cost, high thermal efficiency and capacity and high conversion at high gas load. It is common consensus among the people that cobalt based catalyst are best compromise between the performance and cost of the synthesis. Cobalt catalyst was first discovered in the 1930s. In the subsequent years, catalyst technology has advanced from a simple cobalt oxide on asbestos to sophisticated; high activity, highly optimized catalyst supported on modified alumina, silica or titania carriers and promoted with noble metals and basic oxides. Application of iron catalyst for F-T synthesis was demonstrated in 1950s. From 1950-1970s most F-T studies were focused on iron catalyst resulting in significant advancement in catalyst design, support and promoters. The idea of composite catalyst has been recently promogulated for maximizing gasoline production. Apart from iron and cobalt only thorium and nickel catalyst have moderate activity and selectivity for higher hydrocarbon ($C5^+$) production [6].

2.2. Stranded natural gas utilization

Natural gas is an abundant resource; the world contains more recoverable natural gas than oil on an energy equivalent basis. Nine regions are believed to have more than 100 Tcf of stranded gas (in order of size): Western Siberia to Yamal, Persian Gulf, southwest coast of Africa, Northeastern South America (Venezuela), eastern Caspian, Northern Africa, Australia and Alaska and northwest Canada [7]. Other regions that promise to have large reserves include Sakhalin Island, Bolivia and Peru, offshore eastern Canada, Bangladesh and Myanmar [7]. Stranded natural gas is impractical to exploit by conventional gas pipelines and liquefied natural gas (LNG) technology. The most practical alternative for transporting gas without a pipeline is to convert it to a liquid. Technologies to convert gas to liquid ranges from cooling and liquefying for transportation in insulated-tanker vessels to converting it to liquid fuel, such as diesel, kerosene, naphtha, methanol or dimethyl ether. About 11 new LNG export plants and 17 GTL plants are planned for construction within the ten years. Competitive bidding, manufacturing innovations, scale efficiencies, global communications and liberalized world markets have driven down the cost of these plants. Due to special requirements and technological limitation, LNG transportation is still very costly. On the basis of a million British thermal units (MMBtu), LNG transportation costs are at least three times that of the crude oil. Hence, it becomes practically feasible to convert stranded natural gas to liquid by using Fischer Tropsch synthesis. F-T synthesis is an established technology and already applied on commercial scales. F-T projects are scalable, allowing design optimization and application to smaller gas deposits. The key influences on the competitiveness of the F-T are the cost of the capital, operating cost of the plant, feed stock cost, scale and ability to achieve high utilization rate in production. As a generalization however, F-T technology is not competitive against conventional oil production unless gas has low value. F-T technology not only adds value, but also capable of producing products that can be blended into refinery stocks as superior products. Sasol is the leading company in the commercialization of F-T technology that currently operates commercial GTL facility at Secunda, Mossgas and Sasolburg with a total capacity of $1.5x10^5$ barrels a day (bpd). Other companies that have developed GTL processes (pilot plant/commercial) include Shell, Exxon, Statoil, Rentech and Syntroleum. Global commercial GTL capacity is 60000 bpd.

3. Conclusions

Despite numerous technological advancements in piping and LNG technology, significant amount of natural gas remains unusable due to physical and economical reasons. By converting the stranded or remote natural gas reserve to high value hydrocarbon fuels and chemicals, F-T technology can positively contribute to the world energy security and supplies. With the cost of crude oil increasing, syncrude or substituted hydrocarbons (liquid fuels) are poised to become viable alternative. The application of the F-T technology has been limited due to number constraints such as high technology cost, limited plant capacity reactor design and catalyst deactivation. Significant breakthroughs have been achieved in every aspects of the F-T technology. With more and more companies investing F-T facilities and plants, the future of the F-T technology look very pragmatic and positive. If commercialized on a large scale, F-T technology allows to de-strand world's 4500 trillion cubic feet of natural gas [7]. Also the existing infrastructure of transportation and distribution network can be utilized for marketing the F-T products.

4. References

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