Modular Syncrude Conversion Drives Oilfield GTL Solution for Associated Gas

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The associated gas that accompanies oil to the surface in a producing well can be a great advantage and valuable revenue stream, if your oil field is near a pipeline that feeds into a gas market. However, as oil fields move into deeper and more remote areas, away from population centers and gas infrastructure, the options for handling associated gas have become restricted and the question of what to do with it often difficult. The industry is crying out for a solution.

Historically, where there was no local market or available pipeline, associated gas was flared. However, this is now both environmentally and politically unacceptable, and in many countries banned. The alternative of gas reinjection is expensive and can cause reservoir damage, which adversely affects production and reserves.

Seeking a solution that avoids either of these alternatives, the industry for years has experimented with a variety of technologies.

For example, in areas with large associated gas volumes, the gas can be commingled into gathering systems and supply nearby specially constructed liquefied natural gas (LNG), methanol, or ammonia plants. However, this solution comes with a couple of major requirements.

1) High gas volumes must be committed in advance to justify the substantial plant-building cost.

2) Commonly, supplementary nonassociated gas also must be available to offset supply fluctuations, including the eventual decline of field production. One example of how this supply-balancing requirement can work is the Bonny Island LNG plant in Nigeria, which ran on nonassociated gas until gathering systems were built that allowed associated gas to replace part of the original supply stream.

Without both of these prerequisites, commingling is not an option. With oil fields getting smaller and more remote, there will commonly not be sufficient reserves of associated gas to justify installing gas infrastructure or gas-processing plants. Even in areas such as the North Sea, where extensive gas infrastructure and a ready local market exist, small fields with short lives of 4 years or so cannot justify the expense of installing a gas export pipeline.

Other solutions proposed for dealing with associated gas that cannot be exported by pipeline have involved locating a gas-processing plant adjacent to the oil field and using technologies such as floating LNG, gas-to-liquids (GTL), methanol production, or gas-to-wire electrical power generation. These too tend to require large supplies of gas and considerable investment. For example, a standalone facility capable of consuming 100 to 150 MMscf/D of gas would have a capital expenditure of more than USD 1 billion. In addition, a facility would need a steady nondeclining gas stream, which often can only be achieved by combining associated gas with nonassociated gas from other fields. As such, this has led to these large facilities focusing on stranded gas with reserves of 0.5 Tcf or greater, rather than associated gas.

So what becomes of the next generation of smaller oil fields, where there will not be sufficient gas volumes to justify these large investments? Ironically, the smaller the gas volumes, the more difficult the problem they present. This counterintuitive fact has led to the idea of "distressed gas," where an oil field cannot be developed because no economic means exist to dispose of the small quantities of associated gas.

For example, an oil field producing 50,000 B/D of oil with a gas/oil ratio of 400 scf/bbl will generate 20 MMscf/D of associated gas, of which 5 MMscf/D may be used for power generation. This

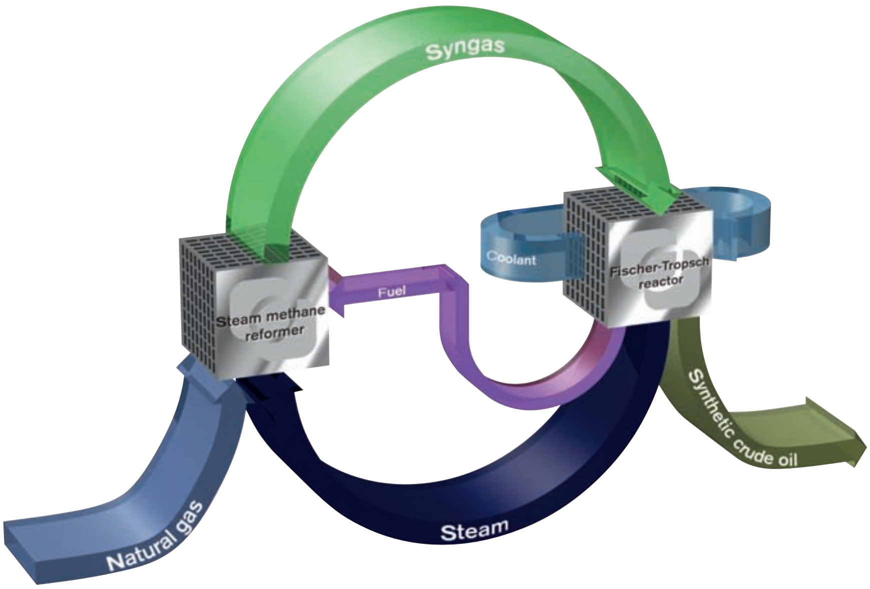

Fig. 1—Picture of the SMR/FT cycle.

Fig. 2—FT section of the UK pilot plant.

leaves 15 MMscf/D of associated gas in need of a disposal solution. These volumes are too large to flare and too small to justify pipeline installation. Even if they were reinjected into the reservoir, it would require an injection well that could cost from USD 100 to 250 million for a single offshore well. The well cost would be the same, regardless of injection volume, and it will have to be abandoned at the end of field life, in as little as 4 to 6 years, with zero residual value. The cost of disposing of low gas volumes, consequently, is proportionately higher than for higher gas volumes.

This situation leaves the industry with a huge dilemma. CompactGTL (CGTL), a UK-based company, has devoted 5 years to finding an answer and recently has developed a proprietary GTL technology that converts the distressed associated gas to synthetic crude oil (syncrude) at the point of production. The syncrude, which is unrefined, can be blended back into the field's main crude stream, with no need for separate storage and transportation. This contrasts with other technologies, such as LNG and methanol production, where the small volumes of these liquids must be stored, transported, and marketed separately from the oil and, thus, require their own parallel infrastructure.

Unlike other GTL companies, CGTL is not primarily concerned with gas monetization. Instead, the company has focused on providing a solution to the distressed-gas problem so that oilfield development can move forward more rapidly and economically. The equipment also is designed to be integrated into a floating production, storage, and offloading (FPSO) vessel or to be set up as a standalone onshore facility.

The technology is modular, allowing it to be matched to an oil field's declining production. Modular reactors are based on a standardized unit that can produce 200 B/D of syncrude from approximately 2 MMscf/D of gas. For the case given above, 15 MMscf/D of gas would require seven reactor modules placed in parallel within a manifold, which would produce 1,500 B/D of syncrude. As the field production declines, reactors are taken offline so that there remain only six, then five, then four parallel reactors, and so on, to match the declining gas production. This granularity is fundamental to the concept and differs markedly from conventional GTL designs, where single mega-reactors are used to achieve economies of scale. The problem with these mega-reactors is that they have limited turndown and so require a constant gas supply.

The technology was developed in Harwell, home of the UK atomic industry, and was acquired by Coller Capital in 2005, with CGTL being formed in 2006. The company is based in Abingdon, near Oxford, and houses laboratories in which the core technologies are developed and tested at laboratory scale. It has recently brought on stream its Wilton-based UK pilot plant, which produces 0.2 B/D of syncrude from simulated associated gas and, thus, allows testing of intermediate-scale reactors. The company also recently has announced the extension of its contract with Petrobras, valued at approximately USD 45 million, for the supply and testing of a 20-B/D pilot CGTL plant

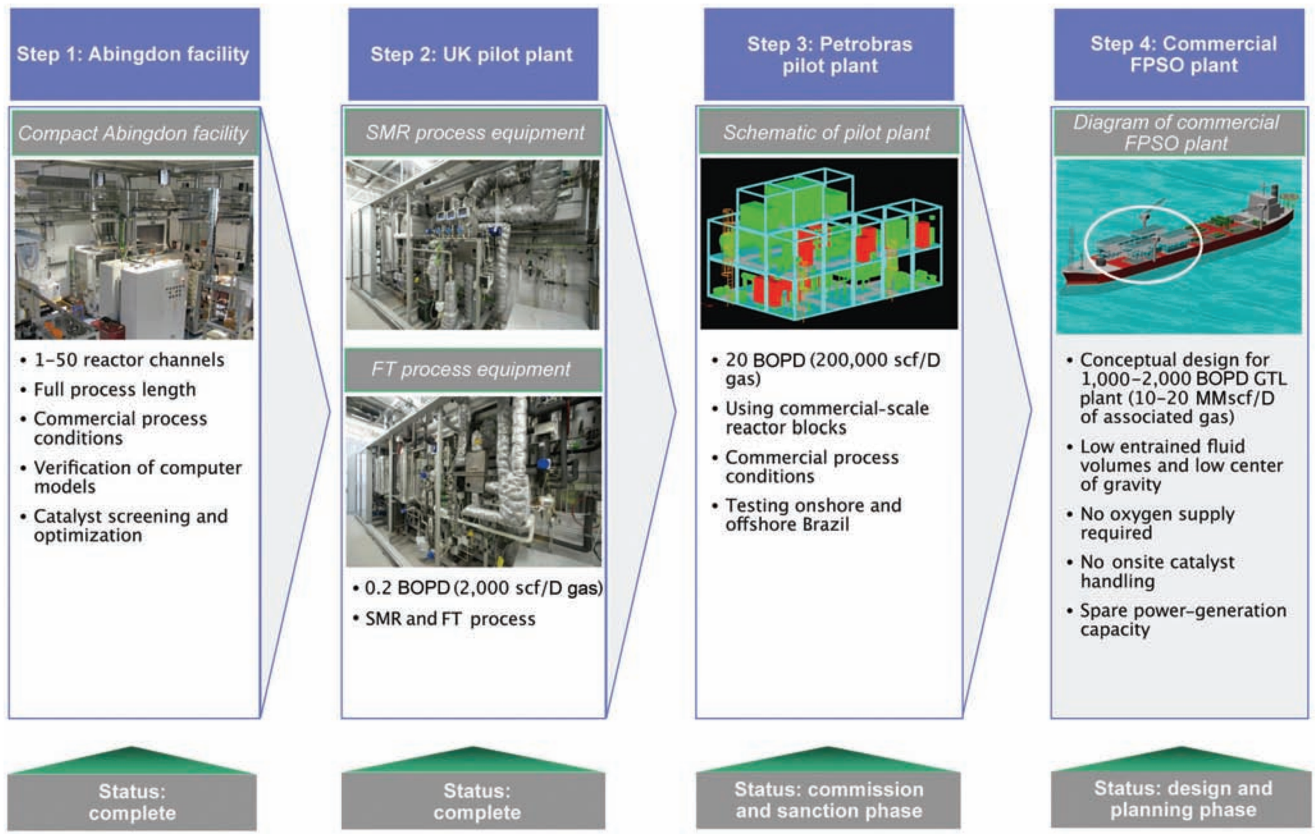

Fig. 3—Commercial-development program.

that will test full commercial-scale reactors. The Brazilian oil provider became engaged with the company in early 2007 because it sought solutions to the problem of associated gas. The pilot plant is on track to be installed and operated at the Petrobras Aracaju gas-processing plant in northern Brazil in 2010.

How the Technology Works

The technology is based on a coupled process, **(Fig. 1),** where the associated gas first is converted to synthetic gas (syngas)—a combination of hydrogen and carbon monoxide—by means of a steam methane reformer (SMR). This syngas then is compressed and fed into a Fischer-Tropsch (FT) reactor, which converts the syngas into syncrude **(Fig. 2).** The process also involves gas pretreatment upstream of the SMR, where contaminants such as sulfur are removed and higher hydrocarbons are converted to methane. However, unlike conventional GTL technology, the process does not employ a hydrocracker downstream of the FT reactor to convert the syncrude to diesel fuel and naphtha. However, this technology easily could be added, if there were a market for these products, as might be the case if the plant were onshore.

Both the SMR and FT reactors are similar in design and consist of a series of mini-channels (0.39 in.×0.20 in.) into which fecraloy foils coated in catalyst are inserted. In each reactor, there are two sets of channels, and the design is analogous to a plate-and-fin heat exchanger.

For the SMR, one set of channels is used to combust gas to provide heat, while the other set hosts the SMR reaction. This reaction requires a temperature of more than 1,292°F, which is provided by heat from the combustion channels. The channels are in layers within the reactor, with a layer of combustion channels alternating with a layer of SMR channels. This close coupling of the channels improves heat transfer to provide process intensification and enable a reduction in reactor size.

For the FT reactor, one set of channels is used for the FT reaction. However, unlike the SMR reaction—which is endothermic—the FT reaction is exothermic. Thus, the second set of channels is used to circulate cooling water to remove heat. Again, the alternating layers of channels improve heat transfer and enable a reduced reactor size.

The UK pilot plant has demonstrated that the technology works. Parallel with this technology-development program, a commercial-development program is in progress to ensure an orderly transition from the laboratory to the field **(Fig. 3).**

Part of this program focused on how to scale up the technology from its UK pilot-plant dimensions to full commercial requirements. It was concluded that trying to scale up from a 0.2-B/D to a 200-B/D reactor design was the wrong approach because the manufacturing techniques appropriate to a small reactor could not be used to manufacture large reactors in volume. Consequently, strategic alliances with world-class manufacturing companies were established to develop reactors that incorporated the CGTL technology but could be manufactured economically at full commercial scale and in the volumes necessary to support the market.

This ongoing program has resulted in commercially aligned reactor designs that allow economic manufacture of 200-B/D modules, which will weigh less than 25 tonnes for ease of handling and replacement on offshore facilities. These full-scale designs were scaled down to provide the reactors for the earlier stages of the commercial-development program, the UK pilot plant, and the Petrobras pilot plant. With these commercial reactor designs, there is no onsite handling of catalysts. Catalyst changeover is achieved by replacing the complete reactor modules and refurbishing those with spent catalyst at another location.

The first stage of this development program, to provide reactors for the UK pilot plant, is well under way. Commercially aligned reactors are being tested. The next stage is to manufacture the reactors for the Petrobras pilot plant.

The pilot-plant contract with Petrobras calls for construction and installation of a 20-B/D plant that will be operated with gas supplied from the Petrobras Aracaju plant. The Petrobras pilot is a fully integrated plant that will take unprocessed gas and produce syncrude. The plant will include the gas pretreatment initial stage and all the necessary utilities systems, such as steam, required to run the plant. The only major imports are power and boiler-feed water. The Petrobras pilot plant, consequently, reproduces completely a full-scale commercial plant and uses commercial-scale reactors.

The pilot plant will be operated for up to 6 months onshore. Petrobras then plans to move the plant offshore and test it on a well-test vessel.

The final part of the commercial-development program was to produce designs for full-scale commercial applications. A generic 5,000-B/D plant design was produced by CGTL and integrated into an FPSO's systems, in collaboration with a leading FPSO contractor. The resulting vessel, with an integrated GTL gas solution, allows accelerated field developments by eliminating the need for independent gas disposal. In addition, turning the distressed gas into syncrude, rather than reinjecting it into the reservoir, adds value both by increasing the amount of bookable reserves produced and eliminating the cost of an injection well.

Conclusion

With the industry move to smaller and more remote oil fields, the issue of distressed associated gas is becoming an increasing problem. The use of flaring is no longer acceptable for both environmental and economic reasons, which has left limited options available. These gas-handling and -marketing solutions tend to be expensive, and many are not suitable for the declining gas profiles of associated gas. The solution to distressed associated gas described herein consists of converting it to syncrude by means of a modular reactor system that can be matched to the gas profile. The syncrude can be commingled with the produced crude oil for transportation and sale, eliminating the need to market the product and allowing additional reserves to be booked. **JPT**