EST technology:
an advanced way to upgrade the bottom of the barrel

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eni.com
1. EST: the answer to market needs
2. First EST Commercial Unit at eni’s Sannazzaro Refinery
3. EST results and operation experience
4. Conclusions
Current C-rejection technologies (i.e. Coking) do not provide complete bottom of the barrel conversion.

H/C 1.3

+ 4% wt. Hydrogen

H-addition

- 24% wt. Carbon

H/C 1.9

Over 100 million tons of petroleum coke produced annually world-wide
EST (Eni Slurry Technology) is a proprietary new process for heavy feedstock conversion & upgrading.

- Petroleum Residues
- Heavy Oils
- Tar Sands
- Bitumen

Result:
- Bottomless Syncrude
- API > 20
EST is a hydrocracking process based on two unique features:

1. Nanodispersed (slurry) non ageing catalyst
2. Homogeneous & isothermal slurry bubble column reactor

The recycle of unconverted heavy ends allows the total conversion of the bottom of the barrel to good quality middle distillates (feedstock conversion >97%)

EST can easily handle very heavy feedstock
Eni Slurry Technology (EST) is a new technology for the full conversion of the bottom of the barrel to distillates.

The availability at industrial level of EST enables the oil industry to solve crucial needs:

- Meet the declining demand of Fuel Oil converting surplus of Refinery Residues into Distillates (Zero Fuel Oil - zero coke Refinery)
- Meet the increasing demand of cleaner distillates without increase of the CDU capacity
- Increase the refinery flexibility to supply of heavier crudes

In this context, EST allows a better use of the conventional oil resources and promotes the use of non-conventional oil resources such as heavy and extra-heavy oils and oil-sands bitumen.
New maritime regulations coming into effect starting in 2015 ➔ significant reduction of residue demand

March 2014: the SECAs established to limit SOx and particulate matter emissions are:

1. Baltic Sea area – as defined in Annex I of MARPOL
2. North Sea area (including the English Channel) – as defined in Annex V of MARPOL
3. North American area (entered into force on 1st August 2012); and
4. United States Caribbean Sea (entered into force on 1st January 2014)

(Source: MARPOL 73/78, Annex VI Regulations for the Prevention of Air Pollution from Ships)
EST Sannazzaro: the industrial project

- TIP
- Reform 2/3
- HDS 1/2
- MTBE
- ALK
- FCC
- IGAS
- VACUUM 1/2
- HDC 1/2
- VSB
- ROSE

Outputs:
- Diesel
- Gasoline
- LPG
- Kero

Inputs:
- Syngas
- O.C.
- Bitumen
- Pitch
Integration of EST Complex in the Sannazzaro Refinery:
Total refining capacity 11Mt/y
Auxiliaries units:
- H2 unit 100 kNm3/h
  (running since Jan 2013)
- SRU 160 t/d

Bunkerized control room
(in operation since Jan 2013)

Slurry reaction unit 23000 bbl/d

Upgrading process unit

PTU
EST Sannazzaro today
EST start-up and first year of operation

- The EST hydrocracker unit has successfully and safely begun operations and is producing high quality distillates (oil-in: 2013, October 14th)

- Synchronization start-up / operation of all the auxiliary facilities associated with the Unit

- First results confirm the proper design of the plant:
  - Major equipments provided the expected performance (as per design)
  - Some minor adjustments in order to improve the global EST plant performance
EST first results

- **Slurry reactors:** perfectly isothermal and homogeneous (axial $\Delta T < 2^\circ C$ and radial $\Delta T < 0.1^\circ C$)

- **Gas/liquid separation:** High efficiency of gas-liquid separation (no foaming occurrence)

- **Conversion:** EST plant has run at nearly 70-80% of design capacity (there are market constraints related to the reduction of purge volume accepted by cement factories compared to their planned absorption capacity). Feed conversion up to 95-96% without coke formation

- **Product slate and quality:** Results are in good agreement with the expected product distribution as calculated by process simulation (based on EST Demonstration plant data). Euro V diesel yields is higher than 40 wt. %
EST results: Slurry reactors temperature profile

Temperature profile from 18/10/2014 to 13/11/2014 with a temperature difference of ΔT = 2°C.
EST results: product yields

Typical EST Feed

- $d_{15^\circ C}$: 1026 g/cm³
- S: 2.9 wt.%
- N: 0.6 wt.%
- CCR: 20.1 wt.%
- C5-Asph: 15.4 wt.%
- Ni: 88 ppm
- V: 199 ppm
- Fe: 41 ppm

Cat feed 0.1% S (or marine fuel 0.1% S)

Euro V diesel

Desulphurized naphtha

Pitch
EST second run

- A power failure occurred in Sannazzaro refinery (about 3 months after start-up), causing the upset of Steam Reformer plant

- Following this event, the decision of EST shutdown was taken, also supported by the following reasons:
  
  - the adverse scenario for cement industry that limited EST maximum production (due to reduction of purge volume accepted by cement industry whose capacity in Italy dropped by 40% in the last few years)
  
  - the opportunity to take advantage of maintenance activities to improve plant reliability, efficiency and operating procedures

- New start up of EST unit: June 2014
- Unit operating in a very stable mode
- Still present constrains in cement market
- Part of the pitch is sent to Sannazzaro existing gasification unit
The first EST hydrocracker Commercial unit is in operation at eni’s Sannazzaro refinery

Key success factors:
- Demonstrated reliability
- High conversion to valuable products
- No coke formation/production
- Option to convert the Bottom of the Barrel overcoming conversion limitations
- Environment-friendly technology
- High energy efficiency
- Excellent option for natural gas valorisation

Further improvements of the technology are in the pipeline as a result of first year of operation

Now, since the successful start up of the Unit, eni has started to license EST technology
Thank you for your attention