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Studies on the FPSO Application of Natural Gas to Dimethyl Ether Process

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Background

Dimethyl Ether (DME) is an ultra-clean burning alternative to diesel and Liquefied Petroleum Gas (LPG). It is easy to liquefy, making it a convenient fuel to transport and store. These properties make DME a versatile and promising solution in the worldwide consideration of clean and low-carbon fuels. DME can be produced from various feedstock like natural gas, Coalbed Methane (CBM), shale gas, biomass, coal, etc. Traditionally, DME has been produced by first producing methanol from syngas and then dehydrating methanol to produce DME. Korea Gas Corporation (KOGAS) had developed the process for direct synthesis of DME from natural gas. KOGAS process is a single-step, direct synthesis of DME from syngas. KOGAS process requires just one reactor to produce DME from syngas. This leads to compact process design and savings in capital and operation cost. KOGAS' DME process is ready to move to commercialization. KOGAS completed the Basic Engineering Package (BEP) of 300,000 metric tons/year DME plant.

The Floating Production Storage & Offloading (FPSO) application enables utilization of low cost gas from remote offshore gas fields as feedstock for the DME production. FPSO is economically attractive for remote or deepwater locations where pipelines are not cost effective. When the FPSO plant is located near the potential markets for the product, the project has the added benefit of lowering the transportation cost.

Aim

This project was carried out for the Preliminary Front End Engineering Design (Pre-FEED) of DME FPSO based on KOGAS DME process and development of basic technology for FPSO application. The production capacity of DME FPSO was 1,000,000 metric tons/year.

Methods

As a collaborative study between KOGAS and Daewoo Shipbuilding & Marine Engineering Co. (DSME), the Pre-FEED package of KOGAS' DME process was recently developed for FPSO application. Along with this pre-FEED study, KOGAS had tested the ship motion effect on the reaction of tri-reformer and DME reactor. Small scale tri-reforming system and DME reaction system were made and tested on a 6-Degrees of Freedom (6-DoF) moving platform.

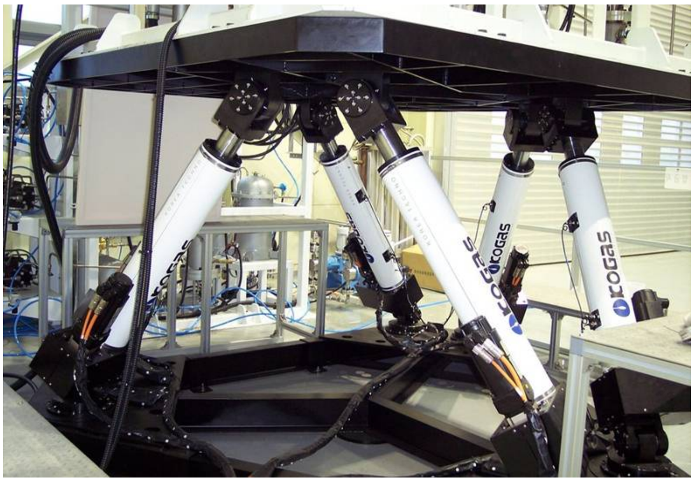

Figure 1. 6-DoF Moving Platform

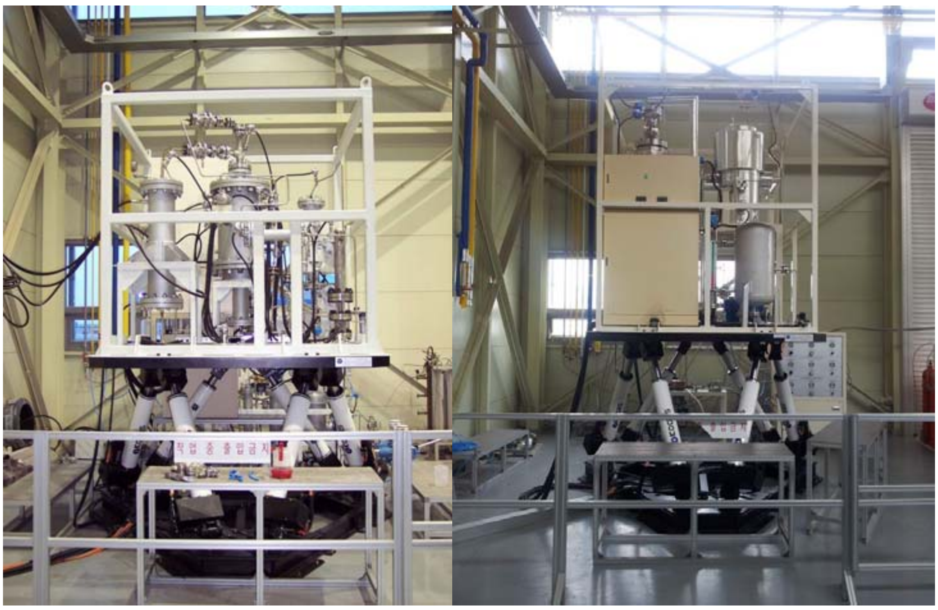

Figure 2. Floating Tri-reformer (LEFT) and Floating DME Reactor (RIGHT)

Results

KOGAS' DME process was redesigned for FPSO application. KOGAS' DME process requires only one reactor section to produce DME from syngas. This makes the KOGAS DME technology suitable for FPSO application. The pre-FEED package includes equipment design to withstand vessel motion, compact design to minimize the topside area and module weight requirement, and greater safety requirement on FPSO application, and additional challenges in process equipment maintenance and material handling. The spatial limitations in both the topside and hull in an FPSO plant puts more restrictions on the process and equipment to a land-based plant.

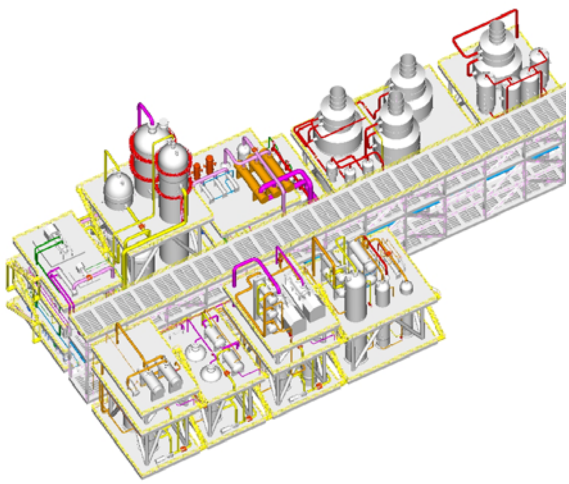

Figure 3. 3D Modeling of DME FPSO Topside

Figure 4. 3D Modeling of DME FPSO Vessel

Inside the tri-reformer, there is a burner underside of the top. The temperature control of tri-reformer is very important because the operation temperature is about 1000□.

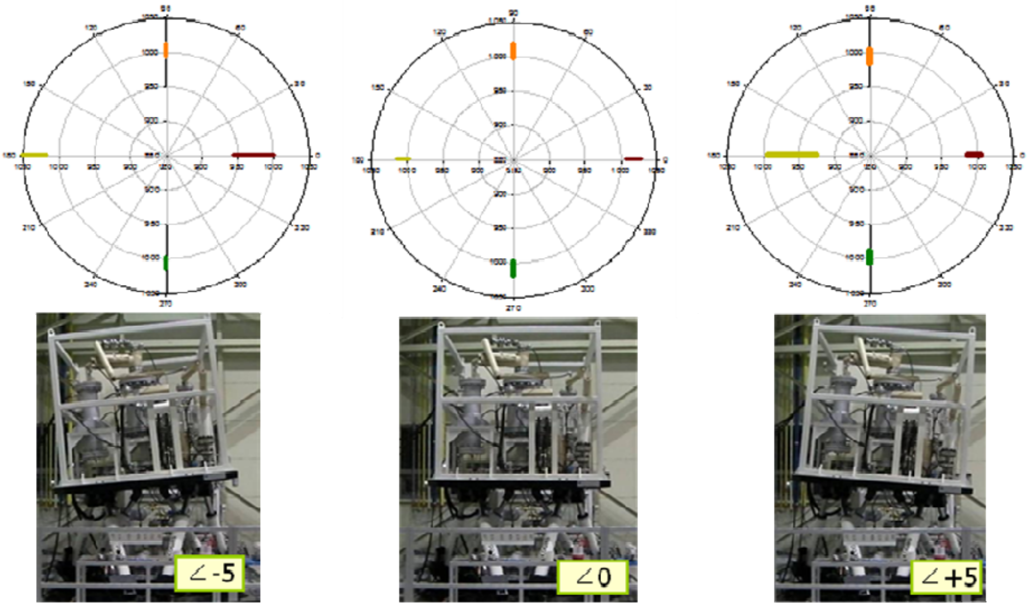

Figure 5. Wall Temperature Profile of Tri-reforming System

Although KOGAS tri-reformer showed no problem when operating with ship motion, small modifications on the refractory wall will be required for the tri-reformer of DME FPSO.

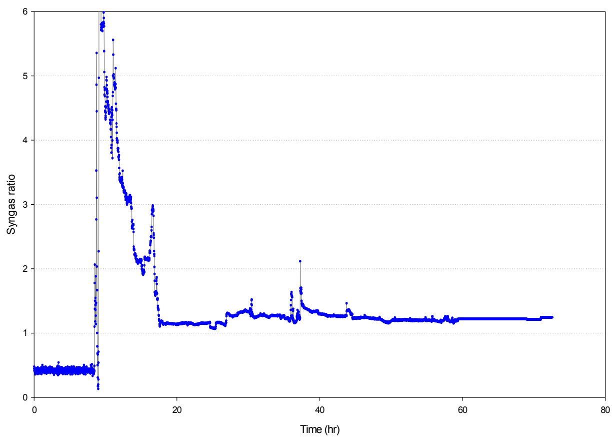

Figure 6. Syngas Ratio of Sloshing Tri-reforming System

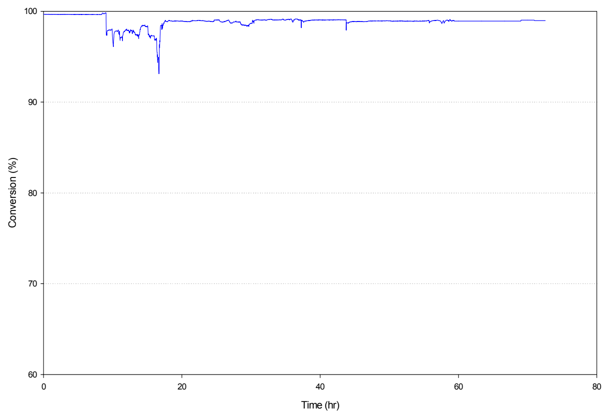

Figure 7. Methane Conversion of Sloshing Tri-reforming System

Methane conversion and syngas ratio of tri-reforming reaction with moving platform were monitored. H_2/CO ratio was maintained near 1.3, which is optimum ratio for DME reaction. And methane conversion was about 97%.

DME Reactor is shell and tube type reactor, so the ship motion effect on the DME reaction is negligible.

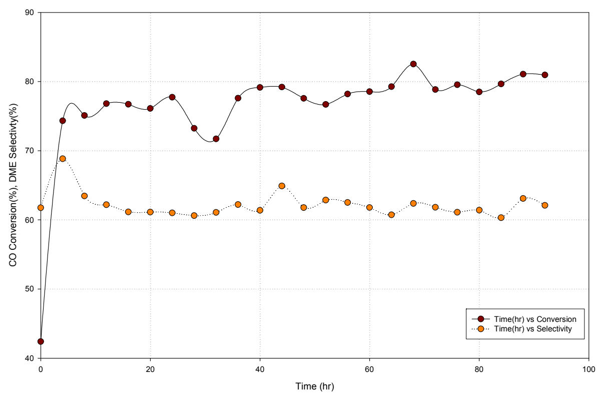

Figure 8. CO Conversion and DME Selectivity of Sloshing DME Reaction System

The temperature was more evenly distributed, when DME reactor was being floated. The CO conversion and DME selectivity were 77.8% and 62.2%, which were almost same as land base DME reactor.

The tri-reformer requires oxygen feed, so air separation unit (ASU) is needed to supply oxygen to tri-reformer. The cryogenic ASU is not an adequate option for FPSO because of the vessel motion. KOGAS is also developing new reformer for the FPSO application.

Because KOGAS process can utilize carbon dioxide in the natural gas, natural gas containing carbon dioxide can be used as a feedstock. The produced carbon dioxide in the process is recycled to the tri-reformer. Carbon dioxide need to be separated and recycled to the tri-reformer. In the land base plant, carbon dioxide is absorbed into solvent in the absorption column and separated in the stripper column. KOGAS has also developed carbon dioxide removal process by membrane separation technology, which is applicable to FPSO vessels.

Figure 9. Bench Scale Membrane Separation System

Conclusions

KOGAS successfully carried out Pre-FEED study for DME FPSO based on KOGAS' DME process and tested ship motion effect on the main reactors for the design of optimal process for FPSO application.

Authors

Taekyong Song, Senior Research Engineer, KOGAS, South Korea
Yonggi Mo, Research Engineer, KOGAS, South Korea