

CHEMSYSTEMS PERP PROGRAM
Report

Olefins via Enhanced FCC Processes

07/08S5

December 2008



44 South Broadway, White Plains, New York 10601, USA
Tel: +1 914 609 0300 Fax: +1 914 609 0399

This Report was prepared by Nexant, Inc ("Nexant") and is part of the ChemSystems Online® suite. Except where specifically stated otherwise in this Report, the information contained herein is prepared on the basis of information that is publicly available, and contains no confidential third party technical information to the best knowledge of Nexant. Aforesaid information has not been independently verified or otherwise examined to determine its accuracy, completeness, or financial feasibility. Neither NEXANT, Subscriber nor any person acting on behalf of either assumes any liabilities with respect to the use of or for damages resulting from the use of any information contained in this Report. Nexant does not represent or warrant that any assumed conditions will come to pass.

The Report is submitted on the understanding that the Subscriber will maintain the contents confidential except for the Subscriber's internal use. The Report should not be reproduced, distributed, or used without first obtaining prior written consent by Nexant. Each Subscriber agrees to use reasonable effort to protect the confidential nature of the Report.

Copyright © by Nexant Inc. 2008. All rights reserved.

Contents

Section	Page
1 Summary	1
1.1 INTRODUCTION	1
1.2 OVERVIEW OF FLUIDIZED CATALYTIC CRACKING.....	2
1.3 ENHANCED FCC TECHNOLOGIES.....	3
1.3.1 Shaw Stone & Webster/SINOPEC	4
1.3.2 UOP – PetroFCC™.....	5
1.3.3 Indian Oil Corp./Lummus Technology Inc. – INDMAX FCC (I-FCC™).....	7
1.3.4 Kellogg, Brown and Root LLC.....	8
1.3.5 Japan Petroleum Energy Center – HS-FCC.....	10
1.3.6 NExCC™ (Fortum Oy).....	12
1.3.7 Resid Fluid Catalytic Cracking PetroRiser SM (Axens)	12
1.3.8 Middle Distillates and Lower Olefins Selective Process (Shell Global Services).....	13
1.3.9 High-Olefins FCC (Petrobras)	14
1.4 COST OF PRODUCTION ANALYSIS.....	15
1.4.1 Conventional FCC with ZSM-5 Additive.....	15
1.4.2 High Severity FCC.....	15
1.4.3 Advanced Catalytic Cracking (ACO™)	16
1.5 MARKET OUTLOOK	17
1.5.1 United States	17
1.5.2 Western Europe.....	17
1.5.3 Asia Pacific	18
1.6 CONSUMPTION.....	19
2 Technology Analysis	20
2.1 INTRODUCTION	20
2.2 OVERVIEW OF FLUIDIZED CATALYTIC CRACKING.....	21
2.3 FLUIDIZED CATALYTIC CRACKING PROCESS CHARACTERISTICS	24
2.3.1 General.....	24

2.3.2	Catalyst and Chemistry	25
2.3.3	Process Description.....	27
2.3.4	Feeds	28
2.3.5	Products.....	30
2.3.6	Operating Conditions	30
2.3.7	Process Variables, Yields, and Severity	31
2.3.8	FCC Reactor Section.....	33
2.3.9	Revamping an Existing FCC Unit for Olefin Production.....	35
2.4	ZSM-5 ADDITIVES.....	36
2.5	ENHANCED FCC TECHNOLOGIES.....	37
2.5.1	Shaw Stone & Webster/SINOPEC	38
2.5.2	UOP – PetroFCC™.....	45
2.5.3	Indian Oil Corp./Lummus Technology Inc. – INDMAX FCC (I-FCC™).....	50
2.5.4	Kellogg, Brown and Root LLC.....	53
2.5.5	Japan Petroleum Energy Center – HS-FCC.....	60
2.5.6	NExCC™ (Fortum Oy).....	63
2.5.7	Resid Fluid Catalytic Cracking PetroRiser SM (Axens)	64
2.5.8	Middle Distillates and Lower Olefins Selective Process (Shell Global Services).....	65
2.5.9	High-Olefins FCC (Petrobras)	67
2.5.10	SINOPEC	67
3	Economic Analysis	69
3.1	BASIS	69
3.1.1	Pricing Basis	69
3.1.2	Investment Basis	70
3.1.3	Cost of Production Basis.....	70
3.2	COST OF PRODUCTION ANALYSIS.....	71
3.2.1	Conventional FCC with ZSM-5 Additive.....	71
3.2.2	High Severity FCC.....	73
3.2.3	Steam Cracking.....	76
3.2.4	Advanced Catalytic Cracking (ACO™)	76

3.2.5	Cost of Production Sensitivities	79
3.3	CONCLUSIONS	84
4	Commercial Analysis	85
4.1	APPLICATIONS	85
4.2	UNITED STATES	86
4.2.1	Consumption	86
4.2.2	Supply	87
4.2.3	Supply, Demand and Trade	89
4.3	WESTERN EUROPE	89
4.3.1	Consumption	89
4.3.2	Supply	91
4.3.3	Supply, Demand, and Trade	91
4.4	ASIA PACIFIC	94
4.4.1	Consumption	94
4.4.2	Supply	96
4.4.3	Supply, Demand, and Trade	101
5	References	102
Appendix		Page
A	Abbreviation and Acronyms	A-1
B	Nexant's <i>ChemSystems</i> Capital Cost Estimates	B-1
C	PERP Program Title Index	C-1

Figure	Page
1.1 Global Propylene Capacity, 2007	2
1.2 Typical UOP PetroFCC™ Complex.....	6
2.1 Global Propylene Capacity, 2007	21
2.2 DCC Simplified Process Flow Diagram.....	42
2.3 Typical UOP PetroFCC™ Complex.....	46
2.4 Simplified Flow Diagram for KBR - SUPERFLEX™.....	55
2.5 ACO™ Flow Scheme - Reactor Section	57
2.6 Typical ACO™ Flow Scheme – Compression/Recovery Sections	58
2.7 Schematic of the Down-Flow Reactor	62
2.8 Schematic of the PetroRiser SM Reactor	64
2.9 Shell MILOS-FCC Design.....	65
3.1 Sensitivity of Propylene Economics Based on High Severity FCC to Operational Severity	80
3.2 Sensitivity of Propylene Economics Based on High Severity FCC to Economy of Scale	81
3.3 Sensitivity of Propylene Economics Based on High Severity FCC to Pricing.....	82
3.4 Sensitivity of Propylene Economics Based on High Severity FCC to Capital Investment	83
3.5 Sensitivity of Propylene Economics Based on High Severity FCC to ROCE.....	83
4.1 U.S. Propylene Propylene Consumption, 2007	87
4.2 West European Propylene Consumption, 2007	90
4.3 Asia Pacific Propylene Consumption, 2007	96

Table	Page
1.1 High Severity FCC Technology Licensors	3
1.2 U.S. Propylene Supply, Demand, and Trade	17
1.3 West European Propylene Supply, Demand, and Trade	18
1.4 Asia Pacific Propylene Supply, Demand, and Trade	19
2.1 Yields for Conventional and High Severity FCC	23
2.2 Concentration of Aromatics	23
2.3 Reactions in Catalytic Cracking	26
2.4 High Severity FCC Technology Licensors	37
2.5 DCC Product Slate and Olefin Yield	39
2.6 DCC Type I and FCC Design Operating Conditions	40
2.7 Yields: CPP versus Steam Cracking	44
2.8 Yield Patterns – Traditional FCC versus PetroFCC™	49
2.9 Typical Olefin Yields for the I-FCC™ Process	50
2.10 Overall Material Balances for Various Configurations	60
2.11 Comparison of Main Processing Parameters	63
2.12 MILOS Yields for Cracking Raffinate-1	66
3.1 Price and Utility Basis	69
3.2 Cost of Production Estimate for: Polymer Grade Propylene Process: Conventional FCC with ZSM-5 additive	72
3.3 Cost of Production Estimate for: Polymer Grade Propylene Process: High Severity FCC	74
3.4 Cost of Production Estimate for: Propylene Process: High Severity FCC w/Recovery of Ethylene	75
3.5 Cost of Production Estimate for: Olefins Process: Steam Cracking of Light Naphtha	77
3.6 Cost of Production Estimate for: Olefins Process: Advanced Catalytic Olefins	78
3.7 FCC Product Yield comparisons Across Operating Modes	79
4.1 U.S. Propylene Capacity	88
4.2 U.S. Propylene Supply, Demand, and Trade	89
4.3 West European Propylene Capacity	92

4.4	West European Propylene Supply, Demand, and Trade.....	94
4.5	Asia Pacific Propylene Capacity.....	98
4.6	Asia Pacific Propylene Supply, Demand, and Trade.....	101