

Urea

Table of Contents

A Report by NexantThinking™

Process Evaluation/Research Planning (PERP) Program

PERP Report 2014-7 – Published December 2014

www.nexantthinking.com

Section	Page
1 Executive Summary	1
1.1 INTRODUCTION	1
1.2 CHEMISTRY	2
1.3 TECHNOLOGY	4
1.3.1 Introduction.....	4
1.3.2 Technology Holders	5
1.3.3 Strategic and Business Considerations	6
1.3.4 Casale	6
1.3.5 Snamprogetti	7
1.3.6 Stamicarbon	7
1.3.7 Toyo Engineering Corporation	8
1.3.8 Uhde Fertilizer Technology	8
1.4 PRODUCTION COST ESTIMATES.....	9
1.5 END USE ANALYSIS	12
1.6 REGIONAL MARKET ANALYSIS	12
1.6.1 Global	12
2 Introduction.....	16
2.1 VALUE CHAIN	17
2.2 TECHNOLOGY OVERVIEW.....	18
2.2.1 Process Chemistry	18
2.2.2 Materials of Construction	20
2.3 TECHNOLOGY DEVELOPMENTS	20
2.4 TECHNOLOGY HOLDERS AND LICENSING STATUS	20
2.5 STRATEGIC AND BUSINESS CONSIDERATIONS	21
2.6 PHYSICAL AND THERMODYNAMIC PROPERTIES	21
2.7 SPECIFICATIONS	22
2.8 HEALTH HAZARD	22
2.9 STORAGE AND TRANSPORTATION.....	23
3 Commercial Technologies	24
3.1 INTRODUCTION	24

3.2	CASALE SA	25
3.2.1	Background	25
3.2.2	Split Flow Loop™ Urea Synthesis Process	25
3.2.3	Finishing	29
3.3	SNAMPROGETTI.....	30
3.3.1	Background	30
3.3.2	Snamprogetti™ Urea Technology	30
3.3.3	Revamp	33
3.3.4	Snamprogetti Operating Performance	35
3.4	STAMICARBON	36
3.4.1	Background	36
3.4.2	Stamicarbon Urea 2000plus™ Pool Condenser Concept.....	36
3.4.3	Stamicarbon Urea 2000plus™ Pool Reactor Concept.....	38
3.4.4	Avancore®	38
3.4.5	Mega Plant Concept.....	40
3.4.6	Low-Pressure Recirculation and Evaporation.....	41
3.4.7	Finishing	41
3.4.8	Waste-Water Treatment.....	43
3.4.9	Revamp	43
3.4.10	Stamicarbon Operating Performance.....	46
3.5	TOYO ENGINEERING CORPORATION	47
3.5.1	Background	47
3.5.2	ACES21® Urea Synthesis Technology.....	47
3.5.3	Finishing	53
3.5.4	TEC Operating Performance.....	56
3.6	UHDE FERTILIZER TECHNOLOGY	57
3.6.1	Background	57
3.6.2	Technical Features of the UFT Urea Fluid Bed Granulation Process.....	57
3.6.3	Products Characteristics	58
3.6.4	Performance Data	58
3.6.5	Application	59
3.6.6	UFT Plant Concepts	59
3.6.7	Process Description	61
3.6.8	Emission	63
3.6.9	Advanced Scrubber Technology	65
4	Developing Technologies	69
4.1	INTRODUCTION	69
4.2	SELECTED RECENT PATENTS.....	69
4.3	STAMICARBON 5XX PROCESS	74
5	Process Economics	75
5.1	COSTING BASIS	75
5.1.1	Investment Basis	75

	5.1.2 Pricing Basis.....	75
	5.1.3 Cost of Production Basis	76
5.2	COST OF PRODUCING AMMONIA VIA CONVENTIONAL REFORMING OF NATURAL GAS	77
	5.2.1 United States Gulf Coast.....	77
	5.2.2 North Western Europe.....	77
	5.2.3 Middle East.....	77
	5.2.4 China	77
5.3	COST OF PRODUCING PRILLED UREA VIA AN AMMONIA STRIPPING PROCESS.....	82
	5.3.1 United States Gulf Coast.....	82
	5.3.2 North Western Europe.....	82
	5.3.3 Middle East.....	82
	5.3.4 China	82
	5.3.5 Comparative Economics for Urea Prilling Processes	82
5.4	COST OF PRODUCING GRANULATED UREA VIA AN AMMONIA STRIPPING PROCESS.....	88
	5.4.1 United States Gulf Coast.....	88
	5.4.2 North Western Europe.....	88
	5.4.3 Middle East.....	88
	5.4.4 China	88
	5.4.5 Comparative Economics for Urea Granulation Processes.....	93
5.5	COMPARATIVE ECONOMICS.....	94
5.6	SENSITIVITY ANALYSIS.....	99
6	Commercial Applications	101
6.1	MARKET APPLICATIONS	101
	6.1.1 Fertilizer.....	101
	6.1.2 Industrial Uses.....	103
7	Regional Market Analysis.....	107
7.1	INTRODUCTION.....	107
7.2	DEMAND	107
7.3	SUPPLY	108
7.4	SUPPLY/DEMAND BALANCE.....	112
7.5	NET TRADE	113
8	Glossary	116
9	References	119
Appendix		
A	Definitions of Capital Cost Terms Used in Process Economics.....	A-1
B	Definitions of Operating Cost Terms Used in Process Economics	B-1
C	PERP Program Title Index (2005 – 2014).....	C-1

Figure	Page
1.1 Urea Yield as a Function of NH ₃ /CO ₂ Ratio	3
1.2 Conversion of Carbon Dioxide to Urea at Different Temperatures	3
1.3 Summary of Urea via a Prilling Process.....	10
1.4 Summary of Urea via a Granulation Process.....	11
1.5 Urea Value Chain	12
1.6 Global Urea Consumption by Region.....	13
1.7 Global Urea Capacity by Region.....	14
1.8 Global Urea Supply/Demand.....	15
2.1 Value Chain of Main Ammonia and Urea Derived Fertilizers.....	17
2.2 Urea Value Chain	18
2.3 Urea Yield as a Function of NH ₃ /CO ₂ Ratio	19
2.4 Conversion of Carbon Dioxide to Urea at Different Temperatures	19
3.1 Casale Split Flow Loop™ Process	27
3.2 Casale-Dente High-Efficiency Trays	28
3.3 Casale High-Efficiency Hydrolyzer	29
3.4 Snamprogetti Ammonia Stripping Process for Urea	32
3.5 Snamprogetti Revamped Conventional Total Recycle Plant	34
3.6 Stamicarbon Urea 2000plus™ Pool Reactor	39
3.7 Stamicarbon Film Sprayer.....	41
3.8 Stamicarbon Pool Condenser Concept Process.....	45
3.9 Vertical Submerged Carbamate Condenser	48
3.10 Unique Heat Integration Concept.....	48
3.11 ACES 21® Process Flow Diagram.....	50
3.12 Toyo ACES 21® Synthesis Reaction.....	51
3.13 TEC Spout-Fluid Bed Urea Granulation Process.....	54
3.14 TEC Spout-Fluid Bed Granulator	55
3.15 TEC Dust Scrubber	55
3.16 UFT Basic Urea Granulation Concept for Large Plant Capacities Larger than 2 500 Tons per Day.....	60
3.17 UFT 'Small-Scale' Concept for a Fluid Bed Urea Granulation Plant Located in a Cool Climatic Region	62
3.18 UFT's Proprietary Ammonia Convert Technology.....	65
3.19 Schematic of Horizontal Cross-Flow Scrubbing System as Used in UFT Plants	67
3.20 Schematic of a Horizontal Cross-Floé Scrubber with an Added AEROSEP® Stage	68

4.1	Block Flow Diagram for the Production of Urea (WO 2013/165245 A1).....	71
4.2	High Pressure Section (U.S. 8 721 975 B2).....	72
4.3	Urea Synthesis Reactor	73
5.1	Summary of Urea via a Prilling Process.....	87
5.2	Summary of Urea via a Granulation Process.....	93
5.3	Summary of Urea Costs – USGC	95
5.4	Summary of Urea Costs – North-Western Europe.....	96
5.5	Summary of Urea Costs – Middle East	97
5.6	Summary of Urea Costs – China	98
5.7	USGC Ammonia Market Price.....	99
5.8	Sensitivity of Urea Production Cost to Feedstock Price.....	100
7.1	Melamine End-Use Applications	104
7.1	Global Urea Consumption by Region.....	107
7.2	Global Urea Consumption by Region.....	108
7.3	Global Urea Capacity by Region	109
7.4	Global Top 10 Urea Producers	112
7.5	Global Urea Supply/Demand.....	113
7.6	Global Urea Net Trade	114
7.7	Urea Net Trade Flow Pattern	115

Table	Page
1.1 Urea Synthesis and Finishing Technology Licensors	6
1.2 Strategic/Business Considerations	6
1.3 Summary of Urea via a Prilling Process.....	9
1.4 Summary of Urea via a Granulation Process.....	10
2.1 Urea Synthesis and Finishing Technology Licensors	21
2.2 Strategic/Business Considerations	21
2.3 Key Physical and Thermodynamic Properties	22
2.4 Sale Specifications for Urea	22
3.1 Casale Split Flow™ Urea Process Performance.....	28
3.2 Casale Vortex® Granulator Performance Data.....	30
3.3 Snamprogetti Urea Performance Data.....	35
3.4 Stamicarbon Revamping Concepts.....	43
3.5 Stamicarbon Urea Performance Data	46
3.6 TEC Typical Urea Granule Quality	56
3.7 TEC Typical Urea Granule Quality	56
3.8 Selected UFT References	57
3.9 UFT Typical Specifications.....	58
3.10 UFT Performance Data	59
3.11 Emission Sources in a Fluid Bed Urea Granulation Plant.....	66
5.1 Prices of Raw Materials, Products, Utilities, and Labor	76
5.2 Cost of Production Estimate for: Ammonia Process: Conventional Natural Gas Reforming; USGC Basis	78
5.3 Cost of Production Estimate for: Ammonia Process: Conventional Natural Gas Reforming; North Western Europe Basis	79
5.4 Cost of Production Estimate for: Ammonia Process: Conventional Natural Gas Reforming; Middle East Basis.....	80
5.5 Cost of Production Estimate for: Ammonia Process: Conventional Natural Gas Reforming; China Basis	81
5.6 Cost of Production Estimate for: Prilled Urea Process: Ammonia Stripping; USGC Basis.....	83
5.7 Cost of Production Estimate for: Prilled Urea Process: Ammonia Stripping; North Western Europe Basis	84
5.8 Cost of Production Estimate for: Prilled Urea Process: Ammonia Stripping; Middle East Basis	85
5.9 Cost of Production Estimate for: Prilled Urea Process: Ammonia Stripping; China Basis.....	86

5.10	Summary of Urea via a Prilling Process.....	87
5.11	Cost of Production Estimate for: Granulated Urea Process: Ammonia Stripping; USGC Basis.....	89
5.12	Cost of Production Estimate for: Granulated Urea Process: Ammonia Stripping; North Western Europe Basis	90
5.13	Cost of Production Estimate for: Granulated Urea Process: Ammonia Stripping; Middle East Basis	91
5.14	Cost of Production Estimate for: Granulated Urea Process: Ammonia Stripping; China Basis.....	92
5.15	Summary of Urea via a Granulation Process.....	93
5.16	Summary of Urea Process Economics – USGC	94
5.17	Summary of Urea Process Economics – North-Western Europe	95
5.18	Summary of Urea Process Economics – Middle East	96
5.19	Summary of Urea Process Economics – China	97
7.1	Global Urea Capacity Additions (Excluding China).....	110
7.2	Chinese Urea Capacity Additions	111

Nexant Thinking™ PERP PROGRAM



www.nexantthinking.com

The NexantThinking™ Process Evaluation/Research Planning (PERP) program is recognized globally as the industry standard source for information relevant to the chemical process and refining industries. PERP reports are available as a subscription program or on a single report basis.

Contact Details:

New York: Marcos Nogueira Cesar, Vice President, Global Products, E&CA: Nexant Thinking™
Phone: + 1-914-609-0324, e-mail: mcesar@nexant.com

New York: Heidi Junker Coleman, Global Programs Support Manager
Phone: + 1-914-609-0381, e-mail: hcoleman@nexant.com

Nexant, Inc. (www.nexant.com) is a leading management consultancy to the global energy, chemical, and related industries. For over 38 years, Nexant has helped clients increase business value through assistance in all aspects of business strategy, including business intelligence, project feasibility and implementation, operational improvement, portfolio planning, and growth through M&A activities. Nexant has its main offices in San Francisco (California), White Plains (New York), and London (UK), and satellite offices worldwide.

Copyright © by Nexant Inc. 2014. All Rights Reserved.