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THE CHEMICO THERMO UREA PROCESS: A FUTURE FORERUNNER^{1/}

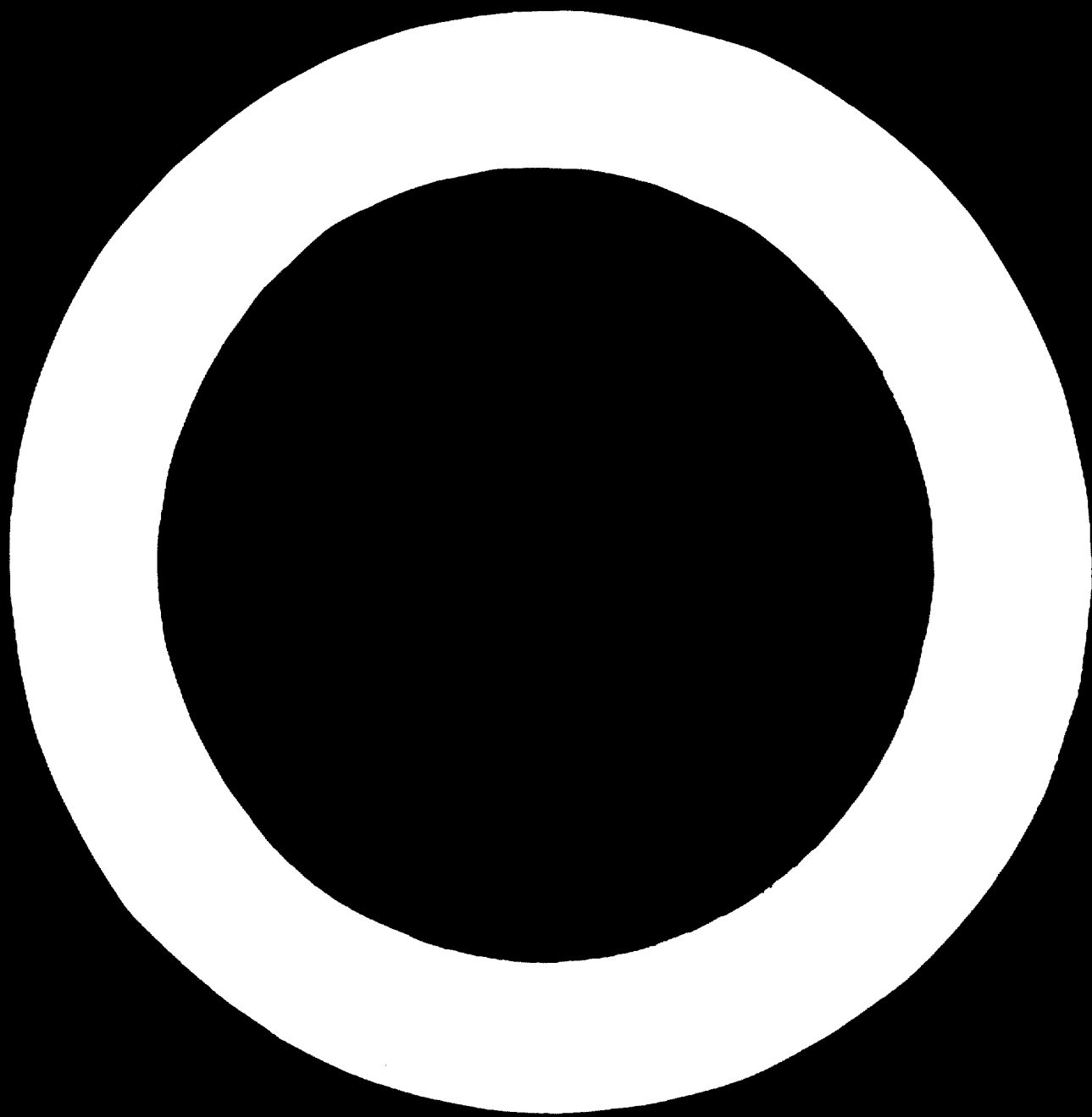
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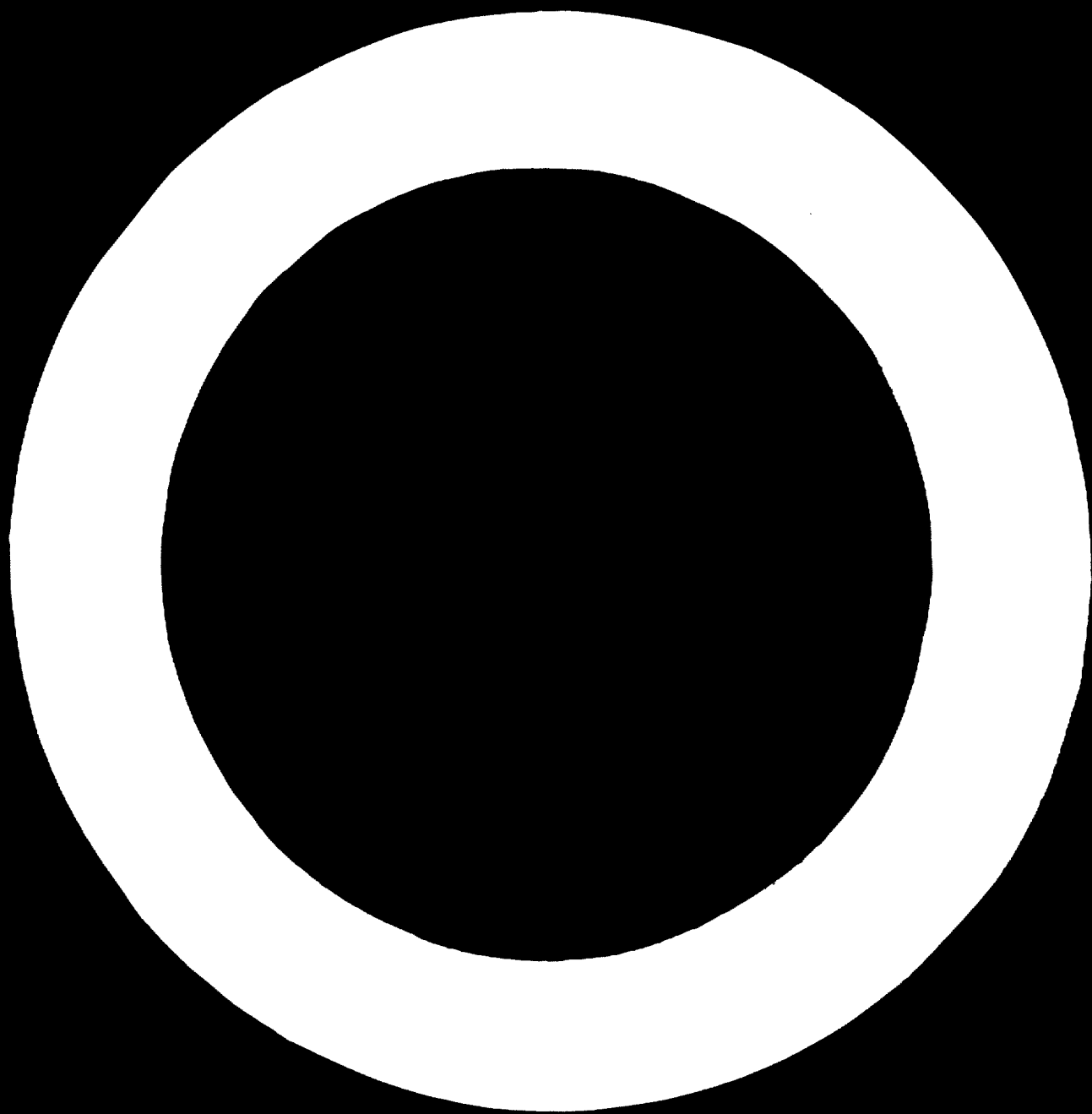
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CHEMICO'S THERMO UREA PROCESS: A FUTURE FORERUNNER

FOREWORD

The urea market is big and will continue to be so; and, any producer who wishes to maintain a strong position in it must be ready to scrap the old "world beating" process he now operates; and, adopt one of the more economical processes which suddenly became available. Back in the thirties and forties he was operating a once-through process; and, used the unreacted ammonia to produce other nitrogen fertilizers. He didn't have to worry very much about the cost of production because he was one of a few supplying resin and glue producers who were willing to pay high prices. The by-product fertilizer, usually ammonium sulfate, was also in big demand. Process "know-how" was scarce; and, this of course held back prospective producers.

The development of recycle urea processes became necessary when the demand for urea started to grow; and, producers could not dispose of the by-product ammonium sulfate which was meeting stiff competition from the sulfate being

produced from waste pickle liquor. Besides, urea was replacing ammonium sulfate in the cultivation of rice and other heavy crops. The first recycle urea processes were developed with no regard for heat recovery as the early literature indicates. They consisted of many unit operations which required steam in some cases; and, cooling water (heat loss) in others. Producers were primarily interested in getting the unreacted raw material back to the urea reactor to avoid the production and marketing of large quantities of by-products. These early recycle processes didn't drastically reduce the price of urea.

Ammonium nitrate also became popular, as did nitrogen solutions; and, this saved many low tonnage once-through urea plants from going out of business. The current practice of using by-product ammonia for the production of nitric acid and ammonium nitrate on an integrated basis has also kept a number of once-through urea plants on stream (1). However, many of these plants do not produce solid urea (prills or crystals) but use the urea solution to prepare nitrogen solutions for direct application or for the production of mixed fertilisers. These plants avoid

stiff competition because they are located near their principal customers.

Prospective urea producers found it difficult to select a process back in the early fifties because process evaluations had to be made on the basis of little or no pilot plant experience. Many of them stayed in production after correcting the problems that were encountered in the operation of the prototype plants. Many reports of these early experiences can be found in the literature. A new generation of recycle urea processes grew out of these experiences because more technical data became available.

The so-called "conventional liquid recycle process" was considered a nightmare in the early fifties. The big scare stemmed from the prospect of pumping a hot corrosive ammonium carbonate solution. However, the economics of production looked very favorable; and, it was predicted that the process would find wide acceptance (2). The Chemico liquid recycle process found favor because the Second Decomposer could

be operated without the need for import steam. (See Ref. 5; page 214). This brought on a flood of new heat recovery schemes which have helped some liquid recycle processes to remain temporarily competitive. Heat recovery operations require additional equipment; and, the increased investment is not justified by the usual small reduction in utility cost.

The D.S.M. CO₂ Stripping Process; SNAM-Progetti NH₃ Stripping Process; and, Chemico Thermo Urea Process are new types of heat recovery processes which were first publicized in 1965. The first named has been adopted for use in a number of large tonnage plants; the second has also been put into commercial operation; and, the third is still in the process evaluation stage. The heat recovery techniques used in these processes were described in the literature (3). The acceptance and application of these new concepts is a sign that "conventional liquid recycle processes" will soon become obsolete. We can be certain that every new process must go through a shake-down stage; but, the "bugs" are ultimately erased in most instances; and, the process becomes well established.

Urea producers are in the best position to bring a new process from conception to commercial application. It is relatively simple to tie a small pilot operation to their existing commercial plants. Independents simply cannot afford to build a pilot plant for every process they wish to sponsor. This is especially true in the case of urea pilot units which must be located adjacent to an ammonia plant which can readily supply both of the raw materials; viz., ammonia and carbon dioxide.

Process innovations don't always come from engineers who are employed by the producers who develop and license processes. The presentation of papers such as this affords licensing producers a means of keeping abreast of new developments which stem from sources outside of their normal sphere of activity in this field.

I. Introduction

1. The first version of the Thermo Urea Process was covered by a patent application which was filed in the USA on December 24, 1962 (4); and, the process was first disclosed to the public in 1965 (5). Continuous process development work led to additional patents (6, 7); and, the present version, which is the subject of this paper, incorporates several new improvements which are covered by supplementary patent applications. Early research work provided the vapor-liquid equilibria which were required for the initial process evaluation. The nominal operating conditions for the present process were determined on the basis of data recently obtained from the operation of a small scale pilot plant (8).

2. The increasing interest which has been shown for this process since its inception has been very rewarding (9, 10, 11); and, has helped to promote further study and development work. The purpose of this paper is to: describe how the present process will operate; point out its salient features; and compare its utility requirements with other processes. This information will show why the Chemico Thermo Urea process has the potential of

becoming a future forerunner.

II. Process Description

(The Process Flow Diagram is shown on Page 29).

3. The gas mixture leaving the High Pressure Recycle Gas Compressor which contains NH_3 , CO_2 , and Water Vapor, is fed to the shell sides of the Low Pressure Steam Generator and the Reactor-1st Decomposer. Make-up liquid NH_3 is also fed to the shell sides, the combined volumes of which serve as the reaction chamber which operates at 175-210 Kg/cm^2 and 190°C-200°C. The reaction operates with 25% to 50% excess NH_3 and a low water to CO_2 mol ratio; and the percentage conversion of CO_2 to Urea is 55% to 60%. The reaction is highly exothermic due to the low NH_3/CO_2 feed mol ratio and high temperature of the High Pressure Recycle Gas.

4. The reaction product streams leaving the shell side bottoms of the L. P. Steam Generator and Reactor-1st Decomposer combine and flow into the Flash Separator which operates at a pressure of 60-80 Kg/cm^2 absolute. The gas mixture which flashes leaves the top of the Flash Separator; and, the liquid flows

down through the tubes counter-current to the rising stream of Low Pressure Recycle Gas which contains NH_3 , CO_2 , and Water Vapor. The gas mixture leaves the Low Pressure Recycle Gas Compressor and flows to the bottom of the tube side of the 1st Decomposer. The rising gas stream combines with the gas mixture which is produced due to the decomposition of ammonium carbonate; desorption of free NH_3 ; and, vaporization of water. The heat necessary to operate the 1st Decomposer is supplied by exothermic reaction heat; a part of the reaction heat is used to generate the low pressure steam (4 Kg/cm^2 abs. sat.). The resulting gas mixture leaves the top of the 1st Decomposer; flows to the Flash Separator; and, then to the High Pressure Recycle Compressor. The 1st Decomposer operates at $60\text{-}80 \text{ Kg/cm}^2$ absolute and $160^\circ\text{-}170^\circ\text{C}$. About 90% of the ammonium carbonate is decomposed; and, a like percentage of the free NH_3 desorbed in this operation.

5. The solution leaves the bottom of the 1st Decomposer; and flows into the Precooler which operates at $20\text{-}30 \text{ Kg/cm}^2$ abs. The cooled solution then flows to the Inert Gas Scrubber. Condensate is used to recover ammonia from the flashed gas

mixture; and, the inert gas is vented to the atmosphere.

6. The solution then leaves the bottom of the Inert Gas Scrubber; and flows into the 2nd Decomposer. The solution flows down through the tubes counter-current to a rising mixed gas stream. CO₂ gas from the CO₂ Compressor is fed to the bottom of the 2nd Decomposer at 6-10 Kg/cm² absolute. The CO₂ gas flows up through the tubes and mixes with the gases produced as a result of the decomposition of ammonium carbamate; desorption of free ammonia; and, vaporization of water. The gas mixture leaves the top of the tubes of the 2nd Decomposer; flows through the Entrainment Separator; and, to the suction of the Low Pressure Recycle Gas Compressor.

7. The urea solution leaves the bottom of the 2nd Decomposer; and flows into the Flash Tank which operates at 2 Kg/cm² absolute and 115°-120° C. Most of the residual ammonia and carbon dioxide flashes from the solution together with some water vapor and the remaining inert gas. The ammonia and carbon

dioxide are absorbed in condensate in a water-cooled condenser and the remaining inert gas is vented to the atmosphere. The solution thus produced is recycled to the 1st Decomposer.

8. The product solution which contains 76.5% Urea by weight is then sent to the Urea Finishing Section of the plant. (Evaporation and Prilling; or, Crystallization, Melting; and Prilling).

Note: The Suction Separators; Inter-case Coolers; and By-pass Coolers for the three Centrifugal Compressors are not shown on the Flow Diagram. Likewise, Ammonia Storage Tank; Auxilliary Low Pressure Steam Generating Equipment; and Condensate Pumps.

III. Process Features

9. Each of the Centrifugal Compressors have two cases and are provided with suction separators; inter-case coolers with separators; and, by-pass coolers. The compressors can be driven by steam turbines (preferred) or electric motors

(plus speed increaser gears).

10. The simple procedures for start-up and shut-down are details which have no place in this paper. The plant can be operated at reduced capacity by means of the by-pass coolers and steam turbine speed control.

11. Conventional urea process equipment such as absorbers; ammonia condensers; circulating pumps and coolers; and, carbonate recycle pumps are not required.

12. The biuret content of the product solution is lower than normal due to the fact that the 2nd Decomposer is operated at higher than conventional pressure.

13. Part of the heat of compression is recovered by feeding the gases to the Decomposers (CO_2 to the 2nd Decomposer and Low Pressure Recycle Gas to the 1st Decomposer). Make-up CO_2 gas is mixed with the decomposition gases and this has three advantages: increased gas volume flow is desirable for more efficient centrifugal compression; the gas mixtures have a higher average molecular weight; and, the high CO_2 to NH_3 mol ratios

of the gas mixtures lowers the ammonium carbamate association temperature throughout the compression in the H.P. and L.P. Gas Recycle Compressors.

14. The process is highly suitable for large tonnage single train plants for a number of reasons. It is the only process which offers a reduction in investment cost and power consumption per ton of product as the single train capacity increases. The compressors (excluding drivers) for a 1,500 mtd plant will not cost much more than the 1,000 mtd plant compressors because the compressor cases are suitable for the capacity range. (Differences: Wheel dimensions; speeds). High capacity compressors have higher high pressure wheel efficiencies; and, this represents a reduction in power consumption.

15. The process does not require steam in the pressure range of 17 to 25 Kg/cm² abs., because the 1st Decomposer utilises reaction heat. Steam at 10 Kg/cm² abs. is not required for the Urea Crystal Malter when the compressors have turbine drives and the CO₂ Compressor has a partial extraction turbine.

16. The Synthesis Section of the plant will have a low level layout since there is no need for high structures to support heavy elevated high pressure equipment. This will further reduce the overall investment cost.

IV. Utility Requirements

17. The following expected utility requirements for the Thermo Urea Process are based on the operation of a plant producing 1,000 metric tons of low biuret prills (0.3% by wt.) by the vacuum crystallization and crystal melt-prilling techniques.

Circulating Cooling Water; Supply at 30°C; 11°C Rise	80 m.t./m.t.
Import Steam; 42 atmos. gage Superheated	1.347 " / "
Electric Power	32 kWh/m.t.
Export Steam; 3 atmos. gage Saturated	0.21 m.t./m.t.

-/-/-/-

18. There have been several excellent reviews on urea processes in recent years (10, 11, 12). They all present flow diagrams with just enough operating data to permit a comparison

from the process standpoint by anyone experienced in the art. However, some technical articles present the utility requirements without specifying what type of urea finishing operations are included. This makes it difficult to make a comparison on the basis of utility requirements. One of the reviews (12) which gave an accurate presentation of the utility consumption figures and unit costs was used as a basis for comparing the Thermo Urea Process with several Key processes.

Plant Capacity: 1,000 metric tons per day.

Product: Low Biuret Urea Prills (0.3% Biuret by Wt.)

Urea Finishing by: Vacuum Crystallization and
Crystal Melt Prilling.

Unit Costs: Utilities:

Circulating Cooling Water	Pounds Sterling	0.004	per m.t.
Import Steam (10 atmos.gage Sat.)	"	"	0.700	" "
" " (25 " " ")	"	"	0.750	" "
" " (42 " " Super-Heated)	"	"	0.800	" "
Export Steam (3 " " Sat.)	"	"	0.500	" "
Electric Power	"	"	0.005	" kWh

19. The following is a comparison of the utility costs for the various urea processes:

Chemico Thermo Urea (Steam Turbine Drives)	Pounds Sterling	1.453
Dutch State Mines (CO ₂ Stripping Process)	" "	1.500
SNAM-Progetti (NH ₃ Stripping Process)	" "	1.570
* Mitsui-Tootsu (Liquid Recycle Process "D")	" "	1.670
Mitsui-Tootsu (Liquid Recycle Improved "C")	" "	1.694

* Note: Reference (12) did specify the cooling water quantities for each process but omitted the temperature rise in some cases; viz., D.S.M. and SNAM-Progetti. A check in other publications (13, 14) showed that the temperature rise is 11°C., corresponding to the consumption quantities for the latter processes. The temperature rise for the Thermo Urea Process is 11°C as specified above; and, 15°C for the Mitsui-Tootsu "C" process as listed in Reference (12). The cooling water consumption for the latter process was therefore increased from 63 to $(63)(15/11) = 86$ m.t./m.t. Urea in order

to compare all of the processes on the same basis. Mitsui-Toatsu's process Version "C" as listed in Reference (12) is actually their Total Recycle Improved "C" process as a comparison with the utility figures in Reference (15) shows. This same reference confirms the cooling water temperature rise of 15°C; and, also gives the utility requirements for the new total recycle process "D". The utility cost figures for the Mitsui-Toatsu processes were calculated on the basis of the information given in References (12 and (15); and, corrections as explained above.

V. Production Economics

20. The vapor-liquid equilibria obtained from the operation of a small pilot plant served to confirm the nominal operating conditions and efficiencies of the decomposers; and, the analyses of the gas mixtures which are to be handled by the Low and High Pressure Recycle Compressors. This information was then used to prepare a flowsheet and material balance for a 1,000 metric ton per day plant with a vacuum crystallization-crystal melt prilling finishing section. Equipment

specifications and equipment drawings were prepared for the purpose of estimating the plant investment cost which proved to be about 10% less than the cost of a conventional liquid recycle plant with the same capacity. It should be again noted that the single train capacity can be increased appreciably without a significant increase in cost if the same size compressor casings can handle the higher capacity. This is a distinct advantage of the Thermo Urea Process.

21. A conservative estimate of the utility requirements was made; and, this included a manufacturer's estimate of the power consumption for each of the three centrifugal compressors. Unit utility costs were applied for each requirement in order to arrive at the total utility cost per metric ton. This cost was then compared with those for the world's key processes. The result shows that the Chemico Thermo Urea Process has a utility cost slightly less than the D.S.M. process. The exact cost differential isn't important because it depends on many factors. However, all of the processes were compared on the same basis; and, it is important to note that Chemico Thermo, D.S.M. and SHAM processes are at the

lower end of the utility cost spectrum as compared to the liquid recycle processes. The efficiencies of the high pressure wheels of a centrifugal compressor are higher at large capacities; hence, the power consumption per metric ton of urea drops as the single train capacity of the plant increases. This is also a big advantage of the Thermo Urea Process.

VI. Process Commercialisation

22. Chemico's Thermo Urea Process was briefly described in several previous technical papers; and, a number of interested parties received more detailed technical data through normal business channels. The process has been improved and simplified as a result of continuous research and development; therefore, only a limited number of people in the fertiliser industry have had the opportunity to make an up-to-date evaluation of it. The information presented in this paper should result in a better understanding of the process and create more interest for its use in future large tonnage plants.

A number of authors have stated that this process

cannot be tested in a low tonnage pilot plant. For instance, D.S.M. and SHAM scaled up data from 20 to 33 mtd pilot plants, respectively, for the design of large tonnage plants (13, 12). The statements referred to above are true because of the limit on the minimum capacity of a centrifugal compressor. This refers to the L. P. and H. P. Recycle Gas Compressors. The carbon dioxide could, of course, be supplied by a reciprocating compressor since centrifugal compressors are being successfully operated in CO₂ service with discharge pressures higher than the 8 Kg/cm² abs. pressure required for the Thermo Urea Process.

23. Centrifugal Compressors have a nominal minimum discharge flow of approximately 5.7 cubic meters per minute. This is equivalent to a production capacity of 640 metric tons of urea per day based on the actual flow from the H. P. Recycle Gas Compressor. A pilot plant with centrifugal compressors is therefore not possible. Centrifugal compressor ammonia plants were adopted for commercial operation without the benefit of pilot plant testing. These plants have a nominal minimum

capacity of approximately 600 tons/day. The limiting factor being the minimum discharge flow as mentioned above. The ammonia process was readily adopted because of the attractive production economics. The compression of a gas mixture containing hydrogen, nitrogen, carbon dioxide, and, etc., was obviously not considered as being a problem.

24. The compression of a gas mixture containing ammonia, carbon dioxide, and water vapor has always been considered as a difficult operation due to the possibility of the formation of solid ammonium carbonate. This is certainly true if a wet or dry mixture of ammonia and carbon dioxide is compressed under conditions which favor the association of ammonia and carbon dioxide in accordance with the ammonium carbonate equilibrium (16). It so happens that the gas mixtures which are to be compressed in the L.P. and H.P. Gas Recycle Compressors are rich in carbon dioxide and this shifts the equilibrium so that dissociation can be assured under the proposed operating conditions. It was previously stated that the gas mixtures contain about 10% water vapor by volume; this establishes the lowest temperatures for

inter-case cooling. In other words, the water dew point is the controlling factor. The temperatures of the gas mixtures leaving the inter-case coolers could be lowered considerably, if the gas mixtures were dry. The presence of water therefore increases the power consumption due to extra mass flow and higher suction volumes. The additional power consumption is however included in the utility requirements. Hence there is no problem relating to formation of ammonium carbamate as such, as supporting calculations indicate. The gas mixtures must be kept above the dew point of water in order to avoid the formation of an aqueous ammoniacal ammonium carbamate solution in the inter-case coolers. The drops of solution will be removed in the inter-case separators hence this is no problem. The temperature must be kept above the water dew point to prevent carry-over into the compressor. Small droplets will however be heated during compression and be completely vaporized. Toyo Katsui (Mitsui-Toatsu) successfully used reciprocating compressors in this service for a number of years (17). BASF also was successful with such operation up until a few years

when they installed a new urea process. It is interesting to note that the centrifugal circulators in ammonia synthesis loops handle an ammonia, hydrogen mixture which contains a small percentage of carbon dioxide. The mol ratio of ammonia to carbon dioxide is very high; yet under high pressure and low temperature the formation of ammonium carbonate can be favored. Some plants have experienced this problem and maintain the gas temperature high enough to avoid deposits of the solid salt.

25. A pilot plant with a capacity of about 25 tons/day should be operated to check out the efficiencies of the various items of equipment. The pilot plant equipment must incorporate the features of the proposed commercial size equipment. The data obtained on long runs will confirm decomposition efficiencies, gas analyses; heat transfer coefficients; and, etc. The pilot unit would be operated in conjunction with an existing commercial urea plant. The overhead gas mixture would be sent to the absorbers (for instance in a liquid recycle plant) and the liquids to the bottoms of the low pressure decomposers. An existing liquid

recycle plant could easily accept the low flow quantities produced in the pilot plant.

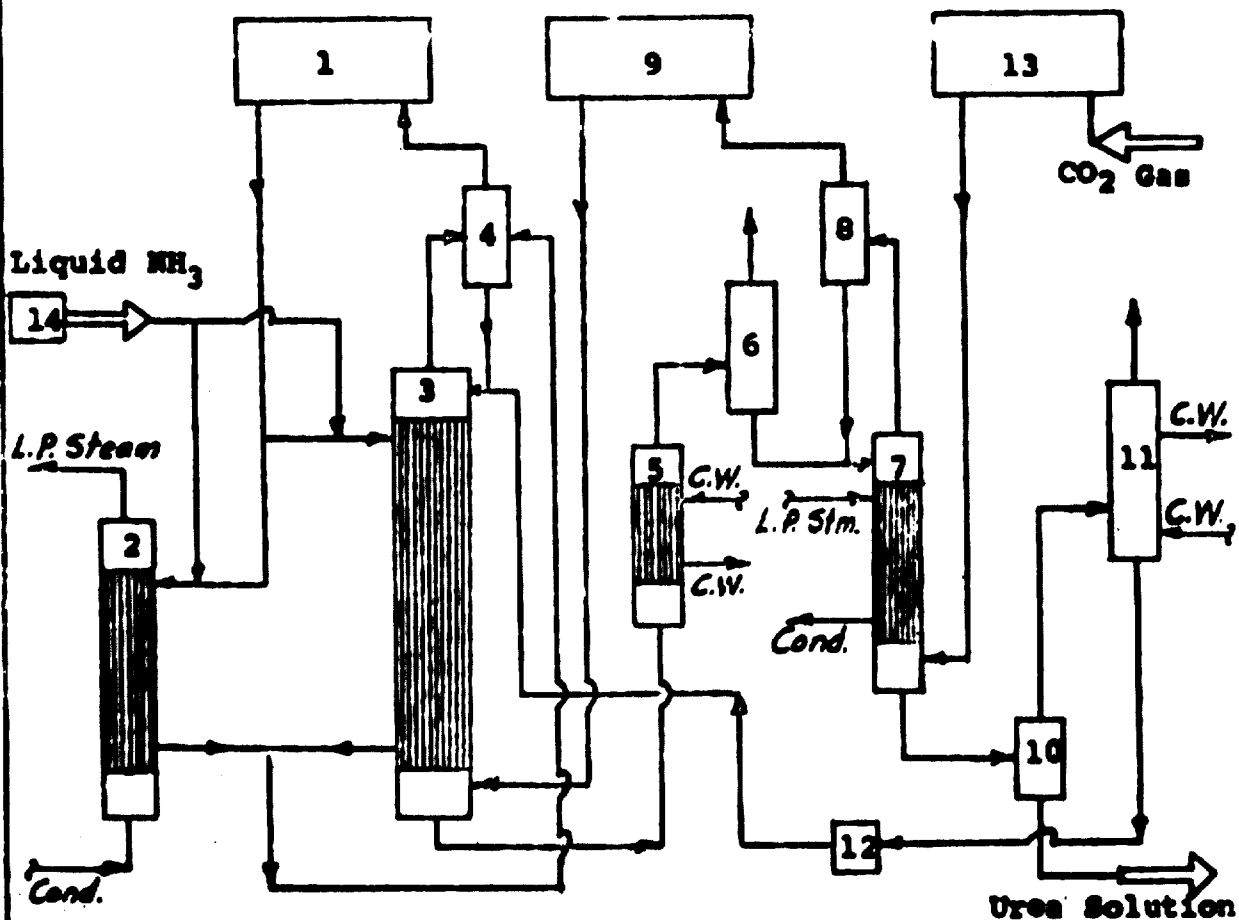
26. There must also be a separate centrifugal compressor test to check out the materials of construction that are selected for this service. The test could be made with a single case of wheels driven by a steam turbine. The compressor would be brought up to capacity by feeding it high pressure vaporized ammonia; CO₂ gas from the urea plant compressor; and steam. Once loaded the compressor can be operated on by-pass through a cooler. This test will also provide the means of checking the seals and lubricants. The compressor manufacturer would also participate in this test.

27. The pilot plant and compressor tests are now under consideration and will provide all of the data necessary for the design and successful operation of a large tonnage single train plant.

VII. Conclusion

28. The paper has presented a brief history of the developments in urea technology leading up to the commercialization of the heat recovery processes. Chemico's Thermo Urea Process which also falls into this category must still be considered as being a "new" process because it has never been used commercially. A considerable amount of information has been "packed" into this short text for the express purpose of pointing out the latent potentialities of this process to the Fertilizer Industry.

VIII. Process Flow Diagram



Chemico's Thermo Urea Process

Nomenclature

- | | |
|---------------------------------|--------------------------------|
| 1. H.P. Recycle Gas Compressor | 8. Entrainment Separator |
| 2. Low Pressure Steam Generator | 9. L.P. Recycle Gas Compressor |
| 3. Reactor - First Decomposer | 10. Flash Tank |
| 4. Flash Separator | 11. Condenser |
| 5. Precooler | 12. Recycle Pump |
| 6. Inert Gas Scrubber | 13. CO_2 Compressor |
| 7. Second Decomposer | 14. NH_3 Feed Pump |

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X. Notes

1. Re: Urea to Melamine Plants

29. A number of new melamine plants have gone on stream in the last few years. These plants, which use urea as a raw material, operate at low pressure; and, produce a high purity product. More than 50% of the urea which goes into the reactor comes out of the plant as a dry gas mixture containing 2 mols of NH_3 to 1 mol of CO_2 . In some instances the NH_3 is used to produce by-product fertilizers. There are however various process schemes for recycling the by-product gas mixture back to the urea plant reactor. The production cost of the urea increases markedly if the gases are recycled as an aqueous solution. In other words, the urea plant has to operate with an appreciable increase in recycle load. A detailed study of the integrated operation of melamine and urea plants was presented in a recent paper (18). The recycle of an aqueous solution also reduces the conversion efficiency of the urea reaction. However, if a dry gas mixture (mol ratio $2\text{NH}_3/1\text{CO}_2$) were to be recycled these problems would be avoided since this stream would serve to

supply a part of the raw materials. This therefore points out another important feature of the Thermo Urea Process. The gas mixture can be fed to the centrifugal recycle gas and be returned to the urea reactor. This is the ideal way to integrate the operations of the melamine and urea plants. Chemico has a patent on this process (19).

Re: Utility Cost Comparison: Evaporation Prilling vs. Vacuum Crystallization-Crystal Melter Prilling.

30. Low biuret urea prills (0.3% by weight) are produced in a urea finishing section which includes a vacuum crystallizer; centrifuge; crystal dryer; airveying system; urea crystal melter; and, a prilling tower. This type of finishing section is much more complex than the simple urea solution evaporation and prilling operations which are carried out in the production of high biuret prills (0.9% by weight). The utility cost per ton of product is about 10% higher for the low biuret prills because of the following additional operations:-

Vacuum Crystallization - Large circulation pump - KWH

Vacuum Crystallizer Condenser - Requires cooling water for indirect or barometric condensing.

Slurry Circulation Pump - KWH

Centrifuge - KWH

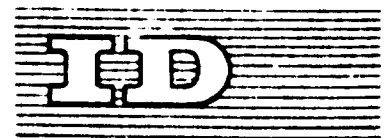
Crystal Airveying System - KWH for Fans; Steam to heat air.

or Crystal Dryer plus Elevator - KWH and Steam.

Urea Crystal Melter - Steam.

31. The melting point of urea is 132.7°C and steam at 4 kg/cm^2 absolute has a saturation temperature of 142°C . The urea melter would have to operate with a 10°C temperature differential if low pressure steam were used for melting. Most plants use steam at pressure of at least 8 kg/cm^2 abs. (170°C) to increase the temperature differential and keep the heat transfer surface within economical bounds. Air for crystal drying or airveying-drying can be preheated with low pressure steam but requires a higher pressure steam to raise the air temperature to 160°C . Low biuret plants also recycle

mother liquor to the urea synthesis section of the plant to destroy biuret. The quantity of recycle liquor may be equivalent to 5% or 10% of the urea production and this increases the consumption of utilities in the synthesis section. Most of the utility cost data in Reference (12) confirms that there is a 10% increment. It is interesting (and puzzling) to note that this does not apply in the case of the D.S.M. process which actually shows a decrement of 1.33%. It is hoped that this point will be clarified in future publications.



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SUMMARY

THE CHEMICO THERMO UREA PROCESS: A FUTURE PROSPECT

by

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A brief description of Chemico's Thermo Urea Process was first publicized in a paper presented at the First Interregional Fertilizer Symposium at Kiev, Ukrainian S.S.R. in 1965. The Thermo Urea Process derives its name from the fact that it is based on the principle of heat recovery. It was compared with two other heat recovery processes viz., Stamicarbon and SHAF in a paper which was presented at Thirty-Sixth International Congress on Industrial Chemistry at Brussels, Belgium in 1966. These publications created a strong interest on the part of many urea producers who then requested process details, and technical data for process evaluation. The process came close to being accepted for commercial production on several occasions on the basis of the vapor-liquid equilibria obtained from small scale pilot plant tests. The UNIDO Fertilizer Manual states: "Thus far, no producer has elected to gamble on this theoretically sound, but untried, process." A technical article by TVA engineers in 1971 states: "The hot gas recycle and ammonia plant combination (integrated ammonia-urea plant) processes are further away from realization but offer potential savings in investment and operating cost. Several years will elapse before they are proved commercially." NITROGEN magazine (March-April 1970) states the following: "There are, however, one or two more recent additions to the processes (urea) available which, although they have not been tried out in commercial-sized operations,

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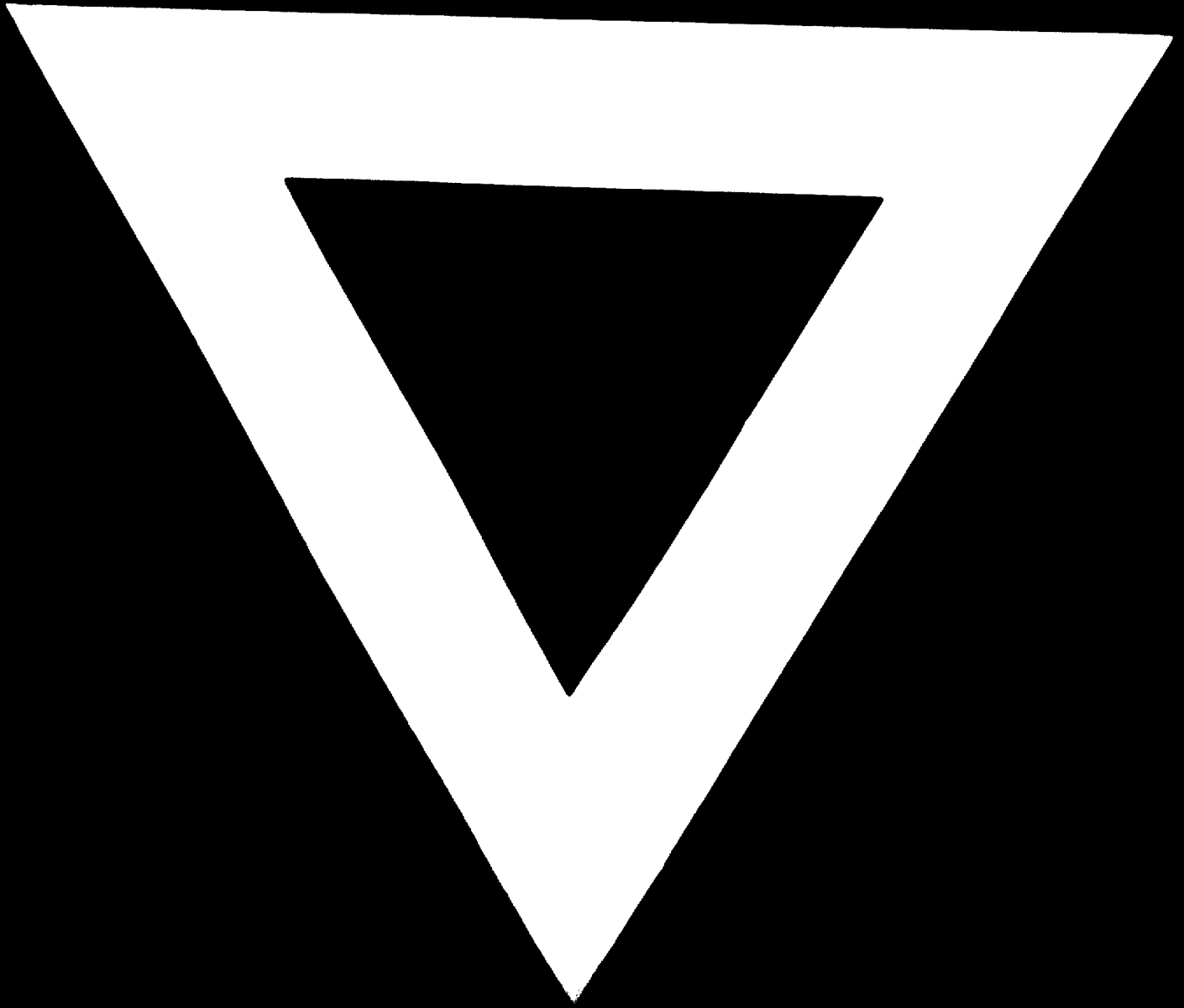
have nevertheless aroused interest, mainly because they involve significant departures from conventional technology. One of these is the Chemico Thermo Urea Process - - - - - Large capacities may benefit from processes of similar type to the Chemico Thermo Urea system, which offers several advantages on paper but still needs to be commercially proven."

A strong interest in the process still persists indicating that it may be put to commercial use in the near future. Chemico realizes this and has been continuously studying the process. A series of pilot plant tests were recently made to obtain data for a simple version of the process. Production economics look very attractive especially for large tonnage plants in the 1,000 to 2,000 tons/day range. Chemico looks forward to a continuous semi-commercial test in the near future.

This paper will present the following information:

- a) Review of Chemico's process development work.
- b) Process description and flow diagram.
- c) Utilities requirements and a comparison with other urea processes.





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