PTX WIND IN H2 MARE

Green Methanol Offshore Plant

Experimental Platform

Process Description

presented by

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1. General

The Green Methanol Offshore Plant on the Experimental Platform is designed to produce around 170 kgpd of crude methanol (methanol + water) from CO2 and hydrogen, which are both supplied from Battery Limit (B.L.). The process description describes all required process steps which are within scope.

The units of the methanol complex are listed in Table 1.

Table 1: Methanol Plant (1011-00)

Unit No.	Description
1011-01	Methanol Synthesis – Syngas Compression
1011-02	Methanol Synthesis
1011-03	Methanol Synthesis- Recycle Gas and High-Pressure Separation
1011-04	Methanol Intermediate Storage

2. Methanol Plant

A simplified process flow diagram of the Methanol Plant is shown in Figure 1. This process configuration is similar conventional methanol plants converting carbon oxides and hydrogen to methanol with only a few modifications. All equipment is proven and state of the art.

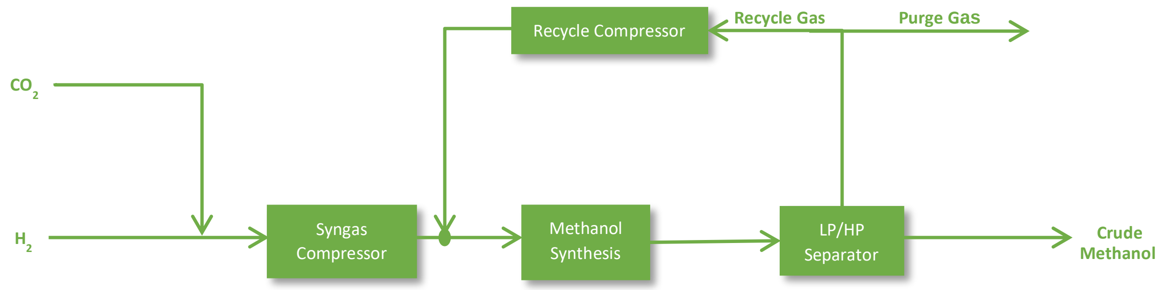

Abbildung 1 Process Overview of the Methanol Plant

Experimental Platform only contains the methanol synthesis process, no methanol distillation process. The capacity of the methanol plant can be reduced to approx. 25% to match the requirements of a fluctuating supply of feedstock.

2.1 Syngas Compression and Synthesis (Unit 1011-01)

(Refer to PFDs 1011-01)

Hydrogen is continuously routed from Battery Limit (B.L.) to the Methanol Plant with the approx. flow of 3 Nm^3/h at a pressure of approx. 27 bara and a temperature of approx. 25 °C and carbon dioxide is also continuously routed from Battery Limit (B.L.) to the Methanol Plant with the flow of approx. 8.9 Nm^3/h at a pressure of approx. 27 bara and a temperature of approx. 25 °C. The resulting mixture is then compressed to approx. 80 bara in the Syngas Compressor 1011U001, a single stage reciprocating compressor driven by an electrical motor. The hydrogen to carbon dioxide ratio at the entrance of the reactor is fixed. The hydrogen flow rate and the H_2/CO_2 ratio is continuously measured and the amount of carbon dioxide added is adjusted accordingly.

The resulting synthesis gas (syngas) is then mixed with recycle gas from the Recycle Gas Compressor 1011U002, which is driven by an electrical motor. The resulting gas is heated up in the Feed/Effluent Electrical Heat Exchanger 1011EE01 and the Reactor Feed Preheater 1011E002 to approx. 215 °C before entering the Methanol Reactor 1011R001.

For the methanol synthesis, a copper, zinc oxide and alumina-based catalyst from a commercial catalyst supplier is used. The preferred temperature range for this catalyst lies between 210 and 250 °C. A minimum temperature is necessary to activate the reaction; a maximum temperature should not be exceeded to prevent catalyst deactivation and side product formation. The conversion of CO and CO2 to methanol is favored by increasing pressure. The main reactions taking place in the reactor are described in the following reaction equations:

$$CO2 + 3H2 \leftrightharpoons CH3OH + H2O$$

$$CO + 2H2 \leftrightharpoons CH3OH$$

$$CO + H2O \leftrightharpoons CO2 + H2$$

To achieve isothermal reaction conditions in Methanol Reactor 1011R001, a water-cooled tube reactor is chosen where process gas on the tube-side is cooled by evaporating water on the shell-side of the reactor. Such type of reactor is also used in conventional methanol plants. The tube side of the reactor is filled with catalyst, the process gas flow is realized from top to bottom of the tube where carbon dioxide and hydrogen are converted to methanol and water. On the shell side liquid water at boiling temperature enters the reactor at the bottom. During start-up, the reactor is heated up by boiling water, whereas during normal operation process gas on the tube-side is cooled by evaporating water on the shell-side of the reactor. After partial evaporation, a steam water mixture leaves the shell side at the top and enters Reactor Feed Preheater 1011E002, where water/steam mixture is condensed and subcooled by approx. 5K. Energy from cooling down the water/steam mixture is used to preheat the feed gas stream into the reactor. The steam circulation is maintained by thermo-syphon effect. During start-up the Start-up Pump 1011P002 is used to ensure the circulation. Before the water is entering the shell side of the reactor again, it is heated up to the required water temperature by Electrical Water Heater 1011EE03. The electrical heater is needed to heat up the reaction system during start-up, but also for normal operation to heat up the water until the boiling point is reached in order to control the reaction temperature. Also, the pressure is measured on top of the Reactor Feed Preheater 1011E002. This pressure is compared with the corresponding vapor pressure of the reactor temperature to correct temperature control of the electrical heater. When the temperature in the water/steam loop increases, electrical heater 4061EE03 stops heating until the set temperature is reached. When the temperature in the water/steam loop decreases, the water heater will increase its heating output. Besides the temperature in the water/steam loop, also the temperature at the outlet of the methanol reactor is measured. If the temperature at reactor outlet increases too much, electrical water heater 1011EE03 will be switched off. The water-cooling loop is operated at a pressure of approx. 29 bara and a corresponding saturation temperature of 232 °C.

The product gas from Methanol Reactor 1011R001 is cooled down in the Air-cooled Heat Exchanger 1011A001 to approx. 50 °C. An air cooler needed to cool down the reactor product The partially condensed gas-liquid mixture is fed to the High Pressure Separator 1011D001, where crude methanol is separated from non-reacted syngas. Non-reacted syngas is compressed by the Recycle Gas Compressor 1011U002 to approx. 80 bara and is then mixed with syngas upstream of the Feed/Effluent Electrical Heat Exchanger 1011EE01. A small side stream is withdrawn from the recycle gas downstream of the High Pressure Separator 1011D001 and is sent to the Battery Limit to avoid accumulation of inert components. Crude Methanol has been sent to the storage tanks 1011D002A-B.

2.2 Methanol Intermediate Storage (Unit 1101-04)

(Refer to PFD 1011-04)

The crude methanol from the High-pressure separator (1011D001) is routed to the Methanol Intermediate Vessels 1101D002A-B at approx. 49°C and at 6 bara. In these vessels the crude methanol is stored until it full to the limit. In case the vessel is full then the methanol is pumped to the Methanol Storage Tank (OSBL) via the Methanol Intermediate Product Pump 1011P003.

The Methanol Intermediate Storage Vessels 11001D002A-B are each designed for a retention time of about 24 hours. Both vessels are inerted with nitrogen. The breathing gases from the Methanol Intermediate Storage are routed to the Flare System (OSBL).