ULSD production…
- in practice

Rasmus Breivik
Presentation outline

- Company Introduction
- Refinery Challenges
- Industrial examples
- Conclusions
Company profile

- Founded 1940 by Dr. Haldor Topsøe
- Process licensor and catalyst supplier
- Philosophy: “second to none”
- Comprehensive R&D activities
- Business areas
  - The refining industry
  - Fertiliser industry
  - The heavy chemical and petrochemical industries
  - The environmental and power sector
Topsøe ULSD catalysts

- Status August 2009:
  - Worldwide more than 150 ULSD hydrotreaters are running or projected to run with Topsoe catalyst
  - Accumulated ULSD capacity: 5 million BPSD
Design experience low sulphur fuels

- Total of 98 units licensed
  - 59 Grass roots hydroprocessing units
  - 39 Revamp of hydroprocessing units

- More than 50 of these units were licensed in the last 5 years
Diesel sulphur specifications (ppm)

- **North America**: Now 15
- **EU**: Now 10
- **Japan**: Now 10
- **South Korea**: Now 10
- **Mexico**: Towards 10
- **South America**: Towards 50 in cities
- **Taiwan**: Now 50
- **Rest of Asia**: Towards 50 in cities

Towards 50 in cities
Crude is getting heavier, more sour

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<th>Density</th>
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Industrial case 1: Improved reactor internals

Syncrude’s HGO upgrader
Relative distributor sizes

New Topsøe “Vapour-lift” distributor

Original Bubble cap distributor
Distributor density comparison

Typical vapour-lift tray

Typical bubble-cap tray
Topsøe VLT principle
Tray sensitivity analysis

\[
\text{Sensitivity} = 100\% \times \left( \frac{V\text{-LIQ}_{\text{MAX}} - V\text{-LIQ}_{\text{MIN}}}{V\text{-LIQ}_{\text{AVG}}} \right)
\]

\[0 \leq \text{Sensitivity} \leq 200\%\]
Sensitivity comparison
Reactor performance
Original internals
Reactor performance
Topsøe internals

![Graph showing reactor temperature change with percent of catalyst for Bed 1, Bed 2, and Bed 3.](chart)
Worldwide references for Topsøe reactor internals

>450 reactor internals in more than 200 hydroprocessing units
Industrial case 2: Low pressure revamp

BP Coryton clean diesel project
Key features of BP Coryton clean diesel project

- Unit operating at 30 bar to produce 50 ppm S diesel and 0.2% S heating oil in blocked mode
- BP wanted to replace by a high pressure unit to produce < 10 ppm S diesel, with higher capacity
- Topsøe one of 2 licensors who proposed revamp
- BP/Topsøe analysis showed twice IRR for revamp vs grassroots
- Scoping study: Additional reactor volume added to increase cycle length and allow processing of heavier feeds
Performance of revamped CHD unit at BP Coryton

- Existing reactor started up in March 2003
- New reactor tied in September 2003
- Operation to date to produce less than 50/10 wppm diesel
- Test run conducted 8 months after tie in of second reactor
- Test run demonstrated production of 5 wppm S diesel at design conditions
- Second Topsøe catalyst charge started up April 2006
Industrial case 3: Low capex revamp

ChevronTexaco, Pembroke refinery ULSD project
ChevronTexaco,
Pembroke refinery before revamp

- Light distillate
- Heavy distillate
- Vacuum distillate
- Visbreaker GO
- LCO
- Hot well oil

HTU-1
39 Barg

Diesel block

HTU-2
57 Barg

Gas oil block

- Kerosene
- Purchased GO

- Reformer H₂, 90%
- Recovered H₂, 99%
Revamp of HTU-1 and HTU-2

- In July 2001, Topsøe selected as technology licensor with the following primary project objectives:
  - Maximise production of EN590 road diesel with a target sulphur of 5 wppm
  - Maximise LCO in the combined distillate pool
  - Minimise kerosene blending and gas oil imports
  - Utilise only existing H₂ resources in the refinery
  - Optimise the revamp investment subject to minimum two year catalyst cycle
ChevronTexaco, Pembroke refinery after revamp

- Light distillate
- Heavy distillate
- Vacuum distillate
- Visbreaker GO
- LCO
- Hot well oil

HTU-1
- 39 Barg
- CoMo

Diesel block
- Sulphur = 5 ppm
- Density < 845 kg/m²
- Cetane > 51
- PNA < 5 wt%
- T95 < 360°C

HTU-2
- 57 Barg
- NiMo

Gas oil block
- Sulphur = 2000 ppm
- Density < 875 kg/m²
- Cetane > 45
- T95 < 360°C

Kerosene
- Purchased GO

Reformer H₂, 90%
- Recovered H₂, 99%
HTU-1 modifications

- New larger diameter two-bed reactor in series with existing single-bed reactor
- Use Topsøe CoMo catalyst to maximise HDS capacity under low pressure conditions
- Addition of new recycle gas compressor not justified
- Addition of new recycle gas amine absorber not justified
- High pressure separator modified for continuous water wash
HTU-2 modifications

- New larger diameter single-bed reactor in series with two existing reactors
- Convert from two-bed to single-bed design in existing reactors
- Use Topsøe NiMo Catalyst to improve aromatics saturation and increase density reduction whilst maximising HDS activity
Performance in HTU-1

![Performance Graph](image)
**Summery**

- Feeds to hydroprocessing units are becoming increasingly difficult.
- Tight distillate product specifications leave no margin for off. spec. products.
- ULSD can be produced at low pressure by using Topsøe technology and catalyst.
- Topsøe has vast experience of ULSD production.
Conclusion

Licensor
- Unique understanding of key cost drivers
- High activity catalysts
- In-depth understanding of the kinetics of ULSD

Customer
- Market intelligence
- Technical experience
- Involvement

= Maximised profit for the refiner