Hydrogen Plant

6,500 Nm³/hr

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Overview

- Capacity: 6,500 Nm³/hr
- Built: 1995
- Shutdown: 2009
- Updated PSA 2006
- Fuel in natural Gas with an end pressure of 17.5 bar
- Products Produced:
  - Nitrogen
  - Electrical Power
  - Demi Water
Process

General Information:

The process is structured in the following main process steps:

- Raw gas conditioning
- Pre-Reforming process
- Reforming process
- CO-Conversion
- Hydrogen purification
- Heat recovering
- Heating system
- Releasing system
Raw Gas Conditioning
The natural gas will be taken over pressure controlled on the border of the plant. A part of the natural gas will be used as fuel for the burners. Most of the gas will be used for the production of Hydrogen. The raw gas will be enriched with the loop hydrogen. Before this gas is going into the desulfonization reactor (R-101), it is getting preheated up to 380°C. The upper part of the reactor is filled with a Comox - packed bed, where the organic sulphur is converted to H₂S. The sulphur hydrides are getting reduced in the lower section of the reactor by reacting with ZnO to a content of > 0.2 ppm in the raw gas.

\[ \text{ZnO} + \text{H}_2\text{S} \rightarrow \text{ZnS} + \text{H}_2\text{O} \]

Pre-Reforming Process
The desulfonated raw gas is getting mixed with steam which is added volume controlled. This is necessary to get the correct relation steam/carbon (S/C). This gas is getting overheated to 530°C in a convection zone. The pre-reforming process is an adiabatic process in the reactor (R-102).

This temperature is needed for the conversion of methane to higher carbon hydrides and from steam to hydrogen. The production of carbon monoxide and carbon dioxide is a result of the temperature drop to 448°C.
**Reforming Process**

The pre-reformed raw gas is heated up by convection to 620°C. In the reforming reactor (H-101) is the mix of raw gas and steam reacting to a mix of Hydrogen, CO, CO₂ and Methane by using a nickel based catalyst (please see the equations below). The reforming processes are endothermic and need high heat supply. The heat supply is getting done by burning the purge gas of the PSA and natural gas. The heat supply is controlled by the volume of desulfonated natural gas. The process gas is leaving the reactor with a temperature of 850°C.

\[
\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + 3\text{H}_2 \\
\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2
\]

**CO-Conversion**

To increase the content of Hydrogen in the Synthesis gas from the reforming reactor the biggest part of CO is reacting with steam to Hydrogen in reactor (R-103). Using a catalyst based on ion oxide and a feed temperature of the process gas of 350°C the CO content of the synthesis gas will be reduced to 4.14% (dry).

\[
\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2
\]
Process

Hydrogen purification
The synthesis gas from the converter is cooling down. The still existing steam is condensing and discharged. In the cleaning system (X-201) the gas which is fortified with hydrogen is getting cleaned by pressure swing absorption (PSA). A low volume a pure hydrogen is getting fed over a compressor (C 103) to the desulfonation. The purge gas is getting reused as heating gas for the reforming reactor. The pure Hydrogen is perfusing the section of measurements and will be taken over on the border of the plant.

Heat Recovering
The reformer gas heat is getting recycled by steam production in the evaporator (E-101). The evaporator is equipped with an internal bypass on the converter inlet for the regulation of the gas temperature. The gas leaving the converter streams to the boiler feed water pre-heater (E-102). Finally the process gas is cooling down to 30°C in the process gas coolers (EA-101 and E 103). The condensate produced is getting discharged before the hydrogen enriched gas is getting supplied to the hydrogen cleaning system (X-201).

The first step of the heat recovering from the combustion gases is taken place in the evaporator (CE-101). Thus the process gas pre-heater (CE-102) is getting protected again too high temperatures. The following pipe coils in the convection zone are the product stream super heater (C-103), the raw gas pre-heater (CE-104) and the air pre-heater (CE-105).

The exhaust gas is going to the atmosphere through the exhaust gas blower (C-101) and chimney (X-101).
Heat Recovering (continued)
The steam produced will be partially taken back as process steam for the reforming process of the natural gas. The remaining steam will be supplied as process steam (steam export).

Heating System
The following heating mediums are available:

- PSA purge gas
- Natural gas

PSA purge gas is used as the main heating medium for the reformer-reactor. The natural gas is used to increase the heat value according the necessary process conditions. The air pre-heating is getting done because of economical reasons and the compliance of the NOX – limits of 200 mg/Nm³.

Releasing system
In case of emergency, the process gas is getting released over a chimney into the atmosphere which is installed on the side of the purge gas vessel of the PSA system. An explosion and flame form locking has been designed. The releasing system is continuously under nitrogen purge.
Major Equipment

- Desulfurization of Natural Gas
  - Desulfurization Reactor (R-101)
  - Recycle-Hydrogen Compressor (C-103)

- Pre-Reformer (R-102)

- Reformer
  - Reformer furnace with 30 tubes (H-101)
  - Convection zone with refractory lining
  - Steam superheater (CE-101)
  - Process gas pre-heater (CE-102A)
  - Process gas pre-heater (CE-102B)
  - Process gas pre-heater (CE-103A)
  - Process gas pre-heater (CE-103B)
  - Process gas pre-heater (CE-104)
  - Air pre-heater (CE-105)
  - Burner system (15 Burners)
  - Process air system
  - Purge gas blower (C-101)
  - Air blower (C-102)

- High Temperature Conversion (R-1103)
Major Equipment

- Process Steam System
  - Boiler feed water pre-heater (E-102)
  - Steam drum (V-102)
  - Process gas boiler (E-102)
  - Sludge cooler (E-104)

- Gas Cooling
  - Air cooler (EA 101A)
  - Air cooler (EA 101B)
  - Process gas cooler (E-103)
  - Process gas cooler (E-105)
  - Gas condensate separator (V-101)
  - Gas condensate separator (V-103)

- Process Gas Cleaning PSA
  - Adsorber (R-201, R-202, R-203)
  - Hydrogen tank (B-202)
  - Purge tank (B-201)

- Process Control System (Yokogawa)
  - Security System (Pepperl&Fuchs)
  - Analysis System
Major Equipment

- Pipelines
  - Natural gas system
  - Complete process gas system
  - Steam system
  - Water network
  - Instrument air network
  - Nitrogen system
  - Hydrogen system

- ETA/MSR-Equipment
  - Complete Electrical Equipment
  - Complete Instrumentation
Compressor

Pre-heater
Contact IPP Today!

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