

TECHNOLOGY & COSTS**Technoeconomics - Energy & Chemicals (TECH)****TECH 2019-7 Urea**

Table of Contents

A Report by **Nexant, Inc.**

Published Date: December 2019

www.nexantsubscriptions.com**Contents**

1	Executive Summary	1
1.1	Overview.....	1
1.2	Urea Technology Licensors.....	2
1.3	Strategic and Business Considerations	2
1.4	Economic Analysis	3
1.5	Market Analysis	6
1.5.1	Commercial Applications.....	6
1.5.2	Supply and Demand Analysis	6
2	Introduction.....	8
2.1	Overview.....	8
2.2	Value Chain.....	10
2.3	Technology Overview.....	11
2.3.1	Process Chemistry	11
2.3.2	Materials of Construction	13
2.4	Technology Developments.....	13
2.5	Technology Holders and Licensing Status.....	14
2.6	Strategic and Business Considerations	14
2.7	Physical and Thermodynamic Properties.....	15
2.8	Specifications	15
2.9	Health Hazard	16
2.10	Storage and Transportation	16
3	Commercial Technologies.....	17
3.1	Introduction.....	17
3.2	Casale	19
3.2.1	Background	19
3.2.2	Split Flow Loop™ Urea Synthesis Technology	19
3.2.3	Finishing	24
3.2.4	Operating Performance	26
3.3	Saipem	27

3.3.2	Snamprogetti™ Urea Technology	27
3.3.3	Revamp	31
3.3.4	Operating Performance	35
3.4	Stamicarbon	35
3.4.1	Background	35
3.4.2	Launch Melt™ Flash Design	36
3.4.3	Launch Melt™ Ultra Low Energy Design	39
3.4.4	Pool Condenser Design	41
3.4.5	Pool Reactor Design	42
3.4.6	Finishing	42
3.4.7	Operating Performance	48
3.5	TOYO Engineering Corporation	49
3.5.1	Background	49
3.5.2	ACES21® Urea Synthesis Technology.....	49
3.5.3	Finishing	54
3.5.4	Operating Performance	57
3.6	Thyssenkrupp Industrial Solutions	58
3.6.1	Background	58
3.6.2	UFT® Fluid Bed Granulation Technology	58
3.6.3	Application.....	59
3.6.4	tkFT Plant Concepts.....	59
3.6.5	Process Description	63
3.6.6	Emission	63
3.6.7	tkFT's Formaldehyde Free Additive UFT®Add.....	68
3.6.8	Sulfur Enhanced Urea Granules	68
3.6.9	Operating Performance	69
4	Developing Technologies	71
4.1	Introduction.....	71
4.2	Selected Recent Patents.....	71
5	Process Economics	77
5.1	Costing Basis	77
5.1.1	Investment Basis	77
5.1.2	Pricing Basis.....	77
5.1.3	Cost of Production Basis	79
5.2	Production Cost Estimates	80
5.2.1	Cost of Producing Prilled Urea via an Ammonia Stripping Process	80
5.2.2	Cost of Producing Prilled Urea via an Ammonia Stripping Process – Integrated Complex	85
5.2.3	Cost of Producing Granulated Urea via an Ammonia Stripping Process.....	90
5.2.4	Cost of Producing Granulated Urea via an Ammonia Stripping Process – Integrated Complex	95
5.3	Comparison of Commercial Processes to Produce Urea	100
5.4	Sensitivity Analysis.....	104

5.4.1	Sensitivity to Feed Pricing	104
5.4.2	Sensitivity to Economy of Scale	106
5.4.3	Sensitivity to Capital Investment	107
5.4.4	Historical Analysis of Urea Cash Cost of Production	107
6	Commercial Applications	110
6.1	Fertilizer	110
6.1.1	Direct Application Fertilizer (for Food)	110
6.1.2	Urea Ammonium Nitrate Solution (UAN)	111
6.1.3	Fertilizer for Biofuels	111
6.2	Industrial	111
6.2.1	Melamine	111
6.2.2	Resins	112
6.2.3	Diesel Exhaust Fluid	113
6.2.4	Pharmaceutical	113
6.2.5	Other	113
7	Regional Markets	115
7.1	Global	115
7.1.1	Consumption	115
7.1.2	Supply	116
7.1.3	Supply, Demand, and Trade	116
7.2	North America	118
7.2.1	Consumption	118
7.2.2	Supply	119
7.2.3	Supply, Demand, and Trade	121
7.3	South America	122
7.3.1	Consumption	122
7.3.2	Supply	123
7.3.3	Supply, Demand, and Trade	124
7.4	Asia Pacific	125
7.4.1	Consumption	125
7.4.2	Supply	127
7.4.3	Supply, Demand, and Trade	134
8	Glossary	136
Appendices		
A	Definitions of Capital Cost Terms Used in Process Economics	140
B	Definitions of Operating Cost Terms Used in Process Economics	145
C	TECH Program Title Index (2009-2019)	148
D	References	151

Figures

Figure 1	Urea Licensor Market Share - 2018	2
Figure 2	U.S. Gulf Coast Summary of Urea Production Costs.....	4
Figure 3	China Summary of Urea Production Costs	4
Figure 4	India Summary of Urea Production Costs	5
Figure 5	Global Urea Demand by Application, 2018-e	6
Figure 6	Global Urea Supply, Demand, and Trade	7
Figure 7	Value Chain of Main Ammonia and Urea Derived Fertilizers	10
Figure 8	Urea Value Chain	10
Figure 9	Urea Yield as a Function of NH_3/CO_2 Ratio	11
Figure 10	Conversion of Carbon Dioxide to Urea at Different Temperatures	12
Figure 11	Urea Licensor Market Share - 2018	18
Figure 12	Casale Split Flow Loop™ Process	21
Figure 13	Casale-Dente High-Efficiency Trays.....	22
Figure 14	Casale High-Efficiency Hydrolyzer	23
Figure 15	Casale Vortex® Granulation Process.....	25
Figure 16	Casale Vortex® Granulator	26
Figure 17	Snamprogetti™ Ammonia Stripping Process for Urea.....	29
Figure 18	Snamprogetti Revamped Conventional Total Recycle Plant	32
Figure 19	Modelling of Urea Reactor SuperCups.....	33
Figure 20	Fluid-Dynamic Effects of SuperCups Trays	33
Figure 21	SuperCups Mixer Tray.....	34
Figure 22	Tuttle Prilling Buckets	34
Figure 23	Stamicarbon Pool Condenser Concept with Flash Design	38
Figure 24	Stamicarbon Pool Reactor Concept with Ultra Low Energy	40
Figure 25	Stamicarbon Film Sprayer	43
Figure 26	Stamicarbon Fluid-Bed Granulation Technology.....	44
Figure 27	TOYO ACES 21® Process Flow Diagram.....	51
Figure 28	TOYO ACES 21® Synthesis Reaction	52
Figure 29	Vertical Submerged Carbamate Condenser	53
Figure 30	TOYO Spout Fluid Bed Urea Granulation Process	55
Figure 31	TOYO Spout Fluid Bed Granulator	56
Figure 32	TOYO Dust Scrubber	57
Figure 33	UFT® Basic Urea Granulation Concept for Capacities Larger than 3 000 Tons per Day.....	61
Figure 34	UFT® 'Small-Scale' Concept for a Fluid Bed Urea Granulation Plant Located in a Cool Climatic Region	62
Figure 35	Schematic of Horizontal Cross-Flow Scrubbing System as Used in UFT® Plants	65
Figure 36	Schematic of a Horizontal Cross-Flow Scrubber with an Added AEROSEP® Stage	66
Figure 37	tkFT's Proprietary Ammonia Convert Technology.....	68
Figure 38	tkFT's Urea-ES Technology	69
Figure 39	Block Flow Diagram for the Production of Urea	72
Figure 40	Urea Synthesis Reactor Designs.....	74

Figure 41	Urea Synthesis Method	76
Figure 42	Summary of Prilled Urea Production Costs	84
Figure 43	Summary of Integrated Ammonia-Prilled Urea Production Costs	89
Figure 44	Summary of Granulated Urea Production Costs	94
Figure 45	Summary of Integrated Ammonia-Granulated Urea Production Costs	99
Figure 46	Summary of Urea Production Costs	100
Figure 47	U.S. Gulf Coast Summary of Urea Production Costs	101
Figure 48	China Summary of Urea Production Costs	102
Figure 49	India Summary of Urea Production Costs	103
Figure 50	Regional Ammonia Market Prices	105
Figure 51	Sensitivity of Urea Costs of Production to Feed Price	105
Figure 52	Sensitivity of Urea Costs of Production to Economy of Scale	106
Figure 53	Sensitivity of Urea Costs of Production to Capital Investment	107
Figure 54	Historical Urea Production Cash Costs - United States	108
Figure 55	Historical Urea Production Cash Costs - United States and China	109
Figure 56	Global Urea Demand by Application, 2018-e	110
Figure 57	Global Urea Demand, 2018-e	115
Figure 58	Global Urea Supply, Demand, and Trade	117
Figure 59	North America Urea Demand by Application, 2018-e	118
Figure 60	North America Urea Supply, Demand, and Trade	121
Figure 61	South America Urea Demand by Application, 2018-e	122
Figure 62	South America Urea Supply, Demand, and Trade	124
Figure 63	Asia Pacific Urea Demand by Application, 2018-e	125
Figure 64	China Urea Demand, 2018-e	126
Figure 65	Asia Pacific Urea Supply, Demand, and Trade	134
Figure 66	China Urea Supply, Demand, and Trade	135

Tables

Table 1	Strategic/Business Considerations	3
Table 2	Urea Synthesis and Finishing Technology Licensors.....	14
Table 3	Strategic/Business Considerations	15
Table 4	Key Physical and Thermodynamic Properties.....	15
Table 5	Sale Specifications for Urea	16
Table 6	Casale Urea Performance Data	26
Table 7	Casale Typical Urea Specifications	27
Table 8	Saipem Urea Performance Data	35
Table 9	Saipem Typical Urea Specifications	35
Table 10	Stamicarbon Revamping Concepts	46
Table 11	Stamicarbon Urea Performance Data	48
Table 12	Stamicarbon Typical Urea Specifications.....	48
Table 13	TOYO Urea Performance Data	57
Table 14	TOYO Typical Urea Specifications	58
Table 15	Emission Sources in a Fluid Bed Urea Granulation Plant.....	64
Table 16	tkFT Urea Performance Data	70
Table 17	tkFT Typical Urea Specifications	70
Table 18	Prices of Raw Materials, Products, Utilities, and Labor.....	78
Table 19	Cost of Production Estimate for: Prilled Urea Process: Ammonia Stripping; USGC Basis	81
Table 20	Cost of Production Estimate for: Prilled Urea Process: Ammonia Stripping; China Basis	82
Table 21	Cost of Production Estimate for: Prilled Urea Process: Ammonia Stripping; India Basis	83
Table 22	Summary of Prilled Urea Production Costs	84
Table 23	Cost of Production Estimate for: Prilled Urea Process: Ammonia Stripping Integrated Complex; USGC Basis	86
Table 24	Cost of Production Estimate for: Prilled Urea Process: Ammonia Stripping Integrated Complex; China Basis	87
Table 25	Cost of Production Estimate for: Prilled Urea Process: Ammonia Stripping Integrated Complex; India Basis	88
Table 26	Summary of Integrated Ammonia-Prilled Urea Production Costs	89
Table 27	Cost of Production Estimate for: Granulated Urea Process: Ammonia Stripping; USGC Basis	91
Table 28	Cost of Production Estimate for: Granulated Urea Process: Ammonia Stripping; China Basis	92
Table 29	Cost of Production Estimate for: Granulated Urea Process: Ammonia Stripping; India Basis	93
Table 30	Summary of Granulated Urea Production Costs	94
Table 31	Cost of Production Estimate for: Granulated Urea Process: Ammonia Stripping Integrated Complex; USGC Basis	96

Table 32	Cost of Production Estimate for: Granulated Urea Process: Ammonia Stripping Integrated Complex; China Basis	97
Table 33	Cost of Production Estimate for: Granulated Urea Process: Ammonia Stripping Integrated Complex; India Basis	98
Table 34	Summary of Integrated Ammonia-Granulated Urea Production Costs	99
Table 35	Summary of Urea Production Costs	100
Table 36	U.S. Gulf Coast Summary of Urea Production Costs	101
Table 37	China Summary of Urea Production Costs	102
Table 38	India Summary of Urea Production Costs	103
Table 39	Global Urea Demand, 2018-e	116
Table 40	Global Urea Supply, Demand, and Trade	117
Table 41	North America Urea Demand, 2018-e	118
Table 42	North America Urea Capacity, 2018	120
Table 43	North America Urea Supply, Demand, and Trade	121
Table 44	South America Urea Demand, 2018-e	122
Table 45	South America Urea Capacity, 2018	123
Table 46	South America Urea Supply, Demand, and Trade	124
Table 47	Asia Pacific Urea Demand, 2018-e	125
Table 48	China Urea Demand, 2018-e	126
Table 49	Asia Pacific Urea Capacity, 2018	127
Table 50	Asia Pacific Urea Supply, Demand, and Trade	134
Table 51	China Urea Supply, Demand, and Trade	135

Nexant Inc.

TECHNOLOGY & COSTS

Technoeconomics - Energy & Chemicals (TECH)

The Nexant Subscriptions' Technoeconomics - Energy & Chemicals (TECH) program is recognized globally as the industry standard source for information relevant to the chemical process and refining industries. Technoeconomics - Energy & Chemicals (TECH) reports are available as a subscription program or on a single report basis.

Contact Details:

Americas:

Marcos Nogueira Cesar, Vice President, Global Products, E&CA: Nexant Subscriptions

Phone: + 1-914-609-0324, e-mail: mcesar@nexant.com

Erica Hill, Client Services Coordinator, E&CA-Products

Phone: + 1-914-609-0386, e-mail: ehill@nexant.com

EMEA:

Anna Ibbotson, Director, Nexant Subscriptions

Phone: +44-207-950-1528, aibbotson@nexant.com

Asia:

Chommanad Thammanayakatip, Managing Consultant, Energy & Chemicals Advisory

Phone: +66-2793-4606, email: chommanadt@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. 2018. All Rights Reserved.