Optimizing Distillate Yields and Product Qualities

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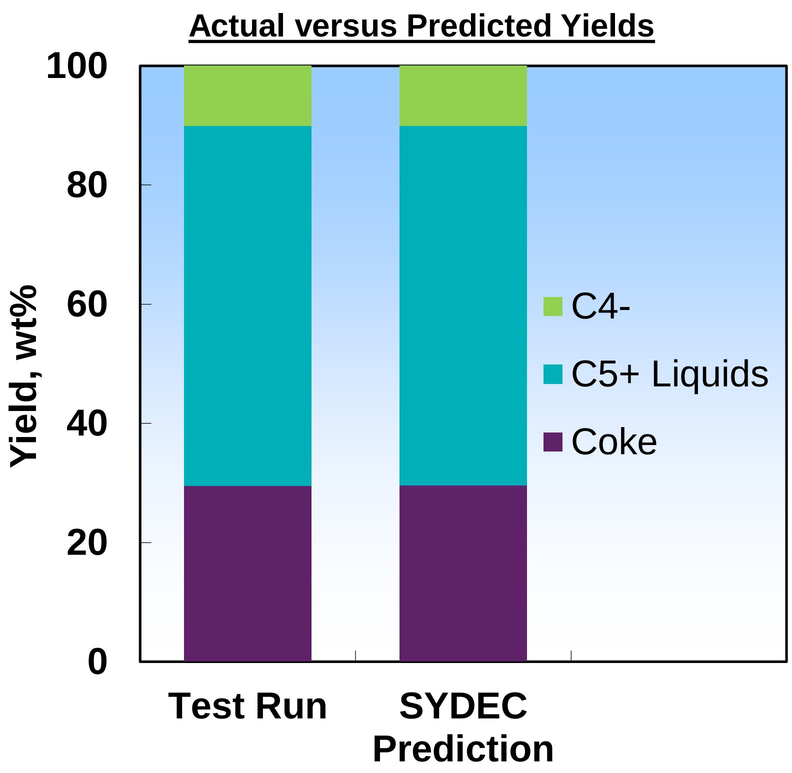
Optimizing Distillate Yields and Product Properties

Overview

- Delayed coker yield determinants
- Case study
- Product quality optimization
- Conclusions

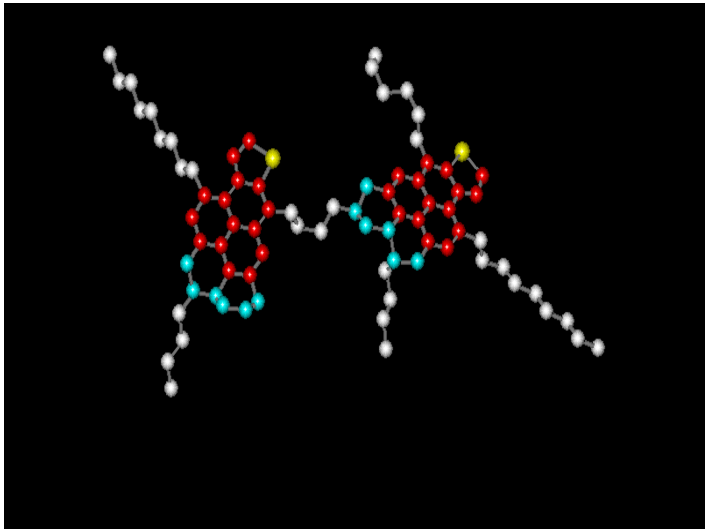
Delayed Coker Yield Determinants



- **Feedstock Properties**
  - TBP cutpoint / distillation
  - API gravity
  - Viscosity
  - Concarbon residue (CCR)
  - Asphaltenes (C7 Insolubles)
  - Sulfur
  - Nitrogen
  - Metals/ash
- **Crude type/source**
- **Operating conditions**
- **Coking cycle time**

Feed properties have the most impact on yields

Delayed Coker Feedstocks



Feedstock type influence yield selectivity

- **Straight Run**
  - Paraffinic
  - Non-paraffinic
    - Asphaltic
    - Aromatic/naphthenic
  - Distillates (VGO)
- Cracked feeds
  - Hydrocracked resids (H-oil, fixed bed HDS, etc.)
  - Thermally cracked resids (visbreaker tar)
  - Distillate tars (slurry, coal tar, pyrotar, etc.)
  - Unconverted oil (UCO)
- SDA pitch
- Shale oil residues (kerogen derived)

DCU Non-Typical Feed Impacts

Paraffinic Feeds

- **Cracks easily**
- **Makes more gas, more lighter distillates and less coke**
- **High sodium in feed could result in accelerated heater fouling**
- **Stability when blended with asphaltenic residue could be an issue**

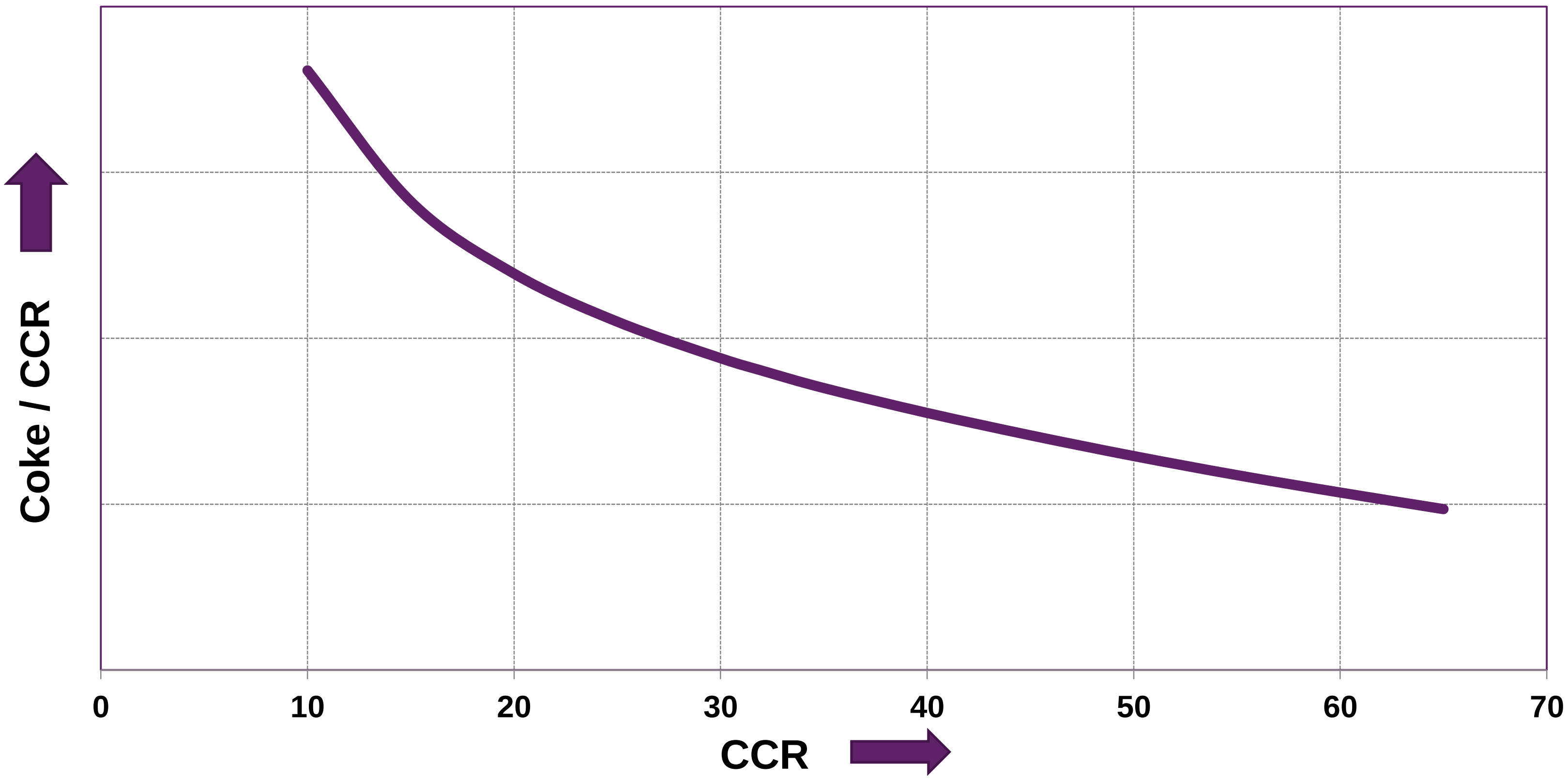
Aromatic Feeds (Decant Oil)

- **Low CCR content → high Coke/CCR ratio**
- **High aromatic content → high HCGO yield**
- **Potential to change coke morphology (shot → sponge)**

Yield model calibrated for wide range of feedstock types

Yield Corrections for Unusual Feeds

Coke yield for unusual feeds like AR and FCC decant oil are to be corrected. Coke yield to CCR ratio is higher for such feeds although actual coke make is much less as CCR is low.



Effect of Operating Conditions

Process Variables for Maximizing Liquid Yields

- Temperature: Higher is better
- Pressure: Lower is better
- Recycle: Lower is better

However…

- Lower recycle increases HCGO
  - End point
  - CCR
  - Heptane insoluble (nC7 asphaltenes)
  - Metals (Ni + V)

Case Study - Selection Of Operating Conditions

- FEED IS VR FROM MIDDLE EAST
  - CCR = 24 / API = 6
- OBJECTIVE IS TO MAXIMIZE REVENUE
- LCGO & LPG PRICED @ 1.49 X HCGO
- LIQUID PRODUCTS:
  - LPG
  - Naphtha IBP - 150 C
  - LCGO 150 C - 370 C
  - HCGO 370 +

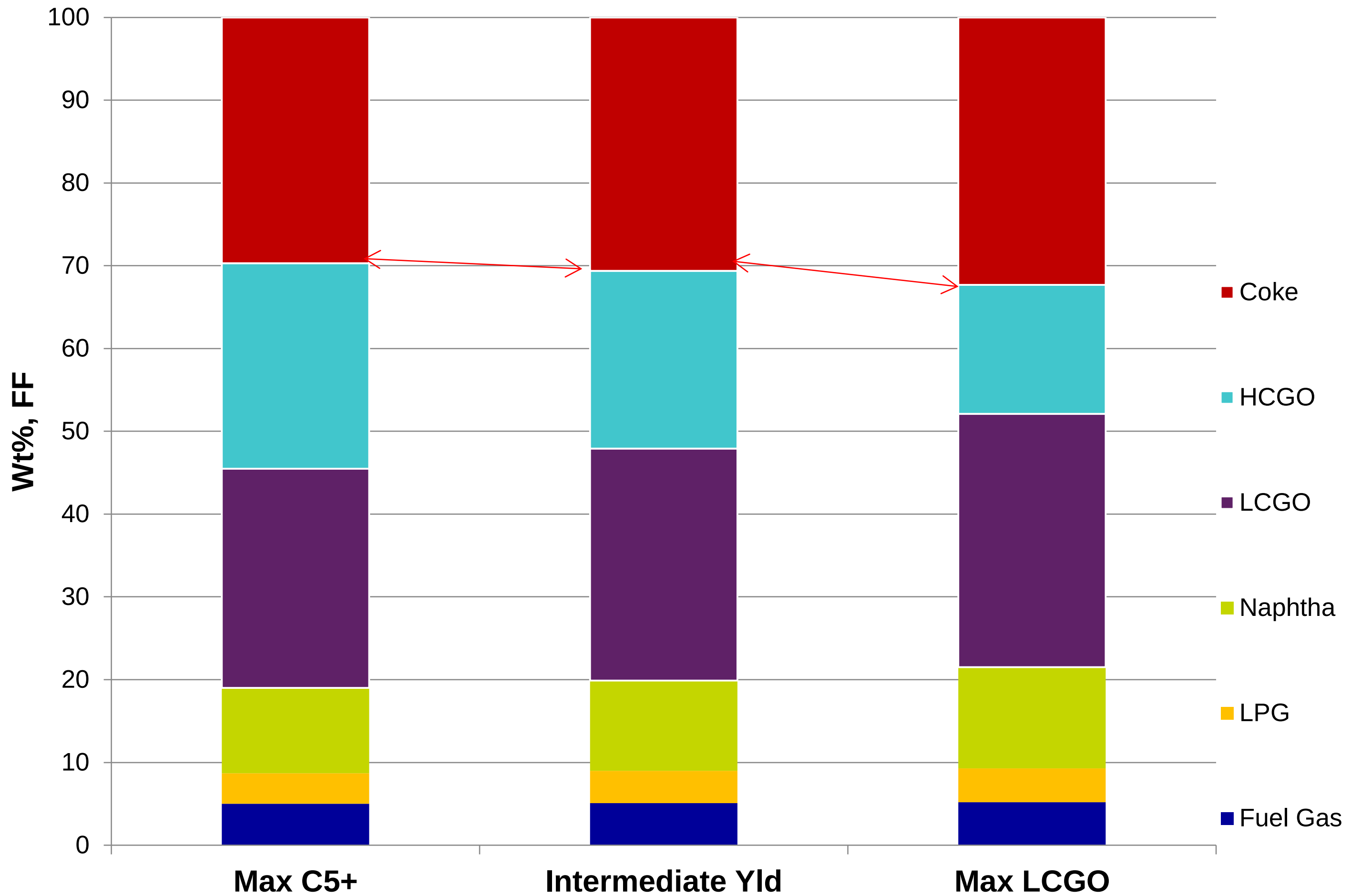
Case Study
Selection of Operating Conditions - Impact on Yields

	Maximum C5+	Intermediate Yields	Higher LCGO
CD Pressure	Base	↑	↑↑
TPR	Base	↑	↑↑
Yields as Wt % Fresh Feed (FF)			
Fuel Gas (w/ H_2S)	5.0	5.1	5.2
LPG	3.7	3.9	4.1
Naphtha	10.3	10.9	12.2
LCGO	26.5	28.0	30.6
HCGO	24.8	21.5	15.6
Coke	29.7	30.6	32.3
Total C5+ Liquids	**61.6**	**60.4**	**58.4**

Maximizing C5+ liquid yields *usually* maximizes revenue unless

- **Coker is hydraulically constrained in revamp scenario**
- **Coke is highly valued, i.e. specialty grade coke**
- **HCGO does not go to a high conversion unit**

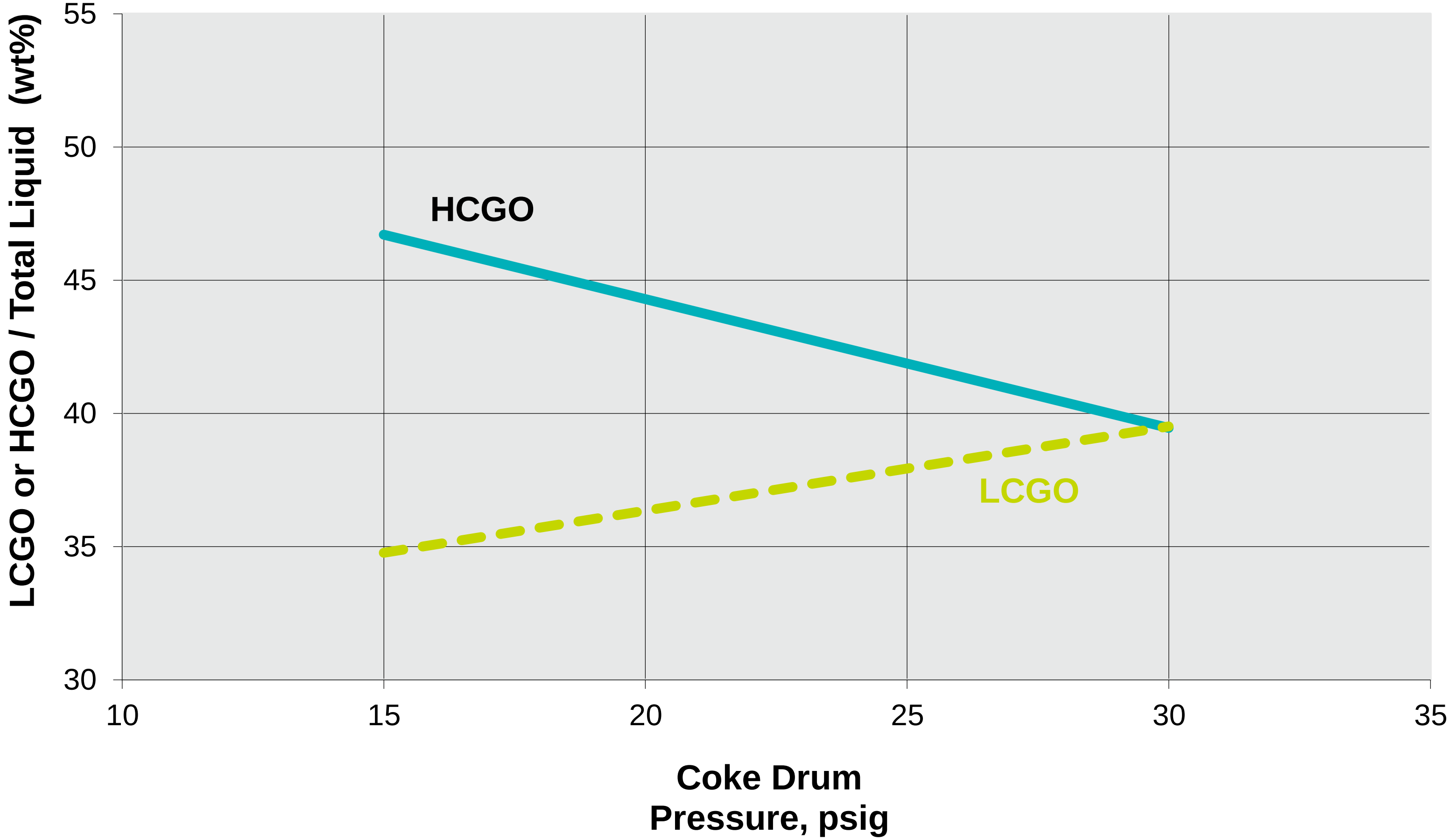
Case Study
Selection Of Operating Conditions – Impact on Yields



BASED ON PRICING, MAX. LCGO CASE INCREASES REVENUE BY $10 MM /YEAR EVEN THOUGH C5+ LIQUID YIELDS ARE LOWER BY 2.8 WT% (FF BASIS)

Effect of Pressure on Liquid Distribution

LCGO and HCGO Distribution in TLP (Case specific)



HCGO – Processing Options

- **Most desired option is to send HCGO to Hydrocracker. However, quality limitations have to be recognized**

- **Feed to FCC. However if FCC bottoms is sent to the coking unit, this recycle could cause a build-up of refractory type material. FCC pre-treatment would be required. Limits to how much FCC decant oil can be processed in a coker**

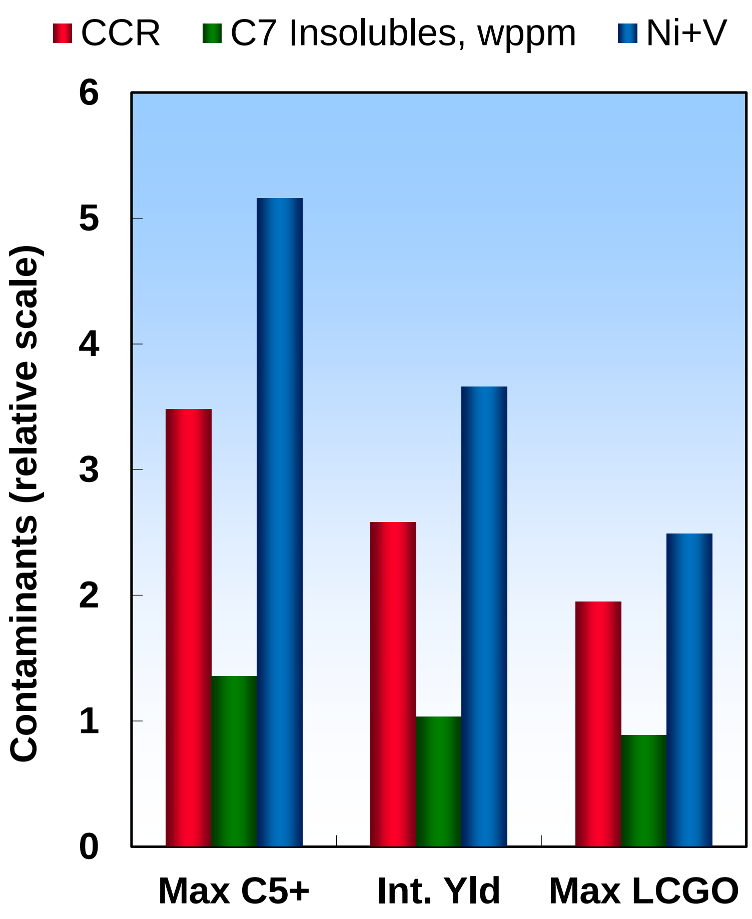
- **VGO hydrotreater – More tolerant to HCGO contaminants. Take a hit on conversion**

HCGO Distillation

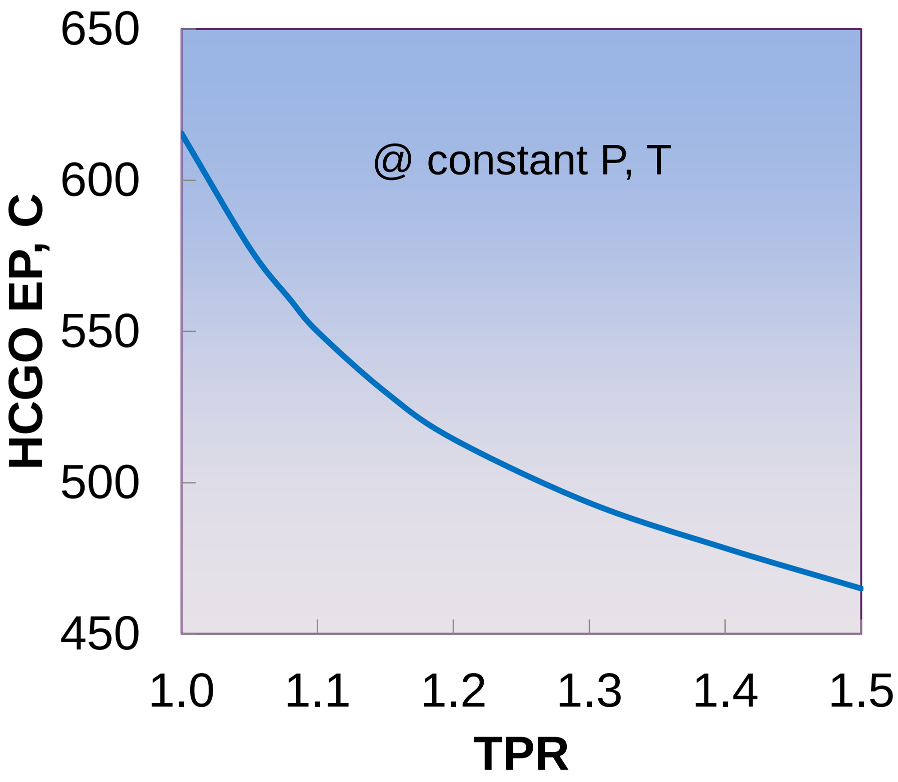
ASTM D1160, °C	Max C5+	Intermediate Yields	Max. LCGO
IBP	382	382	381
10%	393	391	388
30%	424	418	409
50%	459	447	433
70%	501	484	464
90%	546	526	500
EP	572	550	521

Note: Distillations are based on theoretical yields (perfect fractionation). Actual distillation will show a tail based on fractionation efficiency

Product Properties - HCGO



There is a balance between maximizing liquid yields and keeping HCGO “clean”

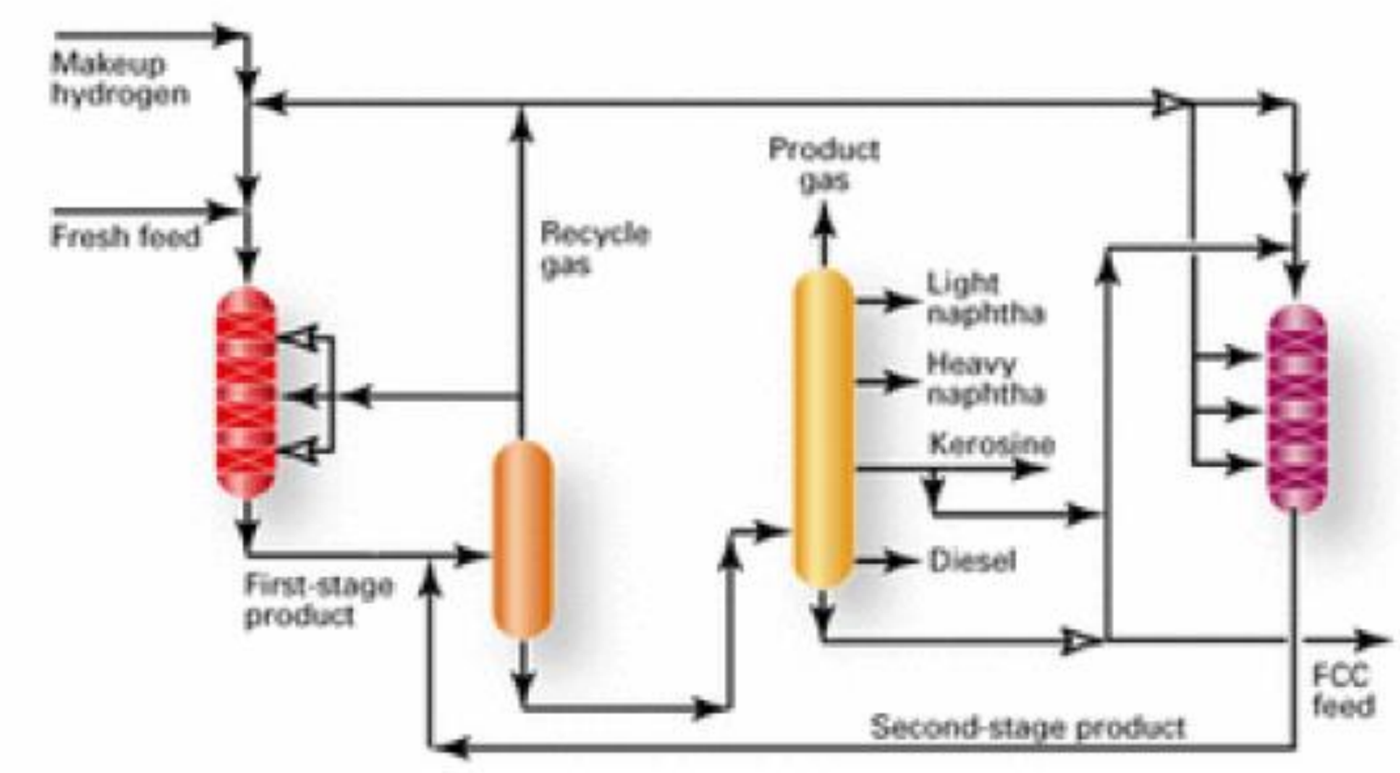


HCGO Processing in a Hydrocracker

- Hydrocracker licensors restrict the EP of HCGO stream to lower contaminant levels and increase catalyst life
- HCGO with EP as high as 578 C (1072 F) has been processed in Hydrocracker making quality product.
  - US Gulf coast installation, operating since 2000
    - 35,000 BPSD Capacity. 55% HCGO, 25% Light cycle oil, 20% SR HVGO
    - 2 stage HCK, Common recycle gas loop, 50% conversion of 343 C + (650 F +) material with 13,000 BPSD fed to FCC (bottoms from first reactor)
    - HCGO Quality

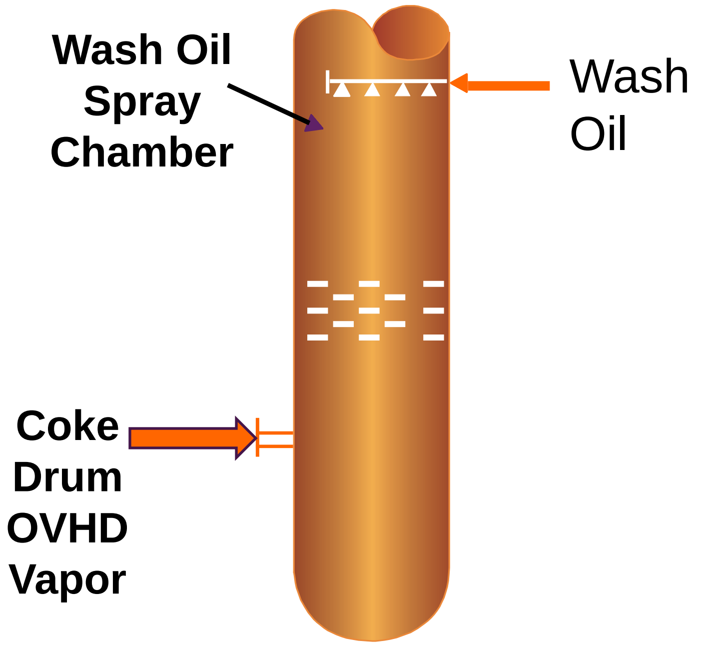
CCR	0.48 wt%
Asphaltenes	<100 ppmw
Ni + V	1.82 ppmw

2 Stage Hydrocracker



HCGO Product Quality Control

- Use spray pattern and backup spray system for ultra-low recycle operations
  - 5% recycle or lower
- Open Wash Zone
- Use of Sheds
  - Distribute vapor flow
  - Impingement of liquid mist
  - Subject to coking: Open design



LCGO Quality

Typical Specifications for LCGO

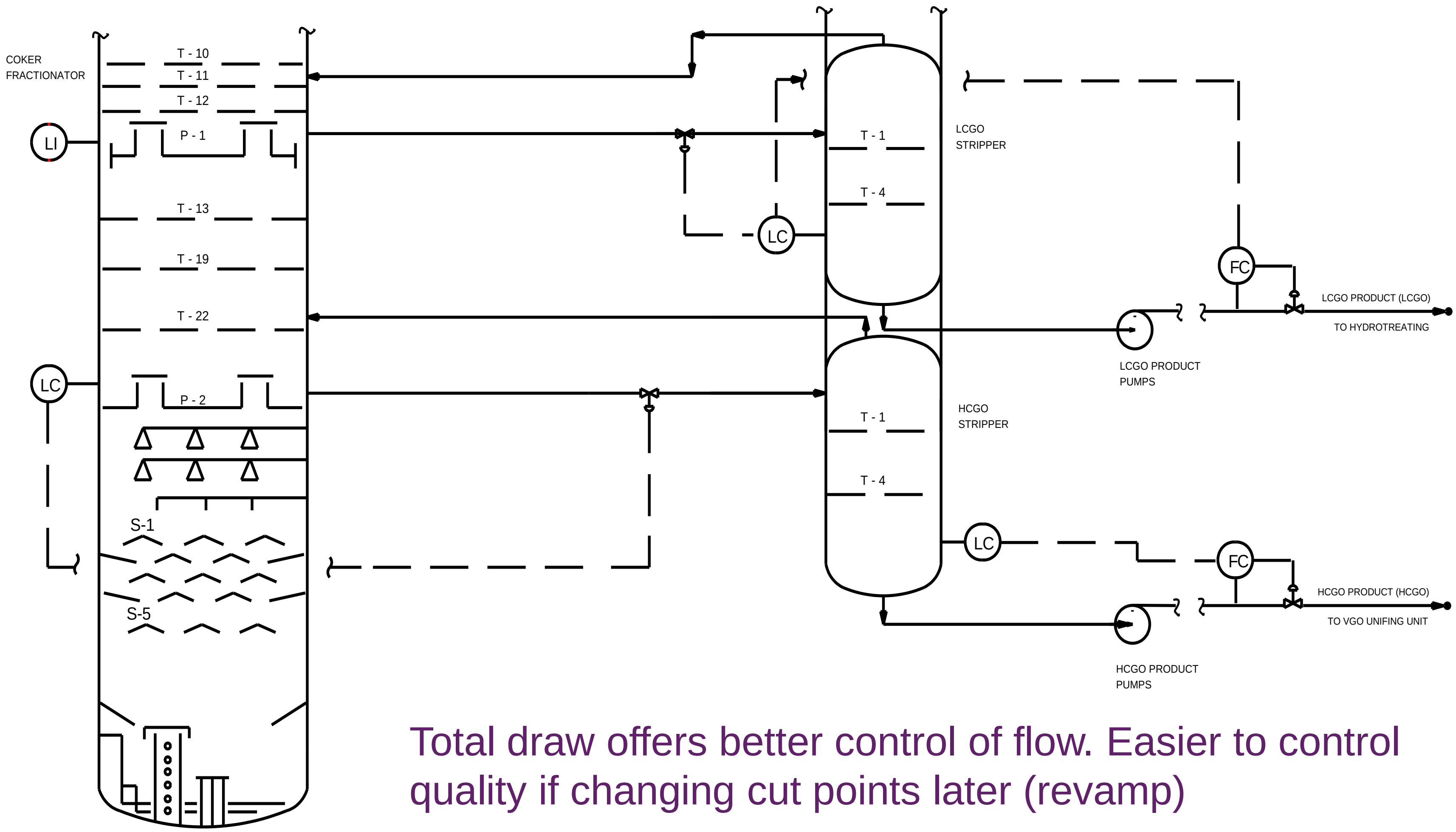
- Flash point
- Distillation - D86 90% and/or EP, Gap (LCGO - HCGO)

Flash point met by addition of LCGO stripper

Distillation – Specification achieved by varying draw rates, internal reflux, addition of trays between LCGO draw and HCGO P/A return in the fractionator

Consider total draw-off tray with pump back for more stable operation

LCGO Quality – Partial Draw vs. Total Draw



Total draw offers better control of flow. Easier to control quality if changing cut points later (revamp)

Naphtha Quality

Typical Specifications for Naphtha

- Vapor Pressure
- Distillation - D86 90% and/or EP, Gap (Naphtha - LCGO)
- Si content (to be watched)

Issues with low Naphtha EP

- Low Fractionator overhead temperatures – can lead to salt deposition in top section of column
- Recommend a back end Naphtha Splitter

Other Considerations

- Provide water wash section in the fractionator
- Consider Si guard bed followed by di-olefin reactor upstream of naphtha Hydrotreater

Conclusions

- **Delayed Coker yields are dependent on feedstock quality, operating conditions and cycle time**
- **Limitations of downstream processing units impact selection of DCU operating conditions**
- **Maximizing C5+ Yields may not be the best option for every refiner**
- **Naphtha and distillate yields can be optimized by careful selection of operating parameters and design considerations**

Thank you!

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