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Review article

QAFAC: Carbon dioxide recovery plant

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ABSTRACT

This short report outlines Qatar Fuel Additives Company (QAFAC) plan to reuse the carbon dioxide emitted from their methanol plant. It is estimated that 500 tn/day of CO_2 will be recovered from its Methanol Reformer stack which will be injected into the Methanol Synthesis unit to enhance the production capacity. The Recovery Unit will be constructed under license from MHI (Mitsubishi Heavy Industries, Japan) and will be a specific and novel application of CO_2 recovery focused to optimize methanol production. Overall, since operations are designed to produce 982,350 tonnes per annum of methanol and 610,000 tonnes per annum of MTBE, the QAFAC Plant will be one of the world's largest commercial-scale CO_2 capture facilities.

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THE METHANOL PLANT

A schematic of the methanol production from natural gas feedstock is shown in Fig. 1.

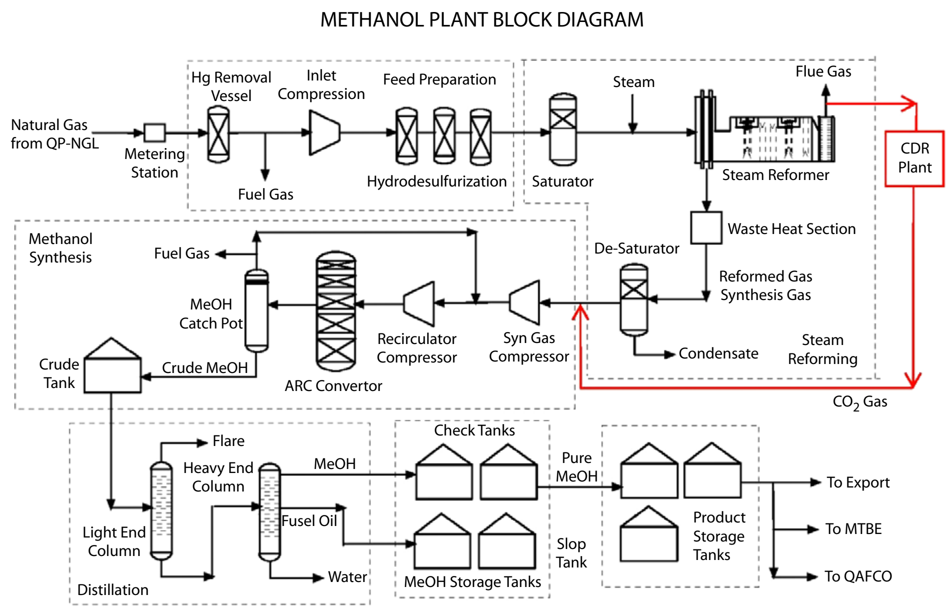

Figure 1. A schematic of the methanol production from natural gas feedstock.

Shown are four stages. In outline:

- Feed Purification: The hydrocarbon feed contains mercury, which is completely removed at the inlet of the plant. Sulphur is completely removed in the desulphurization section.
- Reforming Section: The desulphurized hydrocarbon is reformed together with steam to produce the synthesis gas containing hydrogen, carbon monoxide, and carbon dioxide.
- Methanol Synthesis Section: The synthesis gas is, after compression to a pressure of about 7,700 kPaG, converted into methanol by a catalytic reaction. Finally, dissolved gases and impurities are removed from the methanol by distillation.
- Distillation Section: The crude methanol is distilled to separate the product methanol from dissolved gas and the impurities.

This procedure is standard and based on the reversible reaction at the reforming stage:

$$CH_4 + H_2O \leftrightarrows CO + 3H_2.$$

And, for the methanol synthesis, one has,

$$2H_2 + CO \leftrightarrows CH_3OH.$$

Further, however, carbon monoxide will react with water in the reforming process to yield carbon dioxide and hydrogen:

$$CO + H_2O \leftrightarrows CO_2 + H_2.$$

At the synthesis stage, the CO_2 reacts with excess hydrogen to synthesize methanol,

$$CO_2 + 3H_2 \leftrightarrows CH_3OH + H_2O.$$

It turns out that about 50% of the carbon oxides contained in the synthesis gas is converted into methanol per pass under the condition of excessive hydrogen. Hence, the unconverted synthesis gas is recycled as indicated in the figure.

THE CO_2 RECOVERY PLANT

The flue gases from the reformer are vented to the atmosphere at a rate of ∼600 to 620 tn/hr. Since the flue gas composition during normal plant operation on a volume/mol percent basis is CO_2-5.49%, O_2-1.83%, N_2-65.90% and H_2O-26.78%, approximately 55 tonnes of CO_2 are emitted per hour. But, the chemistry indicates that adding CO_2 to the synthesis gas mixture can increase the capacity of the methanol plant due to excess hydrogen available in the synthesis loop. Clearly, then, it would be advantageous to recover and use a significant proportion of the waste CO_2. This is the described project.

MHI's CO_2 recovery technology is known as the KM CDR Process®. It uses MHI's proprietary KS-1 solvent for CO_2 absorption and desorption which MHI jointly developed with Kansai Electric Power Co., Inc. MHI's technology features considerably lower energy consumption compared with other processes and has won high evaluations for its performance. It is noted that, following the first plant in Malaysia in 1999, MHI has licensed and delivered its CO_2 recovery technology to nine commercial CO_2 recovery plants around the world with another plant under construction.

As indicated in the figure, the flue gas will be transferred from the Reformer Stack to the CO_2 Recovery Plant. As the flue gas temperature is ∼230 °C, and thus too hot for feeding to the CO_2 absorber, it is quenched by water then mixed with the KS-1 solvent on a packed bed. The CO_2 free gas is washed and emitted to the atmosphere. The CO_2 rich gas is then sent to a packed column regenerator where the solvent is heated and the CO_2 is stripped from the column. The regenerated CO_2 is washed to remove any traces of solvent, compressed, and send back to the Methanol plant to mix with the synthesis gas.

The key result is that, not only is the capacity of the Methanol Plant increased, the atmospheric CO_2 emission is reduced from the approximately 55 tn/hr to about 34 tn/hr, a reduction of 38%.

SUMMARY

Established in 1991, QAFAC is a joint venture between Industries Qatar, OPIC Middle East Corporation, International Octane LLC and LCY Middle East Corp. The Company commenced operations in 1999.

With the initiation of this project – targeted for completion in October 2014 – QAFAC aims to optimize the utilization of the country's vast hydrocarbon resources. Furthermore, the project demonstrates the intent to be a leader in cutting industrial greenhouse gas pollution, and to play a front line role as an environmentally conscious company.