Hydrogen Plant #522




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1. Executive Summary

1.1 Plant History

- Equipment manufactured in 2009
- Plant never installed.
- Equipment never used.

1.2 Design Capacity

- 35,000 Nm^3/hr based on naphtha feedstock
- 35,000 Nm^3/hr based on LPG feedstock
- At least 35,000 Nm^3/hr based on natural gas feedstock
- Turndown ratio: 40%

1.3 Process Technology

- Steam Methane Reformer (SMR) by Uhde
- Pressure Swing Adsorption (PSA) by Linde

1.4 Products

- Hydrogen
    - Pressure: 40 bara (after compression)
    - Temperature: approximately 40 °C
    - Purity: mini. 99.9 vol.%
    - Impurity: CO + CO2 max. 20 ppmv; N2 + CH4 balance

- Medium Pressure Steam
    - Pressure: max. 37 bara
    - Temperature: 450 °C

2. Process Description

The hydrogen plant includes the following process sections.

2.1 Feed Evaporation / Preheating

Naphtha and LPG are considered as liquid feedstocks come at process pressure of 42 bara and evaporated by condensing low pressure steam in naphtha evaporator I and saturated steam in the naphtha evaporator II.

Natural gas must be compressed. A motor driven integrally geared compressor will be used. To prevent any liquid causing damage, a separato, recycle cooler and preheater will be used.

A stream of product hydrogen is recycled from the hydrogen product compressor discharge and added flow controlled to the feed gas. The hydrogen recycle stream is introduced for

hydrogenation purposes in the desulphurization section. The hydrogen amount depends on the feedstock. In naphtha or LPG, a hydrogen content of approximately 23 – 25 vol%; in natural gas, only 3 vol% is needed.

2.2 Feed Desulphurization

After evaporating the liquid feedstock, the feed gas (naphtha, LPG or natural gas) is heated by superheated steam. The desulphurization reactor contains three catalyst layers (dichlorination catalyst, desulphurization catalyst and deep desulphurization catalyst) to remove chlorine, hydrogen sulfide and organic sulfur compounds.

2.3 Feed Steam Mixing and Pre-Reforming

Before reforming, the sulfur-free feed will be mixed with steam containing of process steam and MP steam as balance to establish the required steam to carbon ratio. Pre-reforming of naphtha, LPG or natural gas to CH4, CO, CO2 and H2 is carried out at moderate temperatures in an adiabatic reactor containing Ni catalyst. Pre-reforming results in the cracking of heavy hydrocarbons into methane and the partial conversion to hydrogen, carbon monoxide and carbon dioxide.

2.4 Steam Reforming and Waste Heat Recovery

Steam reforming of methane and higher hydrocarbons, i.e. the conversion into mixture of H2, CO and CO2 by reaction with steam, is achieved by passing a mixture of feed and steam over nickel catalyst. The steam reformer is a box-type furnace containing 76 catalyst-filed tubes arranged in 2 rows. The reformer tubes are centrifugally cast of micro-alloy material.

2.5 HT / LT Conversion & Cooling Train

The aim of the CO shift is the conversion of CO into H2 via a reaction with steam. CO2 is a by-product of this reaction. A high temperature and low temperature shift in series have been chosen with a copper doped iron oxide/chromium oxide catalyst (HT-shift) and a copper /zinc oxide catalyst (LT-shift) for the maximum conversion. The process gas leaving the process gas cooler at 350 °C and passes through the HT converter from top to bottom where its CO content is reduced to 3.9 – 4.9 vol% by producing H2 and CO2. The converted gas leaving the boiler feed water preheater and passes through the LT converter from top to bottom where its CO content is reduced to 0.6 – 0.8 vol% by producing H2 and CO2. The hydrogen raw gas leaving the final separator located downstream of the final cooler is routed for final H2 purification to the pressure swing adsorption unit.

2.6 Pressure Swing Adsorption

In PSA Unit, gaseous impurities such as CO, CO2, CH4 are adsorbed at high pressure and desorbed at low pressure. The process operates with repeating the steps without using any addition or removal of heat. In the first step, the feed gas mixture passes through adsorbent bed. The impurities are adsorbed, and downstream pure hydrogen is recovered from the adsorber. As soon as sufficient enrichment of the adsorbent bed is reached, desorption by co-current depressurization begins. The hydrogen desorbed here may be used later for pressurization or purge.

2.7 Hydrogen Product Compression

The hydrogen product stream leaving the PSA Unit is compressed by 3 X 50% reciprocating compressors with dedicated water coolers. Each hydrogen product cooler cools down to 40 °C.

3. Steam System

3.1 Main MP Steam System

The boiler feed water is preheated in BFW preheaters by effluent process gas from CO shift conversion before entering the steam drum. A small part of the saturated MP steam leaving the steam drum is used for evaporating naphtha or LPG in the naphtha evaporator II. The remaining part of the saturated MP steam is superheated to a temperature of approximately 410 °C by the steam superheater I in the convection bank. The superheated steam is used for superheating of naphtha or LPG feed. Subsequently the steam is reheated to 460 °C by the steam superheater II in the convection bank.

3.2 MP Steam System from Process Condensate

The process condensate obtained from unconverted surplus steam is collected in the separators of the cooling train downstream of the LT shift converter, from where it is pumped by means of process condensate pump via the process condensate preheaters to the process condensate steam drum. The steam produced from process condensate is used exclusively as process steam.

3.3 LP Steam and Condensate System

MP steam condensate from naphtha evaporator is flashed into steam condensate flash drum. The flash steam leaving the drum on top is mixed with superheated LP steam from battery limit and used for preheating the combustion air in combustion air preheater and for evaporating naphtha and LPG in naphtha evaporator. The low-pressure blow-down condensate from the steam condensate flash drum is route together with the low-pressure steam condensate from combustion air preheater and naphtha evaporator to battery limit.

3.4 Blow Down System

The blow down streams from the steam drum and from the process condensate steam drum flash into the process condensate blow-down drum.

3.5 Condensate Slop System

The condensate slop drum collects process condensate from the blow down cooler and from the nitrogen recycle KO drum. During start-up, the accumulated process condensate in separators downstream of the LT shift converter is cooled down in process condensate cooler and rejected over condensate slop drum Two condensate slop pumps are available for pumping the condensate out of the drum to battery limit.

4. Equipment List

TAG #	EQUIPMENT NAME	EQUIPMENT TYPE	Note
03D001	Steam Drum	Vessel	
00E001	Naphtha Evaporator II	Heat Exchanger	Missing
00E002	Naphtha Superheater	Heat Exchanger	Missing
00E004	Naphtha Evaporator I	Heat Exchanger	Missing
03D005	PC Steam Drum	Vessel	
03D004	Combustion Air Silencer	Silencer	Missing
03B002-E01	Spray Attemperator	Attemperator	Missing
03B002-E02	Spray Attemperator	Attemperator	Missing
03E010	Spray Attemperator	Attemperator	Missing
03K001	Combustion Air Fan	Fan	Missing
03K002	Flue Gas Fan	Fan	Missing
03V901	Stack	Stack	Missing
04F001	PC Hot Separator	Vessel	Missing
03F002E11	Feed/Steam Preheater I	Heat Exchanger	
03F002E12	Feed/Steam Preheater II	Heat Exchanger	
03F002E31	Steam Superheater I	Heat Exchanger	
03F002E32	Steam Superheater II	Heat Exchanger	
03F002E41	Combustion Air Heater I	Heat Exchanger	
03F002E42	Combustion Air Heater II	Heat Exchanger	
03F00271	Steam generator	Heat Exchanger	
03002E81	Process Condensate Preheater	Heat Exchanger	
03F002E82	Process Condensate Evaporator	Heat Exchanger	
04E001	Process Condensate Evaporator	Heat Exchanger	
03E001	Process Gas Cooler	Heat Exchanger	
03E004	Combustion Air Preheater	Heat Exchanger	
04F002	PC Cold Separator	Vessel	Missing
04E002	Boiler Feed Water Preheater I	Heat Exchanger	Missing
04E003	Process Condensate Preheater	Heat Exchanger	Missing
04E006	Final Cooler	Heat Exchanger	Missing
04E007	PC Cooler	Heat Exchanger	Missing
04E009	Boiler Feed Water Preheater II	Heat Exchanger	Missing
04P001A	Process Condensate Pump	Pump	Missing
07E001A/B/C	Hydrogen Product Cooler	Heat Exchanger	Missing
07MC002A/B/C	Hydrogen product Compressor Package	Package	Missing
03D002	Blow Down Drum	Vessel	Missing
04E005	Air Cooler	Air Cooler	
04E005-M1/2	Fan Motor		
04E005-K1/2	Fan		

03F001	STEAM REFORMER - BURNERS	Reformer	
03F001	Steam Reformer-Outlet Manifold Refractory	Reformer	
	Steam Reformer - Outlet Manifold Steel		
03F001	STEAM REFORMER TUBES	Reformer	
03F001	Steam Reformer - Feed/Steam Inlet Manifold	Reformer	
03B002	Convection Bank	Bank	
03B002-Y01	Convection Bank Steel Structure	Bank	
03B002-S01	Convection Bank Refractory Lining	Bank	
03D003	Steam Silencer	Silencer	Missing
04F003	Steam Condensate Flash Drum	Vessel	Missing
03E007	PC Blow Down Cooler	Heat Exchanger	Missing
03E009	PC Blow Down Condenser	Heat Exchanger	Missing
03E011	Spray Attemperator	Attemperator	Missing
80D001	Condensate Slop Drum	Vessel	Missing
07MC003	Nitrogen Recycle Compressor	Compressor	
	Nitrogen Recycle Compressor Electrical motor		
07F001	Nitrogen Recycle KO Drum	Vessel	Missing
07E005	Nitrogen Recycle Preheater	Heat Exchanger	Missing
00P001A	Naphta Pump	Pump	
00P001A-M01	E-Motor for Naphta Pump	Electrical motor	
00P001AB	Naphta Pump	Pump	
00P001B-M01	E-Motor for Naphta Pump	Electrical motor	
00P002A	LPG Pump	Pump	
00P002A-M01	E-Motor for LPG Pump	Electrical motor	
00P002B	LPG Pump	Pump	
00P002B-M01	E-Motor for LPG Pump	Electrical motor	
01R001	Hydrogenation Reactor	Reactor	
	Hydrogenation Reactor Template		
01R002A/B	Desulphurisation Reactor Template	Reactor	
01R002A	Desulphurisation Reactor	Reactor	
01R002B	Desulphurisation Reactor	Reactor	
02R001	Pre Reformer	Reactor	
04R001	HT Converter	Reactor	
04R002	HT Converter	Reactor	
07E006	Nitrogen Recycle Cooler	Heat Exchanger	Missing
06U001	PSA Package Unit	Package	
06U001	Adsorber		
06U001	Adsorber		
06U001	Adsorber		
06U001	Adsorber		

06U001	Adsorber		
06U001	Adsorber		
06U001	Adsorber		
06U001	Adsorber		
06U001	Adsorber		
06U001	Adsorber		
06U001	Tail gas drum		
06U001	H2 product filter		
06U001	Purge gas silencer		
80P002A/B	Condensate Slop Pump	Pump	Missing
00D004	Naphtha Slop Drum	Vessel	Eliminated after hazop
00E003	Naphtha Slop Cooler	Air Cooler	Eliminated after hazop
00P003A/B	Naphtha Slop Pump	Pump	Eliminated after hazop
00D001	Naphta Surge Drum		
00D002	LPG Surge drum		

For more details or to discuss this plant, contact:

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