RAZI III
A NEW AMMONIA PLANT DESIGNED BY CASALE

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Abstract

AMMONIA CASALE has licensed its Ammonia Plant Technology, the licensor is PIDEC, an Iranian Engineering Company, who is responsible for the detail engineering. PIDEMCO, an Iranian state- owned Company,is the final user.

Raw materials include 6 recovered hydrogen steams (from nearby plants) in addition to natural gas. The process line includes AMMONIA CASALE Technologies used for ammonia plant debottlenecking and CASALE proprietary technologies supply.

CASALE also supplied the assistance for purchasing the critical equipment, Vendors' drawings check, critical piping check and site assistance for plant commissioning and start-up.

Introduction

AMMONIA CASALE is mostly known for its activity in revamping existing plants, applying its high efficiency designs for critical items. Its activity in the field of new plant design and construction was mostly limited to the supply, to its Licensees, of the design and proprietary equipment for synthesis loops.

Recently AMMONIA CASALE has extended its range of operation, re-entering the market of entire new plants by obtaining a contract for the supply of License, Basic Engineering and Proprietary Equipment of a new complete ammonia plant having a capacity of 2'050 MTD.

The licensed AMMONIA CASALE proprietary process includes its proprietary and most advanced design for secondary reformers, shift converters, MU gas dehydration, synthesis converters and waste heat boilers, making the plant very efficient from all points of view, i.e. energy and capital cost.

CASALE has also supplied to the main contractor its technical assistance for critical equipment purchasing, Vendors' drawings check, critical piping check and site assistance for plant commissioning and start-up.

The plant has been built in Iran, in the RAZI PETROCHEMICAL COMPLEX, and is under commissioning.

Primary Reformer, Secondary Reformer Steam Drum & Waste Heat Boiler

Plant Raw Material

The most common raw material for an ammonia plant in this area is natural gas (NG). In this case, in addition to NG, were available six hydrogen (H_2) streams coming from the nearby petrochemical plants.

These H_2 streams were different in composition, pressure and temperature and their pressures were lower than the process pressure.

The streams were combined considering their composition and pressure and injected into different points of the plant: the streams containing methane were compressed, preheated into the primary reformer and mixed with the NG stream at the desulphurizer outlet, whilst the other stream containing less than 1% vol. of methane and with traces of carbon oxides, was added to the process gas upstream to the methanator.

The contribution of the H_2 to the total ammonia production is about 40% of the plant capacity.

In order to compensate possible fluctuation in the availability of hydrogen, the plants have been designed to maintain the nameplate capacity with 70% of H_2 streams availability.

Process Technology

Taking into consideration the feed stocks type and the plant capacity, it has been decided to design the plant according to the classical steam reforming process.

The main process steps are:

- NG preheating and desulphurization with the addition of H_2 rich stream at desulphurizer outlet, mixing with steam, primary reforming and secondary reforming with air. The secondary reformer is equipped with a CASALE burner.
- Shift conversion of carbon monoxide is performed in two steps, HTS and LTS. The two converters adopt CASALE axial-radial internals to reduce the pressure drop and catalyst volume.
- CO_2 removal through aMDEA removal solution
- Methanation.
- CASALE M.U. gas dehydration by ammonia wash.
- Ammonia Synthesis with three beds, two interchangers and axial-radial CASALE internals
- Hydrogen recovery from loop purge through a membrane recovery unit.

The main process parameters are the following:

- Steam to carbon ratio (referred to NG stream only): 3 to 1
- CO slip from LTS: less than 0.2% vol. (dry base)
- CO_2 slip from absorber: less than 200 ppm vol.
- CO_2 removal is water balanced (no waste water)
- Ammonia Converter inlet pressure: 150 bar g
- Hydrogen recovery unit: recovery about 90% (vol.) of H_2 fed to the unit.
- High pressure steam at 120 g and 505°C (completely used within ammonia plant)
- Medium pressure steam is at 40 bar g and 376°C (completely used within ammonia plant)
- Low pressure steam is at 3.5 bar g and 220°C (completely used within ammonia plant).
- Total energy consumption (evaluated as feeds + fuel + steam import from package boiler) is 7.20 Gcal/MT of produced ammonia.

Primary Reformer (top fired) Radiant Box

The plant has a closed steam balance, for the start-up a 100 t/h package boiler has been provided. During normal operation the package boiler is maintained at 30t/h in order to get the boiler ready in case of plant shut-down.

As it can be seen from the above information's the plant main characteristics, differentiating from the other designs, is the use of the AMMONIA CASALE proprietary equipments, making this plant design very effective in terms of capital cost and process efficiency.

The main characteristics of these proprietary equipments are:

- CASALE secondary reformer burner: it has a low pressure drop on both air and process side and a short flame, with, at the same time, a long duration of the tip, and an high uniformity of temperature and composition at catalyst inlet.
- CASALE axial-radial shift converters (high and low temperature): the axial-radial flow in the catalyst bed ensure a low pressure drop stable all along the catalyst life, a longer catalyst life, a better conversion, a slimmer and less expensive high pressure vessel.
- CASALE M.U gas dehydrator by ammonia wash: it is very simple and it ensures a dry make up gas to the synthesis loop, the mixing contact of ammonia with syngas is achieved by an injector, therefore obtaining a pressure recovery on the M.U. gas and a perfect contact.
- CASALE synthesis converter: it guarantees the highest conversion per pass, reducing the energy consumption and the size of the loop equipments.

All these CASALE technologies mentioned above are also very well proven and reliable, having been used already in many revamped plants, achieving already a very long operating life.

Environmental Impact of the Ammonia Plant

The ammonia plant has been designed in such a way as to reduce the environmental impact as much as possible.

In fact, the only liquid wastes are the boiler blow down and the air compressor interstage coolers condensate.

The boiler blow down, about 4t/h, after flashing and cooling, is used as cooling water make-up for the cooling water loop.

Shift Converters

The same for the air compressor interstage condensate, about 2.5 t/h depending on the season, that is returned to the cooling water return header.

The only waste is the flue gas from the primary reformer (about 400 t/h) that contains less than 1.5 ppm vol. SOx and about 110 mgr/Nm^3 of NOx. The guaranteed figure of NOx is less than the one required by the European Community for new plants (140 mg/NM^3 calculated at 3% oxygen excess).
A report has been prepared for demonstrating to the financing bank that, from environment point of view, the plant is designed according to European Community Regulation.

The Contract

The contract was awarded to AMMONIA CASALE and Pidec, through an official international public bid, where CASALE/Pidec were successful over several international competitors.

Pidec is an Iranian engineering company located in Shiraz and it is the most experienced and well reputed engineering company in Iran with a broad experience in chemical and petrochemical plant detailed engineering, procurement and construction.

The plant's final user is Razi Petrochemical Complex, an affiliate of PIDEMCO, that is one of the Iranian state-owned companies well-known in the field of petrochemical production.

AMMONIA CASALE scope of work was:

- Full plant technology license
- Plant Basic Engineering Package
- Supply of proprietary items
- Assistance to PIDEC for plant detail engineering, commissioning and start-up

The contract was awarded at the beginning of the year 2002 and the effective starting date was at the beginning of August 2002.

AMMONIA CASALE was responsible for the technology license for the entire ammonia plant and the preparation of the Basic Engineering Package (BEP) for the plant. To familiarize PIDEC's and PIDEMCO's personnel with the ammonia plant design, was created a task force that was working face to face with CASALE's task force in Switzerland.

In this way, all the problems and questions arising on the process features of the plant and relevant equipment, machineries, instruments, specifications, equipment arrangement, etc. were solved as soon as they were evidenced and very few questions arose during the detailed engineering phase.

The cooperation with the Engineering Company and the Final User was further continued in Shiraz where, from time to time and upon request, CASALE specialists were sent to attend and to check the development and the good execution of the job. The Iranian task force had been present in CASALE offices for about five months until the first issue of the BEP (issued before HAZOP).
Some of them were also present at the HAZOP plant analysis.

CO_2 Removal

HAZOP was performed one month after the BEP first issue. The final BEP issue, after HAZOP, was carried out by CASALE only, but all the discussions and decisions inherent to the plant final configuration had already been discussed before.

Follow-Up and Assistance during Detail Engineering

The detail engineering was performed at PIDEC's offices in Shiraz.

All the critical items individuated during the basic engineering on the basis of CASALE's experience, were subject to CASALE's control and approval during all the phases from the beginning of the detailed engineering with the material requisition check and approval, to the conclusion with the selected Vendor final drawings check and approval.

The critical items subject to CASALE's control and approval were:

- Ammonia plant compressor (air, syngas and ammonia).
- Heavy duty service pumps (BFW pumps, CO_2 circulating solution pumps, liquid ammonia (-3°C) pumps).
- All high pressure static equipment (working about 100 bar g).
- All reactors and catalyst vessels (alike secondary reformer, desulphurizer, HTS, LTS, etc.).
- Primary reformer for which AMMONIA CASALE prepared the process specification. This item has been designed and supplied by other.
- Start-up heater.

In addition to the above, critical pipe-lines have been checked as pipe routing and stress analysis by CASALE.
In particular, the following lines have been checked:

- All the hot lines working above 350°C in the hot front end
- CO_2 system process gas lines, CO_2 lines and circulation solution lines.
- The synloop main process gas line, from compressor suction to synconverter to exchangers, back to the compressor.

The instrumentation controls have been performed for:

- All control valves of 3" and above.
- All critical instruments (i.e. in-line analyzer).
- DCS configuration inclusive of the implementation of advanced process control for plant load and primary reformer combustion optimization.

Synthesis Converter

- ESD configuration for plant interlocks. In particular all the interlocks signal from/to vendor packages alike, compressor and primary reformer were jointly agreed upon by Casale, Vendors, PIDEC and PIDEMCO.

Assistance during Plant Erection

For assuring the correct erection of the plant, CASALE specialists for welding inspections were sent to the site.

The welding procedures for critical piping mentioned before were supplied by CASALE.

CASALE prepared the procedure for plant commissioning, start-up and normal operation. Presently CASALE supervisors are at the site to supervise these activities.

A training course for operators has been held by CASALE.

The course was divided in two stages: one theoretical at CASALE's offices and one practical at one of our Client's plants.

The plant is being commissioned and CASALE is performing the plant check-out, giving to the Client the process assistance for plant start-up.

Conclusion

CASALE has the capability to license the technology for entire ammonia plants and to give support to the EPC contractor for the best success of the plant. This capability is proven by the construction of the Razi III ammonia plant, and by the recent acquisition of a second contract for another 2'050 MTD plant NG based.

This technology is based on the use of all CASALE proprietary items, ensuring the most cost effective and efficient plant design.

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