

Coking and Gas Processing

Table of Contents

1. Introduction.....	1
2. Coking.....	3
2.1 Market/Technology Trends & Opportunities.....	3
2.1.1 Market Conditions and Outlook.....	3
2.1.1.1 Supply and Demand.....	3
2.1.1.2 Government Legislation.....	5
2.1.2 Technology Competition, Directions, and Future Prospects.....	6
2.2 State-of-the-Art Technology.....	9
2.2.1 Introduction.....	9
2.2.2 Commercial Processes.....	13
2.2.2.1 CB&I Lummus Global (formerly ABB Lummus Global).....	13
2.2.2.2 ConocoPhillips.....	16
2.2.2.3 ExxonMobil Research and Engineering.....	18
2.2.2.4 Foster Wheeler/UOP.....	22
2.2.2.5 KBR (formerly Kellogg Brown & Root).....	27
2.2.2.6 Lurgi/ExxonMobil.....	28
2.2.2.7 Petrobras.....	29
2.2.3 Summary of Commercial Coking Processes.....	29
2.2.4 Additional Coking Technology.....	32
2.2.4.1 New Coke Drum Design.....	32
2.2.4.2 Hydrocyclones.....	32
2.2.4.3 ETX Coker Design.....	32
2.2.4.4 MaxiCoking Technology.....	33
2.2.5 Comparison of Commercially Available Advanced Control and Optimization Systems.....	34
2.3 Plant Operations and Practices.....	37
2.3.1 Meeting Feed Challenges.....	37
2.3.1.1 Processing Refinery Sludge.....	37
2.3.1.2 FCC Slurry Oil Addition to Improve Anode Grade Coke.....	38
2.3.1.3 Coping with High Asphaltene and CCR Feeds.....	38
2.3.2 Process Operating Variables.....	39
2.3.2.1 Significance of Coke Drum Pressure and Recycle Rate.....	39
2.3.2.2 Influences on Heater Run Lengths.....	40
2.3.2.3 Operational Recommendations to Avoid Feed Line Plugging.....	41
2.3.2.4 Optimal Transfer Line Quench Injection Angle to Improve Heat Transfer.....	41
2.3.2.5 Factors Increasing LCGO Yield.....	41
2.3.2.6 Manipulating Distillate Recycle to Control Product Yield.....	41
2.3.3 Coker Product Improvements.....	42
2.3.3.1 Controlling Shot Coke Formation.....	42
2.3.3.2 Methods to Desulfurize Coker Naphtha.....	43
2.3.4 Hardware Solutions.....	44
2.3.4.1 Improvements in Coker Heater Tubes.....	44
2.3.4.2 Selecting Main Fractionator Internals.....	45
2.3.4.3 Valve Selection: Pros and Cons.....	46

WORLDWIDE REFINERY PROCESSING REVIEW – 1Q2008

Coking and Gas Processing

2.3.5	Revamps and Turnarounds	46
2.3.5.1	Revamps to Boost Coker Capacity.....	47
2.3.5.1.1	Increasing Drum Size	47
2.3.5.1.2	Reducing Cycle Time	49
2.3.5.2	Revamping to Recover Coke Drum Blowdown Vapor	49
2.3.5.3	Furnace Tube Revamp to Handle Significantly Heavier Feed	50
2.3.5.4	EPC Management Service to Optimize Coker Revamp Process	50
2.3.5.5	New Revamp Approach Incorporating Modular Equipment.....	50
2.3.5.6	Benefits of Structural Engineering Contractors.....	51
2.3.6	Controlling Emissions	51
2.3.6.1	Coke Drum Emission Reduction.....	51
2.3.6.2	Reduce Flaring from Closed Blowdown System.....	51
2.3.6.3	Minimizing Post-Drum Coke Particulate Emissions.....	52
2.3.7	Mitigating Coker Fouling and Corrosion.....	52
2.3.7.1	Minimizing Heater Tube Coking	52
2.3.7.2	OnLine Steam Spalling vs. Pigging	53
2.3.7.3	Coker Fouling and Corrosion Recommendations.....	54
2.3.7.4	Frequency of Overhead Vapor Line Cleanings.....	54
2.3.8	Analytical Methods and Instrumentation	55
2.3.8.1	Utilizing a Coke Stability Index to Characterize Heater Tube Fouling	55
2.3.8.2	Methods of Coke Drum Level Detection	56
2.3.9	Improving Coker Safety	57
2.3.9.1	General Guidelines.....	57
2.3.9.2	Deheading Safety Measures	57
2.3.9.3	Avoid Low Heater-outlet Temperatures and Conditions for Hot Spots Formation	58
2.3.9.4	Implement Independent Review of Practices	58
2.3.9.5	Identifying and Preventing Drum Cracks	59
2.3.10	Miscellaneous.....	59
2.3.10.1	Reducing Coker Fines in Cutting Water	59
2.3.10.2	Performing a Coker Water Balance to Optimize Steam Purging and Sour Water Make	60
2.3.10.3	Antifoam Additive Use in Coke Drums and Associated Problems.....	60
2.4	Refining R&D Alert!	61
2.4.1	Process.....	62
2.4.1.1	General Scheme.....	62
2.4.1.1.1	Patents	62
2.4.1.1.2	Research.....	65
2.4.1.2	Additives.....	66
2.4.1.2.1	Patents	66
2.4.1.3	Monitoring and Control	68
2.4.1.3.1	Patents	68
2.4.1.4	Processing Alternative Feeds.....	70
2.4.1.4.1	Patents	70
2.4.1.4.2	Research.....	71
2.4.1.5	Shot Coke.....	71
2.4.1.5.1	Patents	71
2.4.1.5.2	Research.....	72
2.4.1.6	Needle Coke.....	73
2.4.1.6.1	Patents	73

WORLDWIDE REFINERY PROCESSING REVIEW – 1Q2008

Coking and Gas Processing

2.4.1.7	Fouling and Maintenance	73
2.4.1.7.1	Patents	73
2.4.1.7.2	Research	75
2.4.1.8	Other Technologies	75
2.4.1.8.1	Patents	75
2.4.2	Hardware	76
2.4.2.1	Unheading Valves	76
2.4.2.1.1	Patents	76
2.4.2.2	Coking Drum	79
2.4.2.2.1	Patents	79
2.4.2.3	Furnace	79
2.4.2.3.1	Patents	79
2.4.2.4	Feed Injector	80
2.4.2.4.1	Patents	80
2.4.2.5	Cutting Tool	81
2.4.2.5.1	Patents	81
2.5	Worldwide Installed Capacity	81
2.6	Construction	84
2.6.1	Recent Construction Activity	84
2.6.2	Completed Construction Projects	90
2.7	References	95
3.	Gas Processing	106
3.1	Market/Technology Trends & Opportunities	106
3.1.1	Market Conditions and Outlook	106
3.1.1.1	Liquefied Petroleum Gas	106
3.1.1.2	Propylene	108
3.1.1.3	Hydrogen	111
3.1.2	Technology Competition, Directions, and Future Prospects	112
3.1.2.1	LPG and Olefins	113
3.1.2.2	Hydrogen	115
3.2	State-of-the-Art Technology	116
3.2.1	Introduction	116
3.2.2	Gas Plant Configuration	118
3.2.2.1	Saturated Gas Plant	119
3.2.2.2	Unsaturated Gas Plant	119
3.2.3	Gas Separation Mechanisms	121
3.2.4	Commercially Available Process Technology	123
3.2.4.1	Advanced Extraction Technologies	124
3.2.4.1.1	Light Olefin Recovery	124
3.2.4.1.2	LPG recovery from saturated offgas	125
3.2.4.1.3	Hydrogen Recovery Unit	125
3.2.4.2	Air Liquide	126
3.2.4.3	Air Products and Chemicals	127
3.2.4.3.1	Cryogenic System	127
3.2.4.3.2	Dephlegmator	128

WORLDWIDE REFINERY PROCESSING REVIEW – 1Q2008

Coking and Gas Processing

3.2.4.3.3	Membrane technology.....	129
3.2.4.3.3.1	Prism Membrane Systems.....	129
3.2.4.3.3.2	Selective Surface Flow Membranes.....	130
3.2.4.4	Black & Veatch.....	130
3.2.4.5	Costain Oil, Gas & Process.....	132
3.2.4.5.1	Light Olefin Recovery.....	133
3.2.4.5.2	LPG Recovery.....	135
3.2.4.6	ExxonMobil.....	137
3.2.4.7	Linde BOC Process Plants.....	137
3.2.4.8	Membrane Technology and Research.....	140
3.2.4.9	Uhde.....	142
3.2.4.10	UOP.....	143
3.2.4.10.1	Propylene Recovery.....	143
3.2.4.10.2	Membrane Separation.....	144
3.2.4.10.3	Hydrogen Recovery via PSA.....	145
3.2.4.11	Other Technologies.....	145
3.2.5	Summary of Commercially Available Gas Processing Technologies.....	147
3.3	Plant Operations and Practices.....	148
3.3.1	Holistic Approach to FCC Gas Plant Optimization.....	148
3.3.2	Capacity Limitations Due to Stripper Flooding.....	150
3.3.2.1	Process Configuration.....	151
3.3.2.2	Operating Conditions.....	152
3.3.2.3	Internals.....	154
3.3.2.4	HP Receiver.....	154
3.3.2.5	Water Draw.....	155
3.3.3	Overcoming Hardware Limitations through Revamp.....	156
3.3.4	Controlling LPG Weathering in a Gas Plant.....	157
3.3.5	Decreasing LPG Content in Fuel Gas (Dry Gas).....	157
3.3.6	Recovering Light Ends from Refinery Fuel Gas Streams.....	158
3.3.7	Debottlenecking Debutanizer Feed.....	159
3.3.8	Maximum Propane Recovery in the Refinery Gas Plant.....	160
3.3.9	Pressure Safety Valves for Light Hydrocarbon Separations.....	162
3.3.10	Feed Properties That Influence Hydrogen Recovery.....	163
3.4	Refining R&D Alert!.....	164
3.4.1	Cryogenic Distillation.....	165
3.4.1.1	Light Hydrocarbons.....	165
3.4.1.1.1	Patents.....	165
3.4.2	Absorption Separation.....	168
3.4.2.1	Light Hydrocarbons.....	168
3.4.2.1.1	Patents.....	168
3.4.2.2	Hydrogen.....	169
3.4.2.2.1	Patents.....	169
3.4.2.3	Light Hydrocarbons and Hydrogen.....	170
3.4.2.3.1	Patents.....	170
3.4.3	Membrane.....	171
3.4.3.1	Light Hydrocarbons.....	171
3.4.3.1.1	Patents.....	171
3.4.3.1.2	Research.....	172

WORLDWIDE REFINERY PROCESSING REVIEW – 1Q2008

Coking and Gas Processing

3.4.3.2	Hydrogen.....	174
3.4.3.2.1	Research.....	174
3.4.3.3	Light Hydrocarbons and Hydrogen.....	175
3.4.3.3.1	Patents.....	175
3.4.3.3.2	Research.....	176
3.4.4	Adsorption.....	176
3.4.4.1	Light Hydrocarbons.....	176
3.4.4.1.1	Patents.....	176
3.4.4.2	Hydrogen.....	177
3.4.4.2.1	Patents.....	177
3.4.5	Hybrid Separation (Combination of absorption, membrane, and/or adsorption).....	178
3.4.5.1	Hydrogen.....	178
3.4.5.1.1	Patents.....	178
3.4.5.1.2	Research.....	179
3.4.5.2	Light Hydrocarbons and Hydrogen.....	179
3.4.5.2.1	Patents.....	179
3.4.5.2.2	Research.....	180
3.4.6	Treating.....	181
3.4.6.1	Patents.....	181
3.4.7	Other Technologies.....	182
3.4.7.1	Patents.....	182
3.4.7.2	Research.....	183
3.5	Construction.....	184
3.5.1	Recent Construction Activity.....	184
3.5.2	Completed Construction Projects.....	187
3.6	References.....	188
4.	Latest Refining Technology Developments & Licensing.....	194
4.1	Fluid Catalytic Cracking.....	194
4.2	Hydrotreating (including HDS).....	204
4.3	Hydrocracking.....	207
4.4	Iso-octane.....	210
4.5	Crude Distillation.....	210
4.6	Heavy Oil, Extra-heavy Oil, and Bitumen Upgrading.....	211
4.7	Hydrogen Production and Purification.....	212
4.8	Gasification.....	212
4.9	Aromatics and Light Olefins Production.....	212
4.10	Catalyst and Carrier Support Developments.....	213
4.11	Process Monitors, Controls, and Simulation.....	214
4.12	Gas-to-liquid and Coal-to-liquid.....	214
4.13	Biofuels Production.....	215
4.14	Energy Management.....	219
4.15	CO ₂ Emissions (Carbon Capture and Sequestration).....	220
4.16	Automobile Engine Design Innovations.....	222
4.17	References.....	223