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Kiev, USSR, 21 September - 1 October 1971

New Delhi, India, 2 - 13 October 1971

Agenda item III/1c/iv

THE MITSUI TOATSU UREA PROCESS

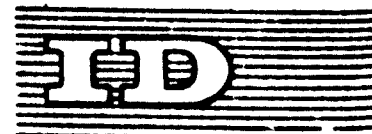
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SUMMARY

THE MITSUI TOATSU UREA PROCESS <sup>1/</sup>

by

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Mitsui Toatsu Chemicals, Inc.  
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Mitsui Toatsu urea processes are now being utilized by 58 plants in 21 countries in the world.

Mitsui Toatsu has been developing various urea processes, all of which are supported by techniques and data taken from operating commercially-proven plants.

Total Recycle C-Improved Process (TR-C-Improved) and Total Recycle D Process (TR-D) are the latest developments, in which our latest advanced techniques and data are incorporated into the commercially-proven Total Recycle C Process. Although TR-D has not been commercially proven yet, TR-C-Improved is already being used in three plants.

The first one was started up in July, 1969, which is a completely single train plant of 1,500 MT/D design capacity at Mitsui Toatsu Osaka Factory and has experienced trouble-free operation since start up.

The second plant with a capacity of 300 MT/D was started up in July, 1970 and is much appreciated by the client, Nippon Kasei Chemicals, because of its excellent plant efficiency.

The third plant is now in the initial start up stage at Nippon Ammonia Inc.

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The feature of TR-C-Improved process is, in comparison with TR-C process, higher conversion in the reactor by reducing the amount of water recycled back to the reactor. This improvement is achieved by higher operating temperature and pressure in the reactor, more decomposition in the high pressure decomposer incorporated with the specially designed heater, CO<sub>2</sub> stripping in the low pressure decomposer and less equilibrium pressure in the low pressure absorber.

The feature of TR-D process is to recover the excess ammonia without losing its enthalpy into the cooling water by adding a 60-80 Kg/cm<sup>2</sup> separation unit to the basic commercially-proven TR-C process. Accordingly steam and cooling water consumption are remarkably improved.

Thus, Mitsui Toatsu is making a great effort to get better utilities consumption, higher on-stream factor and lower investment cost.

## C O N T E N T S

	Page
I. Introduction	5
II. Performance of Large Scale Plants	7
III. Total Recycle C-Improved Process	8
A. Comparison between TR-C and TR-C-Improved	8
B. Process Description - Low Biuret Prills	9
C. Process Description - High Biuret Prills	14
IV. Total Recycle D Process	17
A. Features of Total Recycle D Process	17
B. Process Description	18
V. Consumption Figures and Operability	21
VI. Advanced Technology in Large Scale Plants	23
A. CO <sub>2</sub> Compressor	23
B. H.P. Carbamate Solution Pump - Centrifugal Pump	23
C. Material	25
D. Measures for Pollution Control	26
E. Computer Control	26

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.

## I. INTRODUCTION

In the urea industry one of the remarkable trend at present is to increase the size of plants with the minimum plant cost and running cost. When urea came up to the market, the manufacturing technology started from the once-through process and with the growth of the demand it developed to the partial recycle process and the total recycle process, which is now the most favourable one in the world. Following the development of processes, the plant size has been getting bigger. In 1966-1968, many units of 400-800 MT/D capacity in a single train were started, while 50-300 MT/D capacity plants had formed the basis of the urea industry until then. And now 1,500 MT/D plant is being successfully operated at Osaka, Japan with utilizing Mitsui Toatsu Total Recycle C-Improved Process.

As many companies proceeded in the urea industry, Mitsui Toatsu Chemicals, Inc. has continued the research and development of urea processes since 1940's and once-through, partial recycle and total recycle processes have been steadily developed and commercialized with the full support of the techniques and data taken from the actually running, commercially proven urea plants. Now Mitsui Toatsu Urea Processes are being utilized by 58 plants in 20 countries in the world.

The Table-I below shows how Mitsui Toatsu Processes have been used worldwide.

Table-I:

<u>Process</u> <sup>*1</sup>	<u>Number of Plants</u>	<u>Total Capacity (MT/Y)</u>
PR-A	1	14,850
PR-B	8	639,540
PR-C	3	228,360
TR-A	1	66,000
TR-B	14	1,650,330
TR-C	28	5,891,820
TR-C-Improved	3	1,122,000
<b>Total</b>	<b>58</b>	<b>9,612,900</b>

\*1: PR: Partial Recycle  
TR: Total Recycle

As is clear from Table-I, Total Recycle C Process has been widely adopted in various countries because of its outstanding features such as superior process economics, and steady and easy operation. This process has established firmly the reputation of Mitsui Toatsu Urea Processes in the world urea production.

Based on this widely and commercially proven Total Recycle C Process, the latest developments of Mitsui Toatsu are Total Recycle C-Improved Process and Total Recycle D Process.

Although TR-D has not been commercially proven yet, TR-C-Improved is already being used in 3 large plants. The first one was started up in July, 1969, which is a completely single train plant of 1,500 MT/D design capacity at Mitsui Toatsu Osaka Factory and has been keeping trouble-free operation since start-up. The second plant with the capacity of 900 MT/D was started up in July, 1970 and is much appreciated by the client, Nippon Kasei Chemicals, because of its excellent plant efficiency. The third plant is now under the initial start-up stage at Nippon Ammonia, the capacity of which is 1,000 MT/D.



In this paper the performance of the large scale plants, the technology of large scale plants, and Mitsui Toatsu Total Recycle C-Improved and D Processes are introduced.

## II. PERFORMANCE OF LARGE SCALE PLANTS

With Mitsui Toatsu Total Recycle Processes 24 units out of 37 units with the capacity of more than 500 MT/D have been put into operation and achieved successful performance, in which there are 4 units of 1,000 MT/D capacity or more in a single train.

In Mitsui Toatsu Osaka Factory the world largest urea plant in a single train of 1,500 MT/D design capacity, which was started in July, 1969, has performed the maximum production record of 1,800 MT/D and has also achieved the on-stream factor of 96.3% through 1970 based on the on-stream days excluding annual shut-down for maintenance. This plant is the first one with utilizing Mitsui Toatsu Total Recycle C-Improved Process.

The second plant to have employed Total Recycle C-Improved Process was built at Iwaki, Japan for Nippon Kasei Chemical, Ltd. and went into production in July, 1970. It has a capacity of 900 MT/D in a single train and has been in trouble-free operation from the day it started operation like Osaka 1,500 MT/D plant. It has proved more efficient in terms of raw materials and utilities consumption as below Table-II.

Table-II:

	(per metric ton of prilled urea)
Liquid Ammonia	575 Kilograms
Carbon Dioxide	741 "
Steam	860 "
Electricity	153 KWH
Cooling Water	42 M <sup>3</sup>
Sea Water	50 "

Biuret content has been kept to a minimum of 0.29 weight % and has achieved a production rate of 926 MT/D.

Thus large scale plants by Mitsui Toatsu Total Recycle Processes have been commercially proven for years. From the standpoints of engineering, no problem is foreseen up to the plant capacity of 2,000 MT/D in a single train.

### III. TOTAL RECYCLE C-IMPROVED PROCESS

#### A. Comparison between TR-C and TR-C-Improved

Total Recycle C-Improved Process (as TR-CI hereunder) is same as Total Recycle C Process (TR-C) in its principle. In TR-CI Process, the conversion of CO<sub>2</sub> in the reactor has been much improved up to as high as almost 72%, by reducing the amount of water recycled back to the reactor. The steam requirement is accordingly reduced to the quite economical level of 0.9 tons per ton of urea. This improvement is achieved by adopting the following methods.

1. High operating temperature and pressure in Reactor
2. More decomposition in High Pressure Decomposer

3. CO<sub>2</sub> Stripping in Low Pressure Decomposer
4. Less equilibrium pressure in Low Pressure Absorber

#### B. Process Description - Low Biuret Prills

For the convenience of explanation, the urea plant can be divided into five sections, namely - synthesis section, decomposition section, crystal separation section, drying and prilling section and recovery section.

The explanation will proceed with the process flow diagram of Figure-1.

##### 1. Synthesis Section

This section consists of CO<sub>2</sub> Compressor, CO<sub>2</sub> Booster Compressor, Liquid Ammonia Feed Pump, Ammonia Preheater and Reactor. In this section, urea is synthesized from liquid ammonia, gaseous carbon dioxide and recycle solution under high pressure and temperature in a vertical cylindrical reactor.

High pressure steam, which is available from recent ammonia plants, boosts carbon dioxide gas up to about 10 Kg/cm<sup>2</sup>G, while being let down through steam turbine and extracted at the pressure of 13 Kg/cm<sup>2</sup>G required for the process. Carbon dioxide gas is then compressed up to synthesis pressure by reciprocating CO<sub>2</sub> Compressor. Liquid ammonia from Ammonia Reservoir is pumped up to synthesis pressure by a reciprocating type Ammonia Feed Pump and fed into Reactor through Ammonia Preheater, where liquid ammonia is heated by using steam condensate. The recycle carbamate solution from High Pressure Absorber Cooler is also pumped up to synthesis pressure by Recycle Solution Feed Pump fed into Reactor.

The operating condition in the reactor is 200-270 Kg/cm<sup>2</sup>G and 180-220°C. The one pass conversion of carbon dioxide to urea is almost 72%. The reaction product, which is a mixture of urea, unconverted ammonium carbamate, excess ammonia and water, flows through the let-down valve at the top of Reactor into the next decomposition section.

## 2. Decomposition Section

In this section, consisting of High Pressure Decomposer, Low Pressure Decomposer and Gas Separator, excess ammonia and unconverted ammonium carbamate are separated from the urea solution by steam heating in stepwisely lower pressure decomposers. Further advanced system incorporated in both high and low pressure decomposition stage recovers carbamate more efficiently and minimizes water recycled back to Reactor, thus resulting in higher one pass conversion.

In High Pressure Decomposer operated at 15-19 Kg/cm<sup>2</sup>G, the reaction product is heated up to more than 160°C by two stage heater, and all excess ammonia and most of ammonium carbamate are evaporated from urea solution. The overhead gas flows into High Pressure Absorber Cooler and the urea solution flows into Low Pressure Decomposer, where operated at 110-150°C and 1.5-4.0 Kg/cm<sup>2</sup>G, the remaining ammonia and carbon dioxide are further removed first by heating the solution in a reboiler and then by stripping with carbon dioxide gas while the solution counter-currently falling through the packed column. The overhead gas of this decomposer is sent to Low Pressure Absorber.

Gas Separator has two parts. In the upper part, the residual small amount of ammonia and carbon dioxide in the urea solution is flashed out by pressure reduction. The overhead gas is sent to Off Gas Absorber System together with the stripping air from the lower part. In the lower part, to minimize ammonia content in the urea solution, the

urea solution again flow down counter-currently through the packed column with air.

The urea solution leaving the lower part of Gas Separator is concentrated up to 74 wt.% and pure enough to be used even as industrial grade.

### 3. Crystal Separation Section

Crystal separation part consists of Crystallizer, Vacuum Generator, Centrifuge and Mother Liquor Tank.

The urea solution from Gas Separator is fed into Crystallizer. In the upper part of Crystallizer, water evaporates from the solution under vacuum, and urea crystallizes and grows in urea slurry suspension in the lower part, which operated at atmospheric pressure. The heat recovered in High Pressure Absorber Cooler is utilized for the evaporation of water, together with the sensitive heat of the feed urea solution and the crystallization heat of urea and no steam is required to get crystal urea.

This crystallization process was first incorporated into the urea plant by Mitsui Toatsu for producing low biuret urea prills. The unique design of Crystallizer has been proving excellent operational records.

The urea crystals are separated from urea slurry solution by Centrifuge. The mother liquor from Centrifuge is sent back to Crystallizer through Mother Liquor Tank.

### 4. Drying and Prilling Section

The urea crystals are pneumatically conveyed up to the top of Prill Tower through Fluidizing Dryer, in which the crystals are dried by contacting with hot air. Moisture content of the crystals from Cyclone at the top of Prill Tower is less than 0.2 wt.%.

Those crystals are melted in Melter and the molten urea falls through Prill Head down the tower by its gravity. Urea prills are formed while descending through the tower contacting with cool air and further cooled on Fluidizing Cooler at the base of the tower. Lump of urea, if formed, is removed by Trommel, a rotating screen, and all the urea prills go to storage or bagging hopper as product. As for the effluent from the top of the tower, urea dust is tremendously reduced by the latest developed technique, which is a quite simple and yet effective device.

## 5. Recovery Section

In this section, the overhead gases from the decomposers are condensed and absorbed in their respective absorbers, that is, High Pressure Decomposer to High Pressure Absorber and Cooler, Low Pressure Decomposer to Low Pressure Absorber and Gas Separator to Off Gas Condenser.

A part of condensate in Off Gas Absorber is sent to Low Pressure Decomposer for recovery of ammonia and carbon dioxide and the other is sent to Low Pressure Absorber as the absorbent, and noncondensed gas - air - is recirculated.

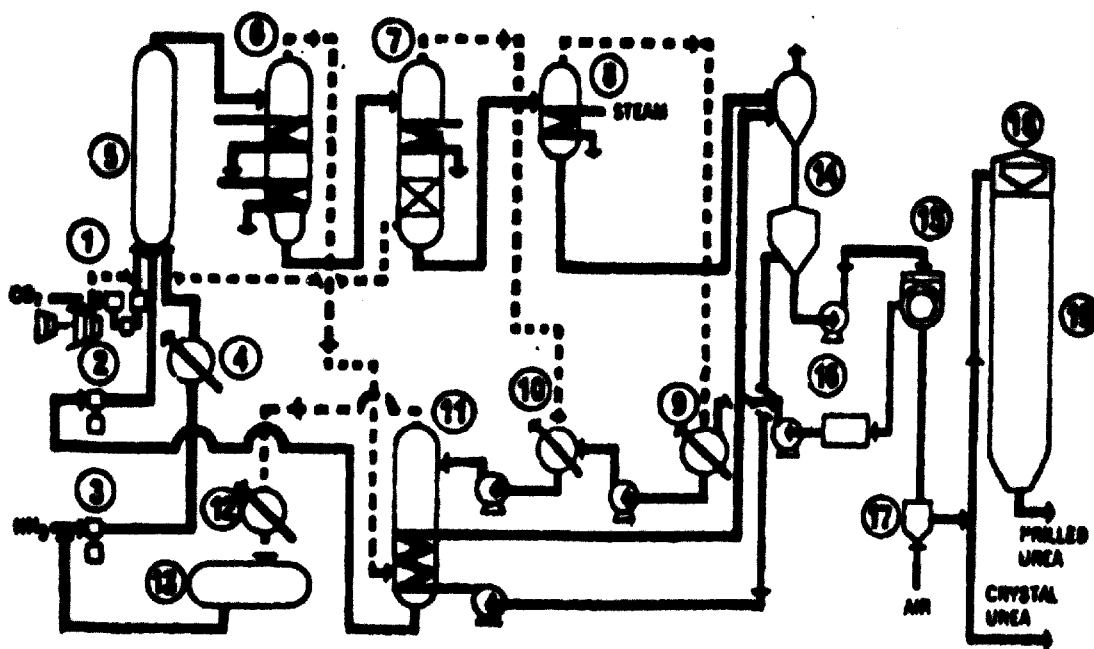
In Low Pressure Absorber, the gases from Low Pressure Decomposer are condensed and absorbed into the absorbent solution from Off Gas Absorber, and mother liquor solution, which is returned from the crystal separation with the purpose of purging biuret accumulated in Crystallizer. This mother liquor return into the recovery section is Mitsui Toatsu patented process for making low biuret urea product.

In High Pressure Absorber and Cooler, all the carbon dioxide and water are condensed and absorbed into the mixture of liquid ammonia and the solution from Low Pressure Absorber. Thus the recycle solution from the cooler is sent back to Reactor and the overhead gas, pure ammonia, of the absorber

is condensed through Ammonia Condenser and recycled back to Reactor.

The inert gas, purged from Ammonia Condenser, is scrubbed with water in Ammonia Recovery Absorber, and the aqueous ammonia solution thus formed is used for scrubbing ammonia gas on the top of High Pressure Absorber. All this high pressure recovery system is operated at 14-18 Kg/cm<sup>2</sup>G.

Figure-1: MITSUI TOATSU TOTAL RECYCLE C-IMPROVED PROCESS



- |                               |                               |
|-------------------------------|-------------------------------|
| 1. CO <sub>2</sub> Compressor | 11. High Pressure Absorber    |
| 2. Recycle Pump               | 12. NH <sub>3</sub> Condenser |
| 3. NH <sub>3</sub> Pump       | 13. NH <sub>3</sub> Reservoir |
| 4. NH <sub>3</sub> Preheater  | 14. Vacuum Crystallizer       |
| 5. Reactor                    | 15. Centrifuge                |
| 6. High Pressure Decomposer   | 16. Mother Liquor Tank        |
| 7. Low Pressure Decomposer    | 17. Dryer                     |
| 8. Gas Separator              | 18. Melter                    |
| 9. Gas Condenser              | 19. Prill Tower               |
| 10. Low Pressure Absorber     |                               |

### C. Process Description - High Biuret Prills

The process description presented in III-B concerns so-called "low biuret prill product process", while it will be of some use for those who require only high biuret fertilizer grade urea to know how to make it and what the advantages are.

As compared with the low biuret prill product process, the high biuret prill product is manufactured without the crystal separation procedure by directly concentrating urea solution up to 99.7% in the evaporator, and therefore this process can be sometimes called "Direct Prilling Process".

The outline of the process is as follows and Figure-2 shows the process flow diagram.

The urea synthesis is carried out under the lower operating temperature to minimize the biuret formation in the reactor.

In the decomposition section ammonia and ammonium carbamate are decomposed and separated at H.P. Decomposer, L.P. Decomposer and Vacuum Decomposer. The operation to be intended in the decomposition section is to get the concentrated urea solution with minimum biuret formation.

The urea solution coming from Vacuum Decomposer has the concentration of 70-75 wt.% and is sent to Evaporator at the top of Prill Tower through Filter where oil in the solution is removed. The solution is instantaneously concentrated up to 99.7 wt.% with counter-current hot air in Evaporator, and then directly prilled through Prill Heads.

In the recovery section the manner to recover the unreacted ammonia and carbon dioxide is similar to the low biuret product process except that the absorbent is only water.



As the whole process is so designed to minimize the biuret formation, the biuret content in the prill product can be expected to be less than 0.8%.

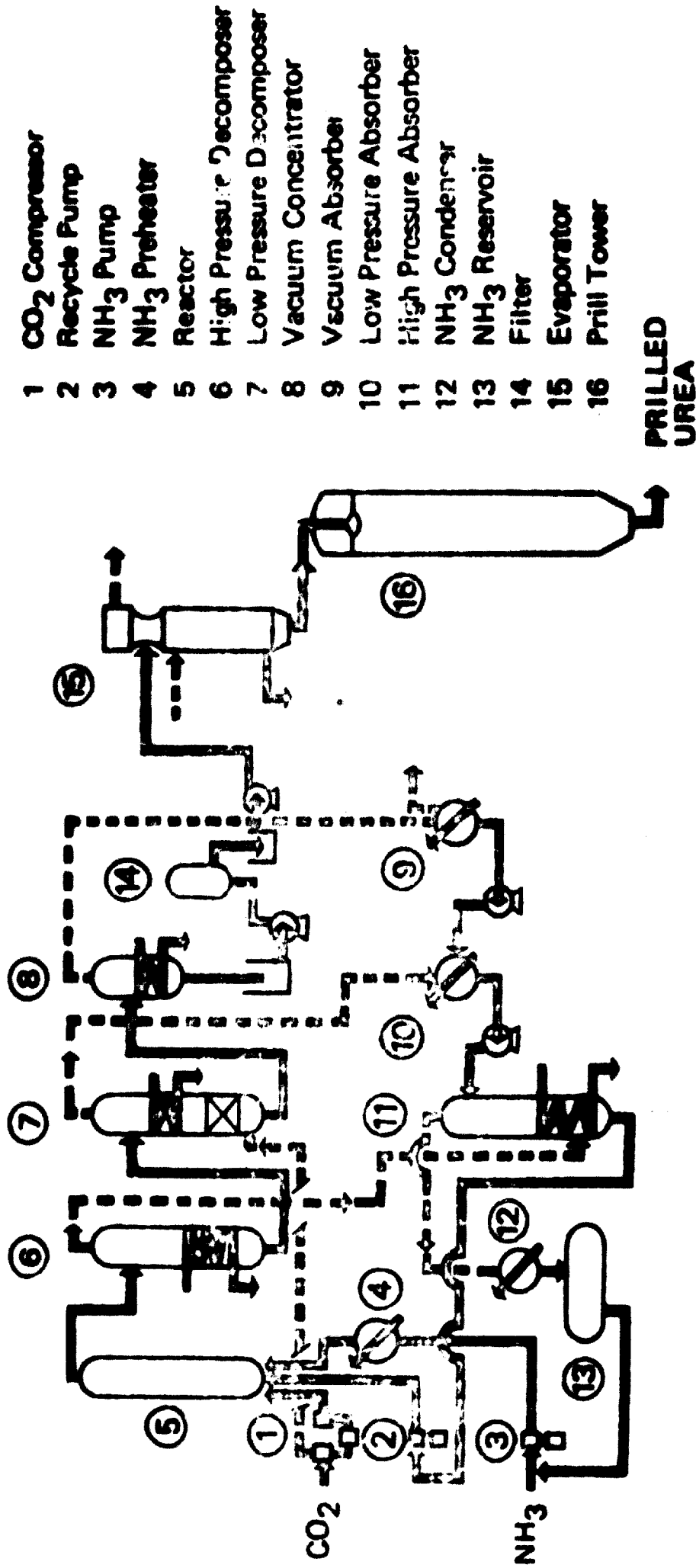
As the alternative of Direct Prilling Process mentioned above, the new process has been developed to improve the steam requirement by installing Crystallizer after Vacuum Decomposer. The urea solution from Vacuum Decomposer is sent to Vacuum Crystallizer where urea solution is concentrated from 70-75 wt.% to 80-85 wt.% with the heat which is recovered in High Pressure Absorber Cooler as the same method as low biuret product process.

As this vacuum crystallizer is installed with the purpose to concentrate urea solution by using the recovered heat, the size is far smaller than the crystallizer for low biuret product process.

Crystals in the slurry from the crystallizer is dissolved through the heat exchanger by steam condensate and 80-85 wt.% urea solution is fed to Evaporator, which require only 50-60% amount of steam as compared with the evaporator to concentrate from 70-75 to 99.7 wt.%. The addition of Crystallizer and Dissolver can be cancelled costwisely by the installation of smaller evaporators. By the recovery of heat from H.P. Absorber Cooler, the steam consumption is now reduced to 1.05 T/T-Urea.

Figure-2: Total Recycle C-Improved Process

—— DIRECT PRILLING ———



#### IV. TOTAL RECYCLE D PROCESS

##### A. Features of Total Recycle D Process

In addition to Total Recycle C-Improved Process, the Total Recycle D Process is one of the newest total solution recycle process derived by distinct improvement in the utilities consumption of the Total Recycle C Process. One of the process features of Mitsui Toatsu Total Recycle D Process is to use the excess ammonia in the reactor to get a higher conversion as same as Total Recycle C Process.

This excess ammonia is separated by pressure release and cooled and condensed for recirculating to Reactor. The enthalpy of the excess ammonia, which is usually condensed by the cooling water, is extremely large and such large quantity of enthalpy is lost into the cooling water.

In the new process with the addition of the high-pressure separation unit the excess ammonia is separated by flashing under the high pressure of 60-80 Kg/cm<sup>2</sup>G and condensed at 100-110°C by direct contact of liquid ammonia. Thus the enthalpy of the gaseous excess ammonia is effectively utilized and maintained.

On the other hand during flashing some carbamate is decomposed and this is scrubbed in High Pressure Absorber by the absorbent solution from Medium Pressure Absorber to remove CO<sub>2</sub>. The resulting carbamate solution at 130-140°C is recycled to Reactor.

Accordingly the feeds of both liquid ammonia and recycle carbamate solution have the higher enthalpy than those of the conventional process, the excess heat of Reactor can be used either to produce the steam in the mixer or as a heat source in Reboiler of the decomposition section.

The above described improvement has brought about a lower utilities consumption and smaller size of equipment down-stream of High Pressure Separator and Ammonia Condenser.

## B. Process Description

The process is outlined under the heads, synthesis section, decomposition section and absorption section according to the process flow sheet shown in Figure-3.

### Synthesis Section

Urea synthesis is carried out with liquid ammonia and gaseous carbon dioxide supplied from the ammonia plant. Carbon dioxide is first boosted up by Centrifugal Compressor and then compressed upto  $180-250 \text{ Kg/cm}^2\text{G}$  by Reciprocating Compressor to be fed to Mixer. Liquid ammonia from Ammonia Absorber is pressurized to  $180-250 \text{ Kg/cm}^2\text{G}$  by  $\text{NH}_3$  Feed Pump and preheated in Ammonia Pre-heater, a part of it flowing into Mixer and another to Reactor. Steam condensate is used for preheating liquid ammonia. Recycle carbamate solution is also charged to Mixer after it is pressurized to  $180-250 \text{ Kg/cm}^2\text{G}$  by Recycle Feed Pump.

In Mixer liquid ammonia, carbon dioxide and recycle solution are mixed. The excess heat in Mixer is recovered by exchanging heat with the solution in Reboiler for Medium Pressure Decomposer. This mixed solution in the mixer is reacted in Reactor to form urea.

### Decomposition Section

The reactor effluent solution, which consists of urea, ammonium carbamate, excess ammonia and water, is depressurized to  $60-80 \text{ Kg/cm}^2\text{G}$  through the let-down valve at the top of Reactor and flows into High Pressure Separator. Here the excess ammonia and some of ammonium carbamate are separated by flashing and the

overhead gas is sent to High Pressure Absorber. The pressure of the solution is then reduced to 15-20 Kg/cm<sup>2</sup>G before it is fed into Medium Pressure Decomposer. In Decomposer the solution is heated in Reboiler by recovering the excess heat from Mixer and further heated by steam in the bottom part heat exchanger. The solution from Medium Pressure Decomposer is then treated in Low Pressure Decomposer and Gas Separator as the same manner as TR-CI Process.

### Absorption Section

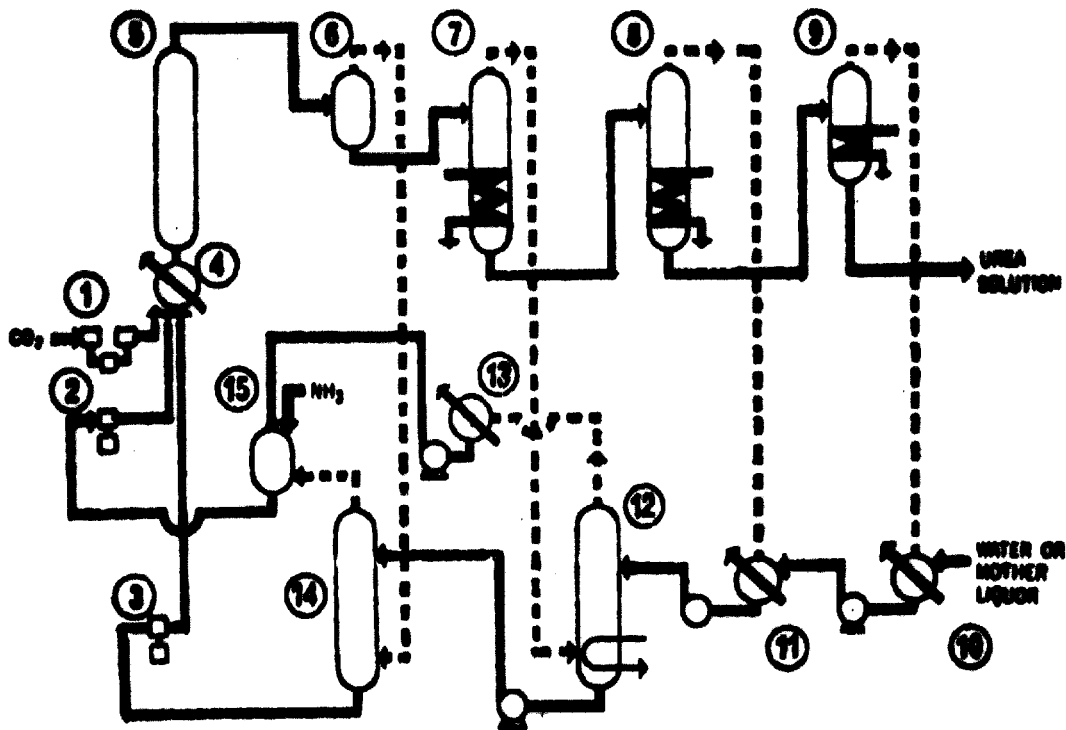
The overhead gas from the upper part of Gas Separator is absorbed in Gas Condenser by the mother liquor from Centrifuge and this solution is sent to Low Pressure Absorber as the absorbent solution for the gas coming from Low Pressure Decomposer. Then the solution is pressurized to be sent to Medium Pressure Absorber. In Medium Pressure Absorber the gas from the medium pressure decomposer is absorbed by the solution from Low Pressure Absorber and also washed by aqueous ammonia solution to remove carbon dioxide completely. The pure ammonia gas from this absorber is cooled and liquefied in Ammonia Condenser and fed to Ammonia Absorber with the fresh liquid ammonia.

The separated gas, from High Pressure Separator is scrubbed in High Pressure Absorber to remove carbon dioxide by the absorbent solution descending from the top of this absorber. Pure ammonia gas is condensed in Ammonia Absorber by direct contact of liquid ammonia from the ammonia condenser, the temperature of which is increased and the condensed ammonia is recycled to the reactor at 100-110°C. The carbamate solution is also recycled to the reactor at 130-140°C from the bottom of High Pressure Absorber.

The gas with the air from the lower part of Gas Separator is scrubbed in Waste Gas Recovery Column and the aqueous ammonia solution so formed is sent back to the upper part of Gas Separator.

The Total Recycle D Process, based on the Total Recycle C Process, is not essentially different from the latter in respect of product quality and operability. The high pressure system of the D Process, including the carbamate pump, has been tested in the pilot plant and excellent operability was ascertained.

Figure-3: MITSUI TOATSU TOTAL RECYCLE D PROCESS



- |                               |                               |
|-------------------------------|-------------------------------|
| 1. Compressor                 | 9. Gas Separator              |
| 2. NH <sub>3</sub> Pump       | 10. Gas Condenser             |
| 3. Recycle Pump               | 11. Low Pressure Absorber     |
| 4. Mixer                      | 12. Medium Pressure Absorber  |
| 5. Reactor                    | 13. NH <sub>3</sub> Condenser |
| 6. High Pressure Separator    | 14. High Pressure Absorber    |
| 7. Medium Pressure Decomposer | 15. NH <sub>3</sub> Absorber  |
| 8. Low Pressure Decomposer    |                               |

V. CONSUMPTION FIGURES AND OPERABILITY

Mitsui Toatsu Total Recycle C-Improved Process and Total Recycle D Process are the latest developments and the utilities consumption figures are remarkably improved.

The improvements of consumption figures are compared in Table-III.

Table-III: IMPROVEMENTS OF CONSUMPTION FIGURES

Process	TR-C		TR-C-Improved		TR-D
		<u>Low Biuret</u>	<u>Low Biuret</u>	<u>High Biuret</u>	<u>Low Biuret</u>
Liq. NH <sub>3</sub>	(tons)	0.570	0.570	0.570	0.570
CO <sub>2</sub>	(tons)	0.750	0.750	0.750	0.750
Power*	(KWH)	160	160	145	155
		(100)	(110)	(85)	(110)
Steam	(tons)	1.10	0.90	1.10	0.85
Cooling Water (m <sup>3</sup> )					
25°C, t=15°C		67	64	55	55

\*: When 42 Kg/cm<sup>2</sup> steam is available, CO<sub>2</sub> is compressed by steam driven turbine at the first stage, and accordingly electric power consumption will be reduced to the figures shown in the parenthesis.

One of the features of Mitsui Toatsu Total Recycle Processes is the good operability because of easy operation. The on-stream factors achieved are shown in Table-IV.

**Table-IV: ON-STREAM FACTORS ACHIEVED**

	TR-B Pusri *1 Indonesia	TR-C MTC Osaka *2 Japan	TR-CI MTC Osaka *3 Japan
1964	103.5%		
1965	94.1		
1966	93.0	start-up	
1967	93.3	98.08%	
1968	95.5	97.75	
1969	84.2	97.28	start-up
1970	98.4	97.80	96.3%

\*1: The plant has the capacity of 300 MT/D and was started up in 1963. On-stream factor is based on the annual production capacity.

\*2: The plant has the capacity of 770 MT/D and was started up in 1966. On-stream factor is based on the on-stream days excluding annual shutdown for maintenance.

\*3: The plant has the capacity of 1,500 MT/D and was started up in 1969.

This Table-IV proves that MTC Urea Processes has performed an excellent on-stream factor even in the developing country.



## VI. ADVANCED TECHNOLOGY IN LARGE SCALE PLANTS

### A. CO<sub>2</sub> Compressor

When the plant capacity is getting bigger, the combination of the centrifugal compressor and the reciprocating compressor gives much advantage to the plant efficiency.

Generally speaking, the reciprocating compressor needs to be shut down every certain period to change the cylinder valves, and it can be said that the cylinder valves of the first stage have far more frequency to be damaged because of the moist carbon dioxide. The compression of carbon dioxide by the centrifugal compressor up to 10 Kg/cm<sup>2</sup>G or more eliminates this problem and accordingly the frequency of the plant shut-down becomes less to obtain a stable operation and a good on-stream factor.

Furthermore the recent ammonia plants generates the high pressure steam for export such as 42 Kg/cm<sup>2</sup>G and Mitsui Toatsu Processes require only 13 Kg/cm<sup>2</sup>G steam as the process steam, and it is quite economical to compress carbon dioxide by the steam driven centrifugal compressor with utilizing the difference of enthalpy between high pressure steam and 13 Kg/cm<sup>2</sup>G steam. This saves the electric power consumption by nearly one third of total electricity requirement of none available steam. Among Mitsui Toatsu Processes, already 4 plants have adopted this combination and it shows quite satisfactory performance as expected.

### B. H.P. Carbamate Solution Pump - Centrifugal Pump

To pressurize the recycle ammonium carbamate solution up to the synthesis pressure, reciprocating pumps have been usually used. But as the plant size was getting bigger, various problems

were encountered or reported because of the higher speed under the very corrosive atmosphere of ammonium carbamate solution, such as short life of the gland packing, crack of cylinder block etc.

All such problems, however, have been solved in the latest Mitsui Toatsu urea plants with co-operation of the pump manufacturer by developing new materials and combinations for gland packing, and unique design of cylinder block to eliminate the parts of stress concentration.

Besides reciprocating pumps, the centrifugal pumps must be considered to be adopted in the urea plant.

The research and development of metalloggy and the recent very accurate fabricating technology have made it possible to use the high speed centrifugal pumps in the service of pumping the recycle solution up to the reaction pressure.

In our Osaka 770 MT/D plant, two centrifugal pumps with different type and speed, both of which have the capacity equivalent to a 1,000 MT/D urea plant, were tested jointly with Toyo Engineering Corp. and two Japanese pump manufacturers, Ishikawajima Harima Heavy Industries, Corp. (IHI) and Ebara Manufacturing Co.

IHI Centrifugal Pump is the 4 stages horizontal split barrel type with the floating ring as sealing mechanism. Ebara Pump is the 8 stages vertical split barrel type with the mechanical sealing mechanism.

Both of these centrifugal pumps have achieved the running record of more than 2,000 hrs and proved both mechanically and metallogically quite satisfactory.

Besides the centrifugal pumps manufactured in Japan and tested as above, Sundstrand Corporation also has the practical experience of centrifugal pumps which are called as "Sundyne Pumps". The first machine was installed in Shell Chemical's 400 MT/D urea plant in U.S.A. of Montedison Process and the second machine in ICI's 1,016 MT/D urea plant in England of Mitsui Toatsu TR-C Process. The reliability of Sundyne Pumps has been commercially proven in both plants for these two years.

We believe that centrifugal pumps will be adopted shortly in place of reciprocating pumps because of the various advantages such as the compact size, lower price, less maintenance, etc., and these advantages will be emphasized in the large capacity plants.

### C. Material

In the chemical plants the material of construction is one of the most concerned subject and this is not exceptional for the urea plants because the urea plants have to treat the very corrosive ammonium carbamate. In the very corrosive atmosphere such as in High Pressure Decomposer, even titanium or AISI 316L has suffered corrosion. Here new material has been developed with the collaboration of Mitsui Toatsu and Japanese Metal Manufacturer. This new material has the similar composition to AISI 329 but lower carbon content. Metallogically it has the two phase structure of ferrite and austenite and improves the corrosion resistance very much, which has been proven in our Osaka Plant. Another outstanding characteristic is to be very strong to chlor ion. This means when sea water is used for both process side and cooling water side, where costly bimetal tubes had to be adopted in the past.

#### D. Measures for Pollution Control

When the prilled urea is produced, the prilling tower is normally used to make prills from the molten urea by air cooling. The air emitted from the top of the prilling tower contains fine urea dusts which is the source of air pollution.

Very recently the unique and economical technique has been developed. The wet resin curtain with several ventilators will reduce the amount of dusts in the effluent air down to less than  $50 \text{ mg/Nm}^3$ .

#### E. Computer Control

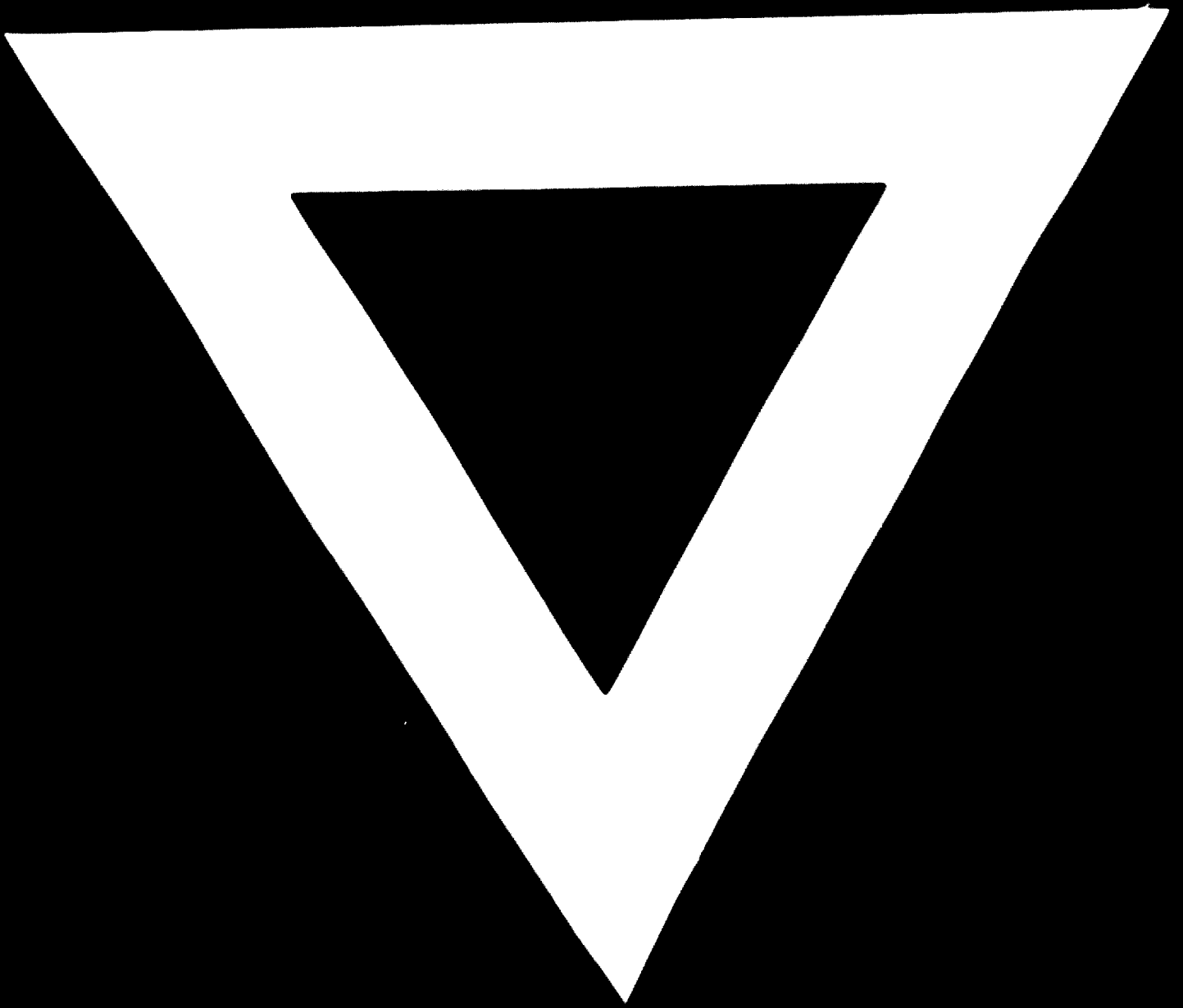
The incorporation of the computer into the process contributes to the efficient production with various advantages.

1. Increase of production by quick and accurate action for the debottlenecking.
2. Stable operation
3. Optimization of operation
4. Rationalization of production control

In Mitsui Toatsu Osaka Factory, 770 MT/D urea plant is operated with the closed loop control by IBM 1800 is being utilized for the data logging.

Thus Mitsui Toatsu has the first hand experience of the computer control in the fertilizer field and this is being appreciated highly in the world.





**22 . 3 . 74**