LOHRMANN GROUP

Ref.-No.:
ProOil-314

50,000 bpd Pre-owned OIL REFINERY

- Presented by: Lohrmann International Germany

Contents

1. History and background

- Thanks to two main phases of modernization and upgrading, the refinery is well adapted to meet local demand in terms of product mix, and is compliant with the most recent European standards and regulations with regard to product specifications (sulphur and aromatics content amongst others) and environmental limits (emissions, etc.)

- The first phase of modernization and upgrade was completed in the early-mid 90's and included mainly Dewaxing, HDS, Isomerization units and sulphur recovery units. In 1997 a combined cycle (power and steam) plant was built. The plant produces electricity through its 25 MW combined cycle covers its own power consumption and offers the opportunity to sell 5-8 MW to the external grid.

- The second phase, completed in 2004, included the implementation of a new RCC (Residue Catalytic Cracker) and additional desulphurization capacity.

1. History and background

- The RCC in particular allowed the increase in production of transportation fuels, with heavy fuel oil production being dramatically reduce, whilst upgrading of desulphurization facilities (including an Axens Prime G gasoline hydrotreater) allowed the refinery to meet the required sulphur-free gasoline and diesel specs.

- During the period 2007-2013, important environmental projects were implemented (with total investments of EUR 73m) to improve air and water emissions and to minimize the risk of soil and ground water pollution.

1. History and background

- The refinery underwent a complete 6-week maintenance turnaround in September 2013 during which all of its parts were inspected cleaned and/or changed when necessary and catalysts were regenerated. The Company spent EUR 25 million to carry out this maintenance turnaround which is due every 5 years.

- A highly flexible and modern refining platform as evidenced by its sophistication indices (ranked within the European 1st quartile as per Cracking, Wood Mackenzie complexity and Nelson Complexity indices (NCI)

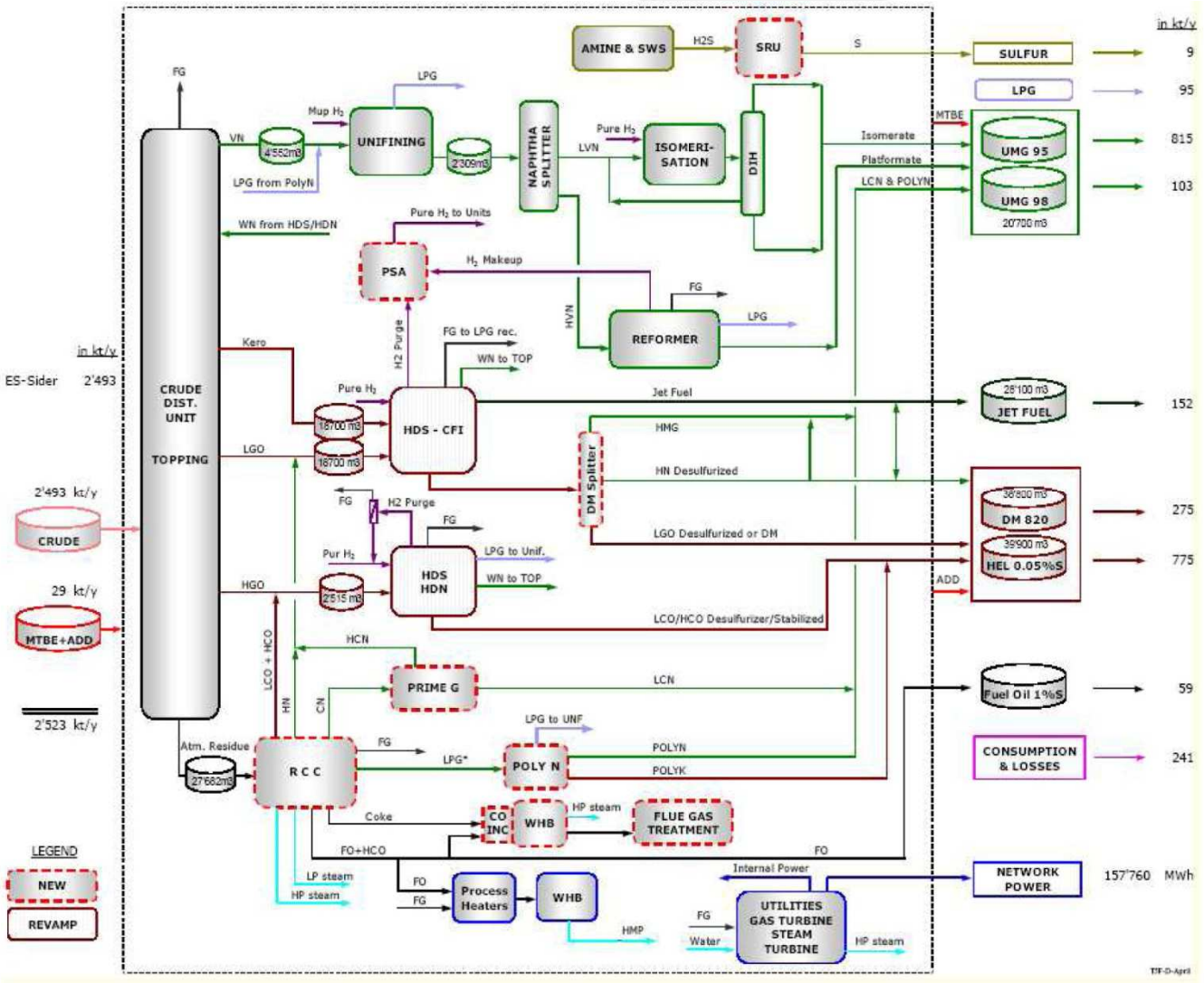
    - NCI: 9.9 - well above NWE refining average of 8.2

    - Important investments made over the last 10 years, including the installation of a RCC unit (increasing production of transportation fuels while minimizing residual heavy oil output), and an upgrade of its desulphurization facilities (allowing the refinery to meet low sulphur gasoline and diesel specifications as required by EU environmental regulations)

2. Operation

- During 2001-2004, the refinery went through a major investment program, including the installation of a Residue Catalytic Cracker, a polynaphtha plant, and a Prime G unit.
- This program also included the revamping of existing units, notably the gasoil hydrotreater to meet diesel fuels sulphur content specifications. In March 2004, the new Residue Catalytic Cracker (TRC2000 project) went on stream allowing to produce motor fuels compliant with EU sulphur content regulation.
- PIMS linear programming model is used for production planning and crude selection. It is considered as one of the best programs for refinery optimization.
- The refinery is fully equipped to fulfill EU product specifications and has incorporated the EU fuels directives into national legislation.
- The refinery complies with REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) regulations.

2. Operation - Block flow diagram



2. Operation – Major revamps

- Thanks to its high conversion capacities and in particular to its recently installed RCC unit, the production of heavy fuel oil (HFO) has been dramatically reduced, down almost to zero. Three units built in 1962 are still in operation (after revamping): Topping, Unifying and Reforming. Major revamps for all the units are listed in the table below.

Unit	Year First Startup	Actual Capacity (bpsd)	Licensor	Year	Major Revamps	Technology
Atmospheric Distillation	1962	57,000	SNAMPROGETTI	1972	Unit expansion	Parsons
				1996	Energy Saving	Foster Wheeler
Unifining (Naptha Desulphurzation)	1962	21,000	UOP	1972	Unit expansion	Parsons
Reforming (UOP Patforming)	1962	12,500	UOP	1972	Unit Expansion	Parsons
				1990	Revamp	UOP
				1997	Addition of packinox feed / effluent exchanger	Alfa Laval
Isomerzation with deisohexanizer	1992	6,800	UOP	-	-	-
Gasoil Hydrodesulphurzation	1994	24,000	Akzo Nobel / Foster Wheeler	2003	Upgrade for 10 ppm S specification and installation	Akzo Nobel / Foster Wheeler
Catalytic Dewaxing	1994	7,500	Akzo Nobel / Foster Wheeler	2003 / 2004	Change of catalyst and operating conditions	Akzo Nobel / Foster Wheeler
Residue Catlytic Cracking	2004	19,000	IFP (Axens)	2012	Expansion joints and springs upgrade	Shaw (Technip)
Sulfrex and Polynaphta Units	2004	3,600	IFP (Axens)	2008	Capaciity expansion (from 16 IFP, Axens, m³/h to current capacity)	

2. Operation – Mayor revamps (cont.)*

Unit	Year First Startup	Actual Capacity (bpsd)	Licensor	Year	Major Revamps	Technology
Prime G	2004	8,300	IFP (Axens)	-	-	-
Amine Regeneration Unit	1994		Foster Wheeler	2004	Revamp to accomodate higher sulphur capacity	Foster Wheeler
Sour Water Stripper	1994	10 m³/h	-	-	-	-
Sulphur Plant	1994	6 t/day sulphur	Comprimo	2004	Unit was ideled	-
Sulphur Plant	2004	21 t/day sulphur	KTI	2013	Upgrade of control logics	
Combined Cycle	1997	100 t/h steam, 25 MW generation capacity	GE (gas turbine)		-	-
CO Boiler	2004	85 t/h steam generation capacity	FWI	2007	Rebuilding of tubesheets	IDI
Condensing Steam Turbine	1962	80 t/h steam, 13 MW generation capacity	ABB	1997	Integration in new combined cycle	Foster Wheeler
Waste Heat Boiler	1997	25 t/h steam generation capacity	Foster Wheeler		-	-
Hydrogen PSA	2004	26000 Nm³/h gas	LINDE		-	-
Refinery Utilities	1962		SNAMPROGETTI	1994	Revamp for first refinery expansion	Foster Wheeler
				2004	Revamp for RCC project	Foster Wheeler

2. Operation – Important indexes

Thanks to investments carried out since 2004, the refinery complies with the sulphur-free gasoline and diesel specs.

Refinery	Crude unit	Cat Cracking	Hydro Cracking	Thermal Cracking	Cooking	Octane Index	Desulph. Index	NCI*	WoodMac Index	Cracking Index
ProOil-314	57	19	0	0	0	44	8.5	9.5	8.7	51%

*NCI: Nelson Complexity Index

3. Process Units

3.1 Atmospheric distillation (topping)

- The topping unit is part of the first units built on the site, in 1962. The original capacity was for 2.000.000 T/y (about 6.000 T/day).
- The unit was expanded in 1970 -1972 to its present capacity of 7700 T/day (2.800.000 T/y- about 57,000 bpd), which is why there are two fired heaters in parallel in the current installation. The unit fractionates the crude in: gas, naphtha + LPG, kerosene, light gasoil, heavy gasoil and atmospheric residue.
- Heavy gasoil and atmospheric residue are currently fed together to the Residue Catalytic Cracking plant.
- The overhead naphtha is fed to the Unifining Naphtha Desulphurization unit.
- Other major modifications:
  - 1996-1997 energy saving project: modifications of column overheads and side-stream integration, replacement of debutanizer internals.
  - 2004: installation of new burners in the main heater F-1101 and up to date Burner Management System.

3. Process Units

3.2 Unifining (naphta desulphurization)

Max capacity: 140 m³/h (21,000 BPSD - Barrels Per Stream Day)

- As the Topping unit, it was originally built in 1962 and expanded in 1970-1972. The unit was built with a UOP license, and was successively revamped in 1997 and 2003 (TRC 2000- residual cracking projects).
- The Unifining heater (1962) is also equipped with an up to date burner and BMS. The unit removes sulphur form naphtha and LPG, using hydrogen from the Platformer.
- The LPG is split from the naphtha in the debutanizer column, which was subjected to an important revamp in 1996.
- The naphtha is then split into light naphtha and heavy naphtha in the Naphtha Splitter.
- The light naphtha is fed to the Isomerization unit.
- The heavy naphtha is fed to the Reformer (UOP Platformer).

3. Process Units

3.3 Reforming unit (UOP Platformer)

Max capacity: 82 m³/h (12,500 BPSD)

- As the Topping unit, it was originally built in 1962 and expanded in 1970-1972. The unit was built with a UOP license, and was revamped in 1989-1990 (furnace retubing and radial reactors, in 1997 (installation of a new Packinox feed/effluent exchanger) and 2003 (TRC 2000).

- The unit is a semi regenerative reformer, with an operating pressure at the separator of about 25 barg. The average catalyst cycle length with actual charge is 18-20 months. The unit is fed with heavy naphtha and produces:

  - Hydrogen rich gas, used for hydrodesulphurization units
  - Stabilized LPG
  - High octane Reformate (RON 97- 99.5 as required)

3. Process Units

3.4 Isomerization unit with deisohexanizer (UOP)

Max capacity: 45 m³/h (6,800 BPSD)

- The Isomerization unit was built in 1991 / 1992, with UOP technology.
- The isomerization unit increases the octane of the light naphtha, by converting linear molecules to branched molecules.
- The unit conversion is enhanced by the deisohexanizer, a special column that separates linear molecules from branched molecules.
- The unit is fed with light naphtha and hydrogen, and produces isomerate and fuel gas.

3. Process Units

3.5 Gasoil hydrodesulphurization

Max capacity: 160 m³/h (24,000 BPSD)

- Reactor replacement to achieve tougher product specifications
- Addition of fractionation section, in order to separate treated RCC heavy naphtha
- The purpose of the gasoil hydrodesulphurization unit is to remove sulphur and nitrogen from distillates. The operating pressure of the reactor is about 40 barg.
- This is achieved by heating the distillates with hydrogen and treating them on a fixed bed catalytic reactor. In current operation, the unit is fed with:
  - Kerosene and gasoil from topping
  - Heavy naphtha from RCC
  - The operation of the unit is dedicated to Diesel production, with a byproduct of light ends that are retreated in other refinery sections.

3. Process Units

3.6 Catalytic dewaxing

Max capacity: 50 m³/h (7,500 BPSD)

- The Dewaxing unit was originally built in 1993 / 1994. The original purpose of the unit was to convert the heavy paraffins contained in the Topping Heavy Gasoil to lighter products (Gasoline and Distillates). The reactor was operating at a pressure of 65 barg. The unit includes a recontacting section to maximize the recovery of the LPG vis-à-vis gas production.

- With the 2003 Refinery expansion, where the RCC (Residue Catalytic Cracking Unit) was introduced, the unit has changed function.

- The Heavy Gasoil is currently fed to the RCC plant, and the Dewaxing is operated at 40 barg pressure. The feed is a mixture of LCO (heavy aromatic gasoil from cracking), atmospheric gasoil, cat kero with the objective of producing both normal heating oil and low sulphur and low nitrogen ECOCALOR heating oil.

3. Process Units

3.7 Residue catalytic cracking

Max capacity: 126 m³/h (19,000 BPSD)

- The Residue Catalytic Unit is a "full residue" cat cracking unit. This means that the entire atmospheric residue (+ Heavy Gasoil) is fed directly to the Unit. In Europe, in most units the feed consists of heavy vacuum distillates and not a full atmospheric residue.

- The unit is subdivided in four sections:
  - Reaction section
  - Catalyst regeneration section
  - Fractionation section
  - Wet gas recovery section

- The unit was built grassroots in 2003 / 2004. Modifications were implemented in 2007 on the CO Boiler and in 2012 in the catalytic section.

- Licensor was IFP, current licensor is Shaw (Technip).

3. Process Units

3.7 Residue catalytic cracking (cont.)

Max capacity: 126 m³/h (19,000 BPSD)

a) *Reaction Section:* In this section, the feed is heated and mixed with a zeolite catalyst in fluid state. The reaction occurs in the riser, and then the catalyst is separated from the product vapors and sent in continuous to regenerate - which essentially consists in burning the coke generated by the cracking of the feed. The unit is equipped with two regenerators, in partial burn mode.

b) *Fractionation Section*: In this section, the reactor effluent (in vapor form) is condensed and separated by distillation in various fractions in the Main Fractionator. The fractions are:

- Overheads (mix of gas, LPG and naphtha sent to section 7600)
- Distillates (LCO)
- Clarified Oil (bottoms)

This sections also redistillates various streams that help in the separation of light products by absorption in section 7600.

c) *Wet Gas Recovery Section:* In this unit, the gases from the overheads of the main fractionator are recontacted, compressed and stabilized to have:

- Clean fuel gas
- Unsaturated (olefinic) LPG
- Gasoline, which is sent to the Prime G unit (Unit 7900)

3. Process Units

3.8 LPG sulfrex and polynaphta unit

Max capacity: 24 m³/h (3,600 BPSD)

- LPG sulfrex: is a unit that removes sulphur from the LPG, in order not to poison the Polynaphtha catalyst. Polynaphtha: as LPG sulfrex, it was built in 2004 with a 16 m3/h capacity and revamped to 24 m³/h capacity in 2008.

- In this unit, olefinic LPG molecules combine to give a high octane gasoline blending component. The products are:
  - Unconverted LPG, sent to LPG product
  - Poly Gasoline, sent to gasoline blending pool

3. Process Units

3.9 Prime G unit

Max capacity: 55 m³/h (8,300 BPSD)

- The Prime G unit is a selective catalytic desulphurization process for the Cat Cracker light naphtha.
- The unit is fed with the whole debutanized naphtha from Unit 7600, and separates:
  - A heavy naphtha stream, which is sent to the HDS unit to be desulphurized and then to gasoline pool
  - A light naphtha stream, which is desulphurized in a special selective reactor. The catalyst in this reactor eliminates the sulphur, but not the olefins in this stream that have a high octane. The Light Cat Naphtha is sent to Gasoline blending pool

3. Process Units

3.10 RCC complex auxiliaries

CO Boiler

- The effluent gas from the RCC regenerators is rich in Carbon Monoxide, that cannot be dispersed to the atmosphere. This flue gas component is burnt in a special boiler. The heat is used to generate steam (up to 85 T/h High Pressure steam), that is used to drive the RCC heavy machinery.

Flue Gas Treatment

- The flue gas exiting from the CO boiler is successively treated in:
  - DeNOx unit to remove this kind of pollutants
  - DeSOx unit to remove this kind of pollutants
  - Particulates abatement unit
- The clean gases are then vented through the chimney.

3. Process Units

3.11 Amine, sour water stripper and suphur recovery units

- The three units treat the sulphur and ammonia contained in refinery gas streams, which carry these contaminants as a result of the various desulphurization processes (Unifining, HDS and Dewaxer fuel gas) and cracking process (fuel gas from RCC).

a) *Amine Unit:* The amine regeneration unit was built in 1993 / 1994. The amine system treats the sour gases in dedicated absorbers, removing sulphur components. The amine is then treated and stripped in Unit 1700. The resulting concentrated sulphur compound stream is sent to the Sulphur Recovery Unit. The unit was revamped during the 2003 / 2004 TRC 2000 project.

b) *Sour Water Stripper Unit*: The unit was built in 1993 / 1994. This unit treats contaminated water (wash water etc.) coming from process units. The water is stripped with steam, then sent to Waste Water Treatment plant.

c) *Sulphur Plant:* The current sulphur plant (21 T/day capacity) was built new in 2003 by KTI. The unit is complete with a SCOT Tail Gas Treatment Unit, which means that the overall recovery capacity is 99.9 % of sulphur in feed. The Sulphur unit built in 1993 (6 T/day capacity) has been abandoned.

3. Process Units

3.12 Combined cycle GT power generating unit

- The combined cycle unit was built in 1997 and includes:
  - 25 MW gas turbine
  - Revamped 13 MW condensing steam turbine (originally built in 1972). This unit is currently out of operation but ready for service
  - Waste heat boiler, to recuperate heat from the gas turbine fumes. The boiler is equipped with post firing and can generate up to 100 T/h high pressure steam
- The unit uses fuel gas from Refinery Units. In 2010, the unit was equipped with a Catalytic DeNOx.

3.13 Waste heat boiler

- This is a unit installed in 1997. It generates 25 barg steam from the hot flue gases of the process units of hydro-skimming block.

3. Process Units

3.14 Waste water treatment

- The Refinery has a waste water treatment unit, recently revamped to be in line with current legislation. The capacity is 300 m³/h of waste water. The main sections are:
  - Homogenization (revamped in 2012)
  - Flocculation (revamped in 2012)
  - Bacterial beds
  - Sand filters (new, installed in 2013)
  - Activate carbon filters (installed in 2013)
  - Settlement basins, water tanks (5000 m³) and mud tank (600 m³)

4. Turnarounds

Extensive maintenance turnarounds were carried out on the refinery in 2007 and 2013. In 2013 the turnaround cost amounted to EUR 25m (plus EUR 2m for the catalysts), covering major turnaround, routine maintenance and small projects to increase the reliability and profitability of the refinery, including:

- Cleaning and inspection of about 900 pieces of equipment of which about 600 required statutory inspection
- Replacement of some equipment (heat exchangers, lines, tower internals, valves, etc.)
- Maintenance of the main rotating machines (compressor, pumps)
- Maintenance of electrical network and main motors
- Maintenance of instrumentation
- Refractory replacement in the RCC catalytic section and furnaces
- Specific reliability project: replacement of 1 slide valve of cracker (specific device to control the flow of catalyst in the cat cracker), tubes of convective section of unifiner furnace, and the rotor of the reformer compressor
- New catalyst at the Dewaxing unit in order to increase the production of the "green" heating oil "ECOCALOR" (sulphur content below 50 ppm and nitrogen content below 100 ppm)

The refinery is now set for a new 5-year period without any maintenance turnaround.

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Thank you!

P.O.Box 130571
20105 Hamburg/Germany
Tel. +49 40 33441944
Fax +49 40 33441945
www.lohrmann.com
info@lohrmann.com