

PERP Report

Reducing Costs in PET Manufacture

04/05S7

July 2005



44 South Broadway, White Plains, New York 10601, USA

Tel: +1 914 609 0300 Fax: +1 914 609 0399

Copyright© by Nexant, Inc. 2005

This Report was prepared by Nexant, Inc. ("Nexant") and is part of ChemSystems Process Evaluation/Research Planning (PERP) Program. 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. The aforesaid information has not been independently verified or otherwise examined to determine its accuracy, completeness, or 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 shall not be reproduced, distributed, or used outside Subscriber's organization without first obtaining prior written consent by Nexant. Each Subscriber agrees to use reasonable effort to protect the confidential nature of the Report.

Contents

Section	Page
1 Summary	1
1.1 CONVENTIONAL TECHNOLOGY	1
1.1.1 Overview	1
1.1.2 Transesterification of Dimethyl Terephthalate	1
1.1.3 Esterification of Terephthalic Acid.....	2
1.1.4 Melt-Phase Polycondensation of bis-HET.....	3
1.2 IPT (INVISTA PERFORMANCE TECHNOLOGIES) NG3™	4
1.2.1 Comparison to Conventional Technology	5
1.3 DEVELOPING TECHNOLOGY	6
1.3.1 Eastman <i>IntegRex</i> Process	6
1.3.2 Eastman Pipe Reactor	8
1.3.3 M&G EasyUp Process	10
1.3.4 Inventa-Fischer Elimination of Solid-Stating	11
1.3.5 Zimmer Elimination of Solid Stating.....	12
1.3.6 Inventa-Fischer Melt to Preform.....	13
1.3.7 Zimmer Direct to Preform	14
1.4 ECONOMICS	15
1.4.1 Eastman <i>IntegRex</i> Economics.....	16
1.5 COMMERCIAL ANALYSIS.....	17
1.5.1 United States	17
1.5.2 Western Europe.....	19
1.5.3 Asia Pacific	20
1.5.4 Supply, Demand and Trade.....	21
2 Commercial Technology	22
2.1 CONVENTIONAL TECHNOLOGY	22
2.1.1 Chemistry	22
2.1.2 Process Description.....	26
2.2 IPT (INVISTA PERFORMANCE TECHNOLOGIES) NG3™	34
2.2.1 Process Description.....	36

2.2.2	Comparison to Conventional Technology	40
3	Developing Technology	42
3.1	EASTMAN	42
3.1.1	Eastman <i>IntegRex</i>	42
3.1.2	Pipe Reactor	45
3.2	IMPROVEMENTS IN SOLID-STATING (SSP)	50
3.3	ELIMINATION OF SOLID-STATING (SSP)	51
3.3.1	Inventa-Fischer	51
3.3.2	Zimmer.....	54
3.4	DIRECT TO PREFORM	57
3.4.1	Inventa-Fischer	57
3.4.2	Zimmer.....	57
4	Economics	63
4.1	CONVENTIONAL TECHNOLOGY	63
4.1.1	Melt-Phase PET from PTA.....	63
4.1.2	Solid-State PET from Melt-Phase Chip.....	63
4.2	ELIMINATION OF SOLID-STATING (SSP)	66
4.3	EASTMAN PIPE REACTOR	66
4.4	M&G EASYUP	69
4.5	COST OF PRODUCTION SUMMARY	72
4.6	EASTMAN <i>INTEGREX</i>	73
5	Commercial	75
5.1	UNITED STATES	75
5.1.1	Overview	75
5.1.2	Consumption	76
5.1.3	Supply	76
5.1.4	Supply, Demand and Trade.....	77
5.2	WESTERN EUROPE	78
5.2.1	Overview	78
5.2.2	Consumption	79
5.2.3	Supply	79

5.2.4	Supply, Demand and Trade.....	81
5.3	ASIA PACIFIC.....	83
5.3.1	Overview.....	83
5.3.2	Consumption.....	84
5.3.3	Supply.....	85
5.3.4	Supply, Demand and Trade.....	87
6	Bibliography.....	89
	Appendix	Page
A	Elements of Nexant’s ChemSystems Capital Cost Estimates Process Evaluation/Research Planning, 2005.....	A-1
B	PERP Program Title Index.....	B-1

Figure	Page
1.1 Eastman Pipe Reactor PET Plant.....	9
1.2 PET Bottle Resin Cost of Production Comparison.....	15
1.3 Integrated PET Cost Comparison	17
1.4 United States PET Bottle Grade Supply/Demand and Trade	18
1.5 West European PET Bottle Grade Supply/Demand and Trade	20
1.6 Asia Pacific PET Bottle Grade Supply/Demand and Trade	21
2.1 Esterification of PTA and EG to BIS-HET.....	28
2.2 Polycondensation of BIS-HET	29
2.3 Continuous Solid - State Polymerization.....	32
2.4 Ethylene Glycol Recovery	35
2.5 INVISTA NG3 Esterification of PTA and EG to BIS-HET.....	37
2.6 INVISTA NG3 Pre-polymerization and Particle Formulation.....	38
3.1 U.S. Patent – US 6,504,051 B1.....	44
3.2 Eastman Pipe Reactor PET Plant.....	47
3.3 Eastman Polycondensation Reactor Pipe With Vapor Offtakes	49
3.4 Uhde Inventa-Fischer’s 2R-Technology.....	52
3.5 Uhde Inventa-Fischer Espree Reactor	53
3.6 Zimmer DHI Four Reactor Process Configuration.....	55
3.7 Uhde Inventa-Fischer’s 2R-Technology.....	58
3.8 Uhde Inventa-Fischer from Melt to Preform “MTP”	59
3.9 Zimmer DTP Process.....	60
3.10 Zimmer DTP Process Comparison	61
4.1 M&G vs. Conventional SSP at Higher Single-Line Capacity (480 KTA)	71
4.2 PET Bottle Resin Cost of Production Comparison.....	72
4.3 Integrated PET Cost Comparison	74
5.1 United States PET Bottle Grade Supply/Demand and Trade	78
5.2 West European PET Bottle Grade Supply/Demand and Trade	83
5.3 Asia Pacific PET Bottle Grade Consumption, 2005, Estimate.....	84
5.4 Asia Pacific PET Bottle Grade Supply/Demand and Trade	88

Table	Page
1.1 Comparison of Conventional and EasyUp SSP	11
1.2 Capital Cost Comparison	13
1.3 PET Bottle Resin Cost of Production Summary	15
2.1 Typical Purified Terephthalic Acid Product Characteristics	22
2.2 Typical Properties of Fiber-Grade Ethylene Glycol	23
2.3 Melt-Phase Technology Configurations	30
2.4 Solid-State Technology Configurations.....	33
3.1 Comparison of Conventional and EasyUp SSP	50
3.2 Capital Cost Comparison	56
3.3 Raw Material Consumption Comparison.....	57
3.4 Uhde Inventa-Fischer Preform Comparison	58
4.1 Cost of Production Estimate for: PET Melt Phase Chip w/Comonomer Process: Conventional.....	64
4.2 Cost of Production Estimate for: PET Bottle Chip Resin Process: Continuous Solid-State	65
4.3 Cost of Production Estimate for: PET Bottle Chip Resin Process: Zimmer DHI (no SSP).....	67
4.4 Cost of Production Estimate for: PET Bottle Chip Resin Process: Eastman Pipe Reactor	68
4.5 Cost of Production Estimate for: PET Bottle Chip Resin Process: M&G EasyUp SSP	70
4.6 M&G vs. Conventional SSP at Higher Single-Line Capacity (480 KTA)	71
4.7 PET Bottle Resin Cost of Production Summary	72
5.1 United States PET Bottle Grade Consumption	76
5.2 Capacities for PET Bottle Grade in the United States	77
5.3 United States PET Bottle Grade Supply/Demand and Trade	77
5.4 West European PET Bottle Grade Consumption.....	79
5.5 Capacities for PET Bottle Grade in Western Europe.....	81
5.6 West European PET Bottle Grade Supply/Demand and Trade	82
5.7 Asia Pacific Capacities for PET Bottle Grade	85-87
5.8 Asia Pacific PET Bottle Grade Supply/Demand and Trade	87