UNION ENGINEERING
Reliable solutions by dedicated people

FlashCO2, CO_2 at 23 $/ton

A cost effective solution of capturing CO_2 from Steam Methane Reforming (SMR) Hydrogen production plants by the FlashCO2 process

Introduction to a cost effective solution

Driven by headlines about flooding, tsunamis and global temperature rise – reduction of CO_2 emissions has turned almost into an everyman conversation topic today.

Even it is possible to capture the emitted CO_2 from fossil fuel powered power plants and various industrial processes, this is hindered by the accompanying very high energy consumption required for the processes capable of doing so. This applies especially for the post combustion capture processes using various types of amines, as they are very energy consuming processes – e.g. resulting in a large drop in electricity output if integrated in a power plant.

Best chances for being realised have projects with a combination of low OPEX and the possibility of increasing the productivity of the plants main production. Fortunately, some refineries and petrochemical plants offer these opportunities. Steam Methane Reformers, with CO_2 recovery can generate higher H_2 yield and CH_4/CO fuel gas at the same time as it offers a high CO_2 concentration source that can be recovered at a reasonable cost.

Not only environmental concerns may drive the interest for CO_2 capture in the future. In addition, the possibilities for extending the lifetime of oil wells is elaborated throughout the world. This has double good effects as easy accessible on-shore wells can be kept in production at considerably lower cost per barrel of oil than deep-sea exploration. In addition, storage in oil formations offers one of the few long-term solutions for CO_2 sequestration.

In this article a technical calculation has been prepared for the proprietary CO_2 capture technology, *FlashCO2* , developed by Union Engineering A/S. A cost effective solution for recovery of CO_2 from e.g. PSA off-gas from a Hydrogen Manufacturing Unit (HMU). By utilising an innovative process of combining conventional physical absorption by means of chilled MeOH and cryogenic CO_2 liquefaction technologies, the FlashCO2 process eliminates the requirement for steam stripping while keeping power consumption at an attractive level.

The FlashCO2 process is developed to provide an attractive solution for the capture of CO_2 from medium-rich CO_2 sources such as PSA off-gas from hydrogen plants.

For PSA off-gas a production price per ton CO_2 below 30 $ is achievable. In addition to this, an increase of H_2 production of up to 15% and additional syngas production makes the FlashCO2 process an attractive solution.

FlashCO2 process advantages

- Our plant can be placed off plot as a stand-alone unit, no need to be placed directly adjacent to the reformer unit
- One FlashCO2 unit can combine PSA tail gas from multiple steam reforming units
- No steam consumption
- High solvent stability and very low consumption
- Non-corrosive solvent supersede the use of stainless steel
- High purity CO_2 and food-grade quality at low cost
- No liquid or solid waste
- High purity (95%) hydrogen off gas for reprocessing in the existing SMR PSA.
- Additional syngas

FlashCO2 Process Description

Tail gas from a Steam Reformer PSA unit is compressed to a pressure of 65 – 70 bara together with CO_2 recycle gas in a highly efficient 6 stage centrifugal compressor with intercoolers. Dehydration of the feed gas by means of desiccant takes place between the 4th and 5th stage of the compression. The discharge of the compressor is cooled in an aftercooler before supplying heat to the CO_2 distillation column reboiler. About 50—55% of the CO_2 in the compressed feed gas is condensed in a refrigerant cooled CO_2 condenser followed by a reflux drum. The condensed CO_2 liquid from the reflux drum is led to the top of the CO_2 distillation column as reflux for the removal of CH_4, CO, H_2 and N_2. Off gas from the distillation column is recycled to the 5th stage of the recycle compressor.

The condensed CO_2 liquid from the reflux drum fed to the top of the distillation column counter flows with the stripper gas from the reboiler through a packed bed removing inert gases from the CO_2 product.

High purity liquid CO_2 (>99,99%) is recovered from the bottom of the CO_2 distillation column and its pressure can be increased to the required pressure for EOR, Urea or methanol production. Depending on the feed gas quality it might also be partly used as food grade quality.

The gas from the CO_2 distillation column reflux drum is led to a cold methanol 2-stage absorption column for additional CO_2 recovery. The CO_2 in the gas stream is absorbed by cold methanol in the absorber together with a small part of the other gasses present in the feed gas. The main part of the total inert gasses is vented from the top of the absorber together with some residual CO_2.

The bulk of the absorbed CO_2 in the CO_2 rich methanol from the bottom of the absorber is released by flashing the methanol at lower pressures in 3 stages in the MeOH flash column. The CO_2 gas released from each flash step is returned to the appropriate feed gas compressor compression stage for recycle. Cold MeOH solvent from the bottom of the MeOH flash column is used for feeding the lower section of the MeOH absorber.

A portion of the MeOH solvent from the 3rd flash stage is passed to a MeOH stripper for further CO_2 recovery. The CO_2 lean MeOH from the MeOH stripper is led to the top section of the MeOH absorber. CO_2 lean gas from the downstream hydrogen recovery unit is used as stripping gas.

The CO_2 lean off gas from the MeOH absorber is further processed in a cryogenic process system for the production of a H_2 enriched gas which could be recycled to the Steam Reformer PSA unit for additional H_2 recovery

The cryogenic process system consist of a CO2/ MeOH adsorber followed by a cryogenic heat exchanger system and a liquid CH_4 / hydrogen gas separator. More than 99% of the CH_4 and most of the CO and N_2 is condensed from the feed gas in the cryogenic heat exchanger system and is separated from the H_2 enriched gas in the separator. The hydrogen enriched gas stream will contain ca.(bedre med "approximately"?) 95% hydrogen.

The CH_4 rich liquid from the separator is reduced in pressure by a Joule-Thomson expansion valve and led to the cryogenic heat exchanger system to provide cold to the system. The hydrogen enriched gas is also expanded in pressure by a Joule-Thomson valve and provides cold to the cryogenic heat exchanger system. The expansion pressure is chosen such that the H_2 enriched gas can be directly returned to the existing Steam Reforming PSA unit. The vaporized CH_4 rich liquid is superheated before being returned to the Steam Reformer furnace fuel gas system for combustion. Part of the superheated fuel gas is used as stripping gas in the MeOH stripper.

Refrigeration for the CO_2 recovery plant is typically supplied by a standard ammonia refrigerant unit utilizing oil-flooded screw-type compressors. As an alternative propane or propylene can be used as refrigerant.

A process flow diagram of the FlashCO2 process is given in Figure 1.

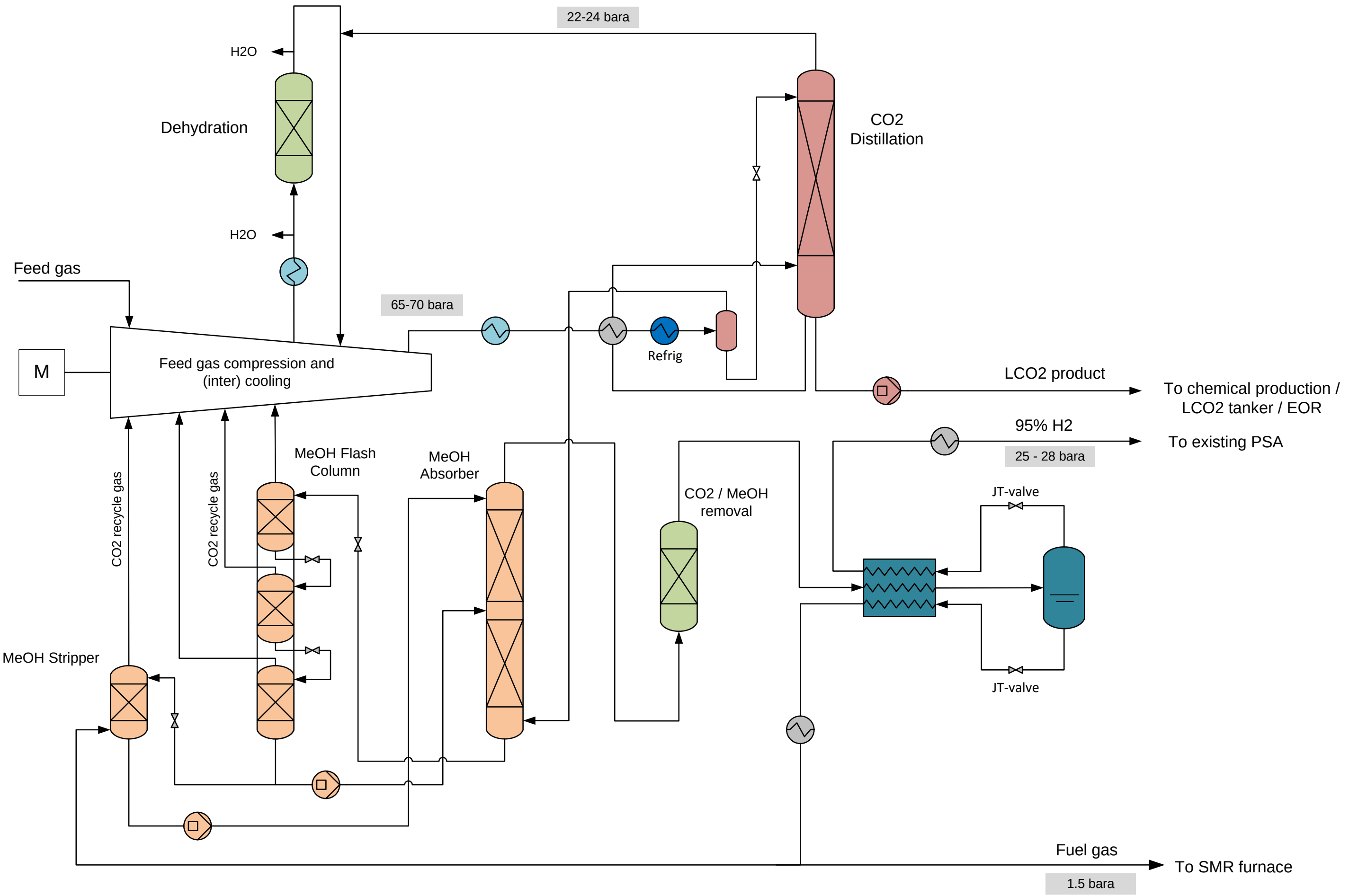

***Figure 1**: Process Flow Diagram of the FlashCO2 process*

$FlashCO_2$ Process performance and Utility Requirements

Table 1 provides a $FlashCO_2$ unit overall material balance for processing 40,000 kg/h of a typical SMR PSA Unit tail gas

Typically, CO_2 recoveries of over 99% are possible if required

Typically, 95% of the hydrogen present in the feed gas is recovered in H_2 rich off gas and 99% of the methane to the fuel gas product for combustion in the SMR unit reformer furnace.

Stream >	Feed gas	LCO_2 product	H_2 rich off gas	Off gas to fuel	Waste
Component	mol %	mol %	mol %	mol %	mol %
Carbon dioxide	47.8	100.0	-		4.4
Hydrogen	27.7		94.9	3.2	
Carbon monoxide	9.4		4.3	35.1	
Methane	14.2	< 100 ppm	0.6	60.6	
Nitrogen	0.3		0.2	1.0	
Water	0.6				95.6
Mass Flow, t/h	40.0	31.4	1.4	6.9	0.2
Pressure, bara	1.3	150	29	1.5	-
Temperature, °C	40	-3	Ambient	Ambient	Ambient

Table 1: *$FlashCO_2$ unit overall material balance*

Table 2 provides the specific utility consumptions corresponding to the provided overall material balance and specified feed and product conditions.

Utility consumptions	**$FlashCO_2$ Unit**
Description	
Specific power consumption, kWh/t LCO_2 @ 150 bara	350
Cooling water consumption, kWh/t LCO_2 @ 150 bara	440
Steam consumption, kWh/t LCO_2 @ 150 bara	-
MeOH consumption, kg/t LCO_2	< 0.5

***Table 2**: $FlashCO_2$ unit specific utility consumptions*

For further information please contact Union Engineering, union@union.dk or +45 7620 7700 and ask for our Oil & Gas department.