OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

15108

Distr.
LIMITED

ID/WG.453/3
4 November 1985

ENGLISH

United Nations Industrial Development Organization

Round-Table Discussions on the Development of Phosphates and Phosphate Fertilizer Industry in Developing Countries

Gafsa, Tunisia, 18 - 22 November 1985

PRODUCTION COST COMPARISON BETWEEN NITROPHOSPHATE AND PHOSPHORIC ACID BASED FERTILIZERS*

Prepared by

Marcel A. Tanke**

* The views expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

** Dep.Sales Manager, Nitrophosphates, Stamicarbon BV, the Netherlands

V.85-32858

Table of Contents

Summary

Stamicarbon has developed an improved variant of the nitrophosphate process with $Ca(NO_3)_2$ crystallization.
A production cost comparion between this nitrophosphate- and phosphosphoric acid-based 28:14:0 and 22.5:22.5:0 fertilizers, shows that the nitrophosphate based products have a cost advantage of about $ 100 per mton of P_2O_5 produced.

1. INTRODUCTION

1.1. STAMICARBON

Stamicarbon bv was established by DSM in 1947 fcr the purpose of commercializing proprietary processes developed by DSM, granting licences for these processes and providing services to customers.
The DSM process know-how is covered by some 7300 patents and patent applications and most of it is available for licencing. The know-how relates to single nutrient and compound fertilizers, urea, caprolactam, fenol and melamine, polymers and rubbers, mineral beneficiation, training and management consultancy and computer software.

The fertilizer know-how offered by Stamicarbon covers almost the full range of fertilizers. Most of the know-how is used in DSM's fertilizer division. DSM is one of the largest fertilizer producers in the world. Its eight production sites in Europe and the United States have a combined annual capacity of about 6.5 million mtons of fertilizer.
More than 300 urea, nitric acid, ammonium nitrate, superphosphate and compound fertilizer plants have been built all over the world on the basis of Stamicarbon know-how.

1.2. NITROPHOSPHATES

A nitrophosphate process may be defined as a process that calls for whole or partial treatment of phosphate rock with nitric acid. A principal advantage of nitrophosphate processes over sulphuric/phosphoric acid-based processes is that nitric acid is used for the dual purpose of (1) converting phosphate rock into soluble P_2O_5 and (2) furnishing nutrient nitrogen to the product.
Unlike phosphoric acid-based fertilizers, which require about 1 mton of sulphur per mton of P_2O_5, nitrophosphates do not require H_2SO_4 and are therefor independent of the sulphur market. In a period of soaring sulphur prices (which are expected to remain high for years to come (Figure 1)), various countries and companies are for both economical and political reasons increasingly anxious to become independent of sulphur prices and suppliers.
The development of the first nitrophosphate processes started in Europe (-1-) some 70 years ago.
Since then, a variety of processes have emerged (-2-). Most of them have in common that calcium has to be removed from the process, usually as $Ca(NO_3)_2$ or as $CaSO_4$.
Adapting to the changing requirements with respect to energy consumption, environmental protection, and quality of raw material (phosphate rock) supplies, Stamicarbon has developed an improved nitrophosphate process (-3,4-) based on the crystallization of calcium nitrate. This new process has been used for the cost comparisons described in the next chapters.

2. THE PRICE OF PHOSPHORIC ACID

As in all calculations, the results of variable cost calculations depend on the data-input used. In fertilizer cost evaluations the price of phosphoric acid often is the subject of discussion.

The variable cost of phosphoric acid is mainly determined by the costs of phosphate rock and sulphur. Sulphur prices (F.O.B.) have increased in the past decade (Figure 1) from US $ 75 to more than US $ 125 per ton.
Although in the long run phosphoric acid prices will surely follow the sulphur prices, as shown in Figure 2, a strange phenomenon can be observed. According to the cost calculations of the Stanford Research Institute (SRI Int. PEP Yearbook 1984), the production cost of phosphoric acid (at 100 % capacity realisation) and at $ 125 per ton sulphur, is about $ 390 per ton of P_2O_5.
Despite the increasing sulphur prices, the F.O.B. market prices of P_2O_5 have decreased to about $ 290 per ton.
It would seem that there is no short term relation between sulphur and phosphoric acid prices at all. The low P_2O_5 prices and costs can only be realized in large, depreciated phosphoric acid facilities, that are usually located at or near the phosphate rock mines and have long term, low price sulphur contracts.

This unnatural market situation cannot last very long and certainly should not be the basis for a long term strategy.
Newer facilities, especially if they have to import raw materials, can not afford to sell their acid for such low prices.
For this study a price of US $ 375 per ton of P_2O_5 has been used.

3. PRODUCTION COST COMPARISON

3.1. INTRODUCTION

Many papers have been published on this subject and have given rise to much debate and controversy. With respect to the production economics, almost all papers discuss only the NPK 1-1-1 grade produced from nitrophosphate with calcium nitrate crystallization, and compare this grade with those based on phosphoric acid. NPK grades with higher N/P_2O_5 ratios are usually ignored, although a ratio of 2 would reflect the actual overall nitrogen and phosphate demands in many countries more accurately.
The present evaluation covers the production economics of the products with grade $N:P_2O_5:K_2O$ 28:14:0 and 22.5:22.5:0, produced by the new Stamicarbon nitrophosphate process (Figure 3) in comparison with the phosphoric acid based route.

3.2. ASSUMPTIONS

With the production of 28:14:0, all off the NH_4NO_3 produced in the $Ca(NO_3)_2$ conversion plant is recycled to the nitrophosphate plant, and no additional (Calcium-) Ammonium Nitrate is produced.
The phosphoric acid based products need a filler to produce the required grade. As usually a higher grade will be produced, the cost of filler is not included in the comparison.
During the production of 22.5:22.5:0, a proportion of the NH_4NO_3 solution (80 % concentration) produced is recycled to the NP plant the remainder is concentrated to 99 % and prilled.
The value of the NH_4NO_3 produced is credited (at $ 119/mt NH_4NO_3) to the nitrophosphate process.
The production capacity used in this evaluation is 70,000 mt of P_2O_5/year, or 500,000 mt of 28:14:0 and 311,000 mt of 22.5:22.5:0 per year.

The investment estimates used are:

Production based on:	28:14:0	22.5:22.5:0
Phos. Acid	$ 22×10^6	$ 16×10^6
Nitrophosphate	$ 37×10^6	$ 32.3×10^6
NH_4NO_3, from 80 % solution	-	$ 6×10^6

The variable cost of NH_4NO_3 production is estimated at $ 8/mton. Phosphate rock contains 32 % P_2O_5 and 50 % CaO.

The total annual fixed costs are assumed to be 34 % of investment.

The production of sulphuric and phosphoric acid is not included in this comparison. Phosphoric acid is purchased outside, and CO_2 is available at no cost as a byproduct from ammonia production.

3.3. RESULTS

A summary of the production cost calculations is presented in the Tables 1 and 2.
At the conditions choosen, 2.7 ton of NH_4NO_3 is produced in conjunction with each ton of P_2O_5 as 22.5:22.5:0.
The total production cost of the nitrophosphate-based 28:14:0 product is found to be about $ 110 less than that of the phosphoric acid-based product.
For the 22.5:22.5:0 fertilizers, after crediting for the NH_4NO_3 produced, this difference is about $ 80. In both cases the difference is the balance of the higher fixed and lower variable costs of the nitrophosphate-based production route.
The variable costs of P_2O_5 for the nitrophosphate process are about $ 250 lower than for the phosphoric acid based route.

4. CONCLUSIONS

* The economics of the nitrophosphate process are independent of the sulphur and phosphoric acid prices.

* Nitrophosphate fertilizers are cheaper to produce than phosphoric acid based products.

References

1. M.A. Tanke, 'Nitrophosphates', paper presented at Maintenance and Production Management Course, Oct. 1982. IFDC, Muscle Shoals Al, USA.

2. Fertilizer Manual, Chapter 15, 1979, IFDC Muscle Shoals Al, USA.

3. M.H.G. Jennekens and G.H.M. Calis 'Significant Energy Savings In The ODDA Process', IFA Techn. Conf., Paris France, Nov. 1984.

4. M.A. Tanke, 'The Present Stamicarbon Nitrophosphate Processes', ACS Meeting, Div. of Fertilizer and Soil Chem., Chicago Ill., Sept. 1985.

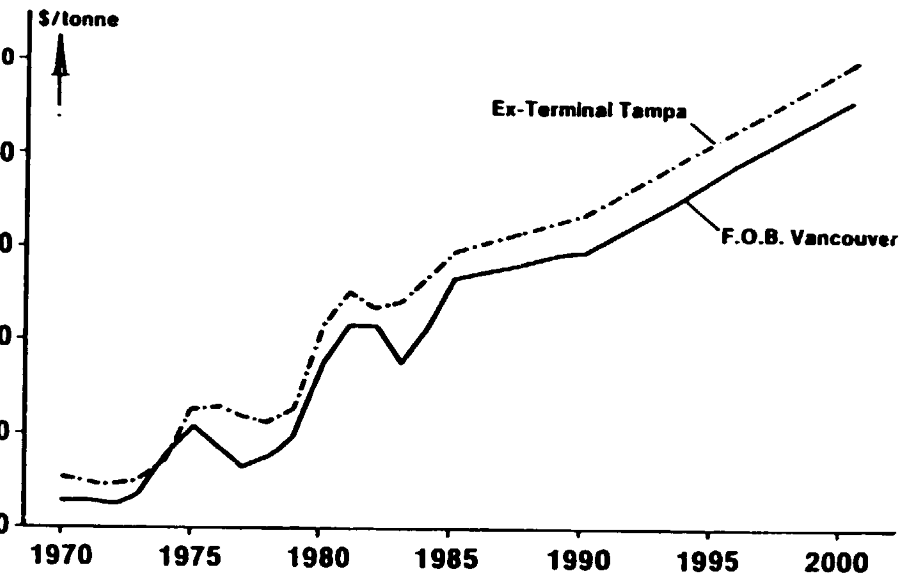
Table 1: Production costs of 28:14:0.

Variable costs/mton of P_2O_5:		Nitrophosphate		Phos. Acid-based	
	Unit price	Quantity	Cost	Quantity	Cost
Phosphoric acid, mton P_2O_5	375	0	0	1.02	382.5
Phosphate rock, mton	40	3.21	128.4	0	0
Nitric acid, mton	75	4.16	312	4.11	308.3
Ammonia, mton	220	1.35	297	1.36	299.2
Steam, mton	12	4.5	54	0.73	8.8
Water, m^3	.04	220	8.8	0	0
Electricity, kWh	.051	385	19.6	220	11.2
Fuel, Gcal	14.7	.9	13.2	.44	6.5
Total variable costs:		US $	833	US $	1016.5
Total fixed costs, 34 % of investment:			179.7 +		106.9 +
Total production costs/mton of P_2O_5:		US $	1012.7	US $	1123.4

Table 2: Production costs of 22.5:22.5:0

Variable costs/mton of P_2O_5:		Nitrophosphate		Phos. Acid-based	
	Unit price	Quantity	Cost	Quantity	Cost
Phosphoric Acid, mton P_2O_5	375	0	0	1.02	382.5
Phosphate rock, mton	40	3.21	128.4	0	0
Nitric acid, mton	75	3.98	298.5	1.81	135.8
Ammonia, mton	220	1.3	286	0.75	165
Steam, mton	12	4.6	55.2	0.63	7.6
Water, m^3	.04	220	8.8	0	0
Electricity, kWh	.051	400	20.4	200	10.2
Fuel, Gcal	14.7	0.7	10.3	0.34	5
NP Plant: Variable costs		US $	807.6	US $	706.1
Fixed costs (34 % of investment)			156.9		77.7
NH_4NO_3 plant: Variable costs			21.4		0
Fixed costs (34 % of investm.)			29.1 +		0 +
Subtotal, prod. costs/mton P_2O_5			1013		783.8
Credit for NH_4NO_3 produced			317.7 -		0 -
Total production costs/mton of P_2O_5:		US $	697.3	US $	783.8

Sulphur price



Source: Proceedings No. 234 of the Fertiliser Society London

Figure 1

Sulphur and Phosporic Acid Prices; 1970-1982

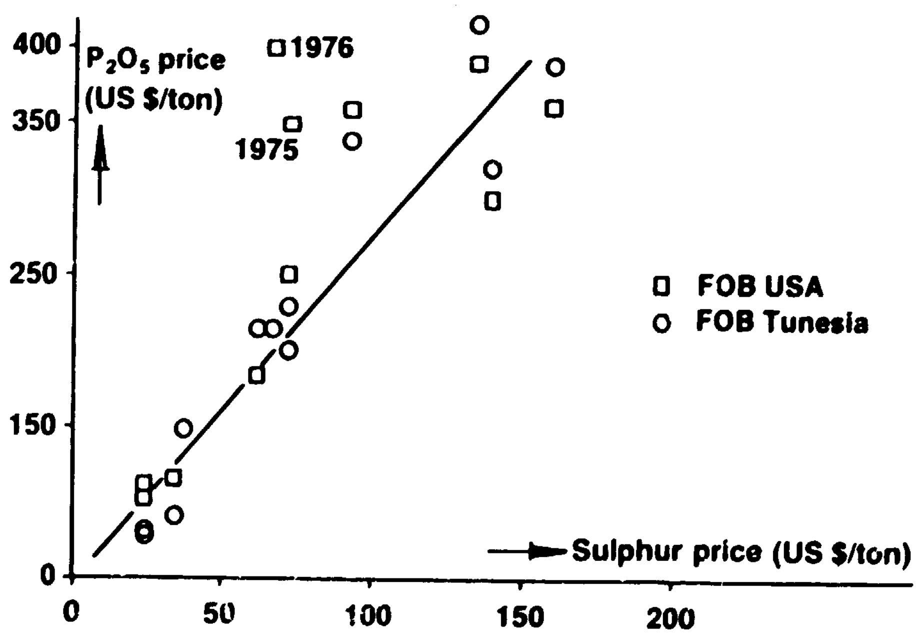


Figure 2

Block diagram of Stamicarbons Nitrophosphate Crystallization Process

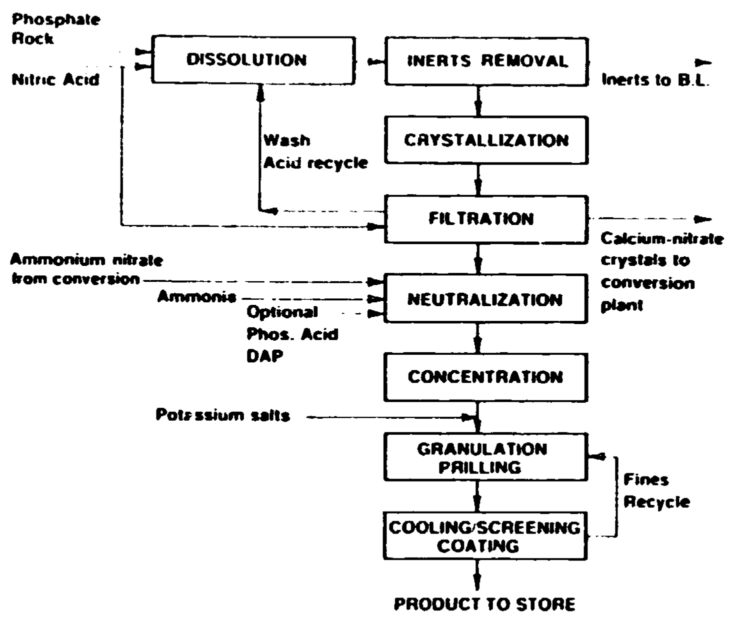


Figure 3