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*\*In 1982, the name of the International Superphosphate Manufacturers' Associations (ISMA) was changed to International Fertilizer Industry Association (IFA).*

A CONTRIBUTION TO ENERGY SAVING: A NEW PROCESS FOR UREA PRODUCTION

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## FOREWARD

Fertilizer production requires a considerable power consumption which can be listed in four different classes:

- hydrocarbon as feedstock
- fuel for thermal uses
- electric power
- steam production.

The Agricultural Division of Montedison produced in 1979:

- ammonia (as intermediate) .....	936 . 10 <sup>3</sup> mt
- complex fertilizer .....	1370 . 10 <sup>3</sup> mt
- ammonium nitrate 26% N .....	415 . 10 <sup>3</sup> mt
- urea .....	890 . 10 <sup>3</sup> mt

The correspondent energy consumption, expressed as TEP (°), are:

- feedstock .....	487 . 10 <sup>3</sup> TEP/y	40.2%
- fuel .....	506 . 10 <sup>3</sup> TEP/y	41.8%
- electric power .....	192 . 10 <sup>3</sup> TEP/y	15.8%
- steam production .....	26 . 10 <sup>3</sup> TEP/y	2.2%

81.2% of these consumption refer to ammonia and 12% to urea production.

A maximum effort for an energy reduction in the fertilizer industry must therefore be directed towards the processes which have the biggest energy consumption, meaning the process for the production of ammonia and urea.

The Montedison's Agricultural Division is operating in this direction and in carrying out important studies and development plans for new processes of ammonia and urea synthesis, both characterized by low energy consumption.

While the new synthesis process is still at a preliminary stage, the development of the new urea process is much more advanced, and the prototype plant on industrial scale will be ready for the start-up operations at the end of the present year.

For this reason, we have decided to devote the following short report to this new urea process, while it is our intention to describe and explain the new ammonia process during the next Technical Conference in Greece.

## HOW TO IMPROVE THE CURRENT UREA TECHNOLOGY

The urea production technology has not shown any significant breakthrough in the last ten years (encompassing the 1973 oil crisis). The latest big step forward was the development of the stripping processes and the almost simultaneous improvement of the total recycle processes.

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(°) 1 TEP = 1 mt equivalent oil having 10.000 kcal/kg n.h.v.

Today four processes dominate the market: carbon dioxide stripping by DSM, ammonia stripping by SNAMPROGETTI and two versions of total recycle by MITSUI TOATSU and MONTEDISON.

The performances of these processes are very similar: roughly they use 1000 kg of process steam per ton of urea produced. MITSUI TOATSU and MONTEDISON adopted centrifugal pumps for the recycle of unreacted carbamate to the reactor, thus eliminating the high maintenance costs associated with the reciprocating pumps formerly used for this service.

Now, we might wonder if the current well established technology is here to stay for a long time in the future, or, on the contrary, there is room for further significant improvements.

MONTEDISON's opinion on this issue is that present day processes (including its own) have not yet been completely optimized, because none of them features a high conversion and, at the same time, an easy way to recycle the unreacted carbamate to the reactor.

Most processes have a simple recycle loop at the expense of a low reactor conversion, whilst the one obtaining a good conversion uses a rather recycle loop.

We feel that further significant improvements can be made in the urea production technology by increasing the conversion without undue complications in the recycle of unreacted matters to the reactor.

Obviously the best way of recycling the carbamate is to minimize the need of recycle by obtaining the highest practical conversion in the reactor.

If we can get this result the problem of the recycle becomes much more manageable.

But what is the price for a high conversion?

To increase the conversion in the reactor, we must increase the  $\text{NH}_3/\text{CO}_2$  molar ratio in the feed and, accordingly, we will get more unreacted ammonia in the reactor effluent.

The price to be paid is therefore the cost related to the recycling of the excess ammonia.

In the new process that we are currently developing we found an effective way of obtaining at the same time a high conversion per pass and a simple recycle of the unreacted matters (mostly ammonia) to the reactor, thus obtaining far better performances than the ones of the most up to date plants.

#### THE NEW MONTEDISON HIGH CONVERSION, ISOBARIC DOUBLE RECYCLE PROCESS (IDR PROCESS)

We are giving here below a short description of the new process. Further details can be found in a recent paper published in Hydrocarbon Processing/1/. As already mentioned, the new process features a high conversion and an easy way to recycle the unreacted matters to the reactor.

The high conversion of carbamate to urea and the relevant energy saving are obtained operating with a fairly high  $\text{NH}_3/\text{CO}_2$  molar ratio in the reactor, whilst the separation of the unreacted carbamate and excess ammonia is effected by two decomposers in series operating at the reactor pressure using as stripping agents  $\text{NH}_3$  and  $\text{CO}_2$  respectively.

(1) Make urea with less energy, Hydrocarbon processing, May 1979

With reference to fig. 1, the urea solution from the reactor flows to the first decomposer, where most of the unreacted carbamate and excess ammonia are decomposed and/or vaporized and recycled to the reactor in vapour phase.

The operation is similar to the one described in U.S. Pat. 3,049,563. The injection of some stripping ammonia in the first decomposer will favor carbamate decomposition, as already said, whilst vapours in excess of the heat demand of the reactor will flow to the carbamate condenser.

The solution outflowing from the first decomposer will contain little carbamate but still a significant amount of free ammonia, due to the excess ammonia used in the reactor/first decomposer system.

Unlike other processes in which a similar solution is flashed and sent to medium and low pressure decomposing steps, in our case the solution is sent to a second decomposer in which it is stripped by CO<sub>2</sub> feed.

We point out that the operation of this second decomposer is different from the one described in Belgian Patent 602,219 because the main purpose of the CO<sub>2</sub> stream is to lower the ammonia partial pressure in gas phase, thus promoting ammonia vaporization, whilst pickup of CO<sub>2</sub> by the solution will be marginal due to the temperature unfavorable to carbamate formation.

In such a way, it will be possible to obtain urea solution with low content of NH<sub>3</sub> and CO<sub>2</sub>, eliminating the need for a medium pressure decomposing step. A simple flash before feeding the solution to the vacuum concentration section will adequately separate the residual amounts of NH<sub>3</sub> and CO<sub>2</sub>.

The vapours from the second decomposer, made up of CO<sub>2</sub>, NH<sub>3</sub> and H<sub>2</sub>O are mixed with the small stream of carbonate solution coming from the downstream operation and condensed in carbamate condenser, which produces medium pressure steam (6 kg/cm<sup>2</sup>).

This arrangement of double stripping and recycles to the reactor makes the achievement of two apparently conflicting goals possible, such as to operate with high NH<sub>3</sub>/CO<sub>2</sub> ratio in the reactor (which means high conversion and low energy consumption) and to obtain directly in high pressure loop an urea solution with negligible amounts of unreacted matter.

We give below the expected performances of the new process:

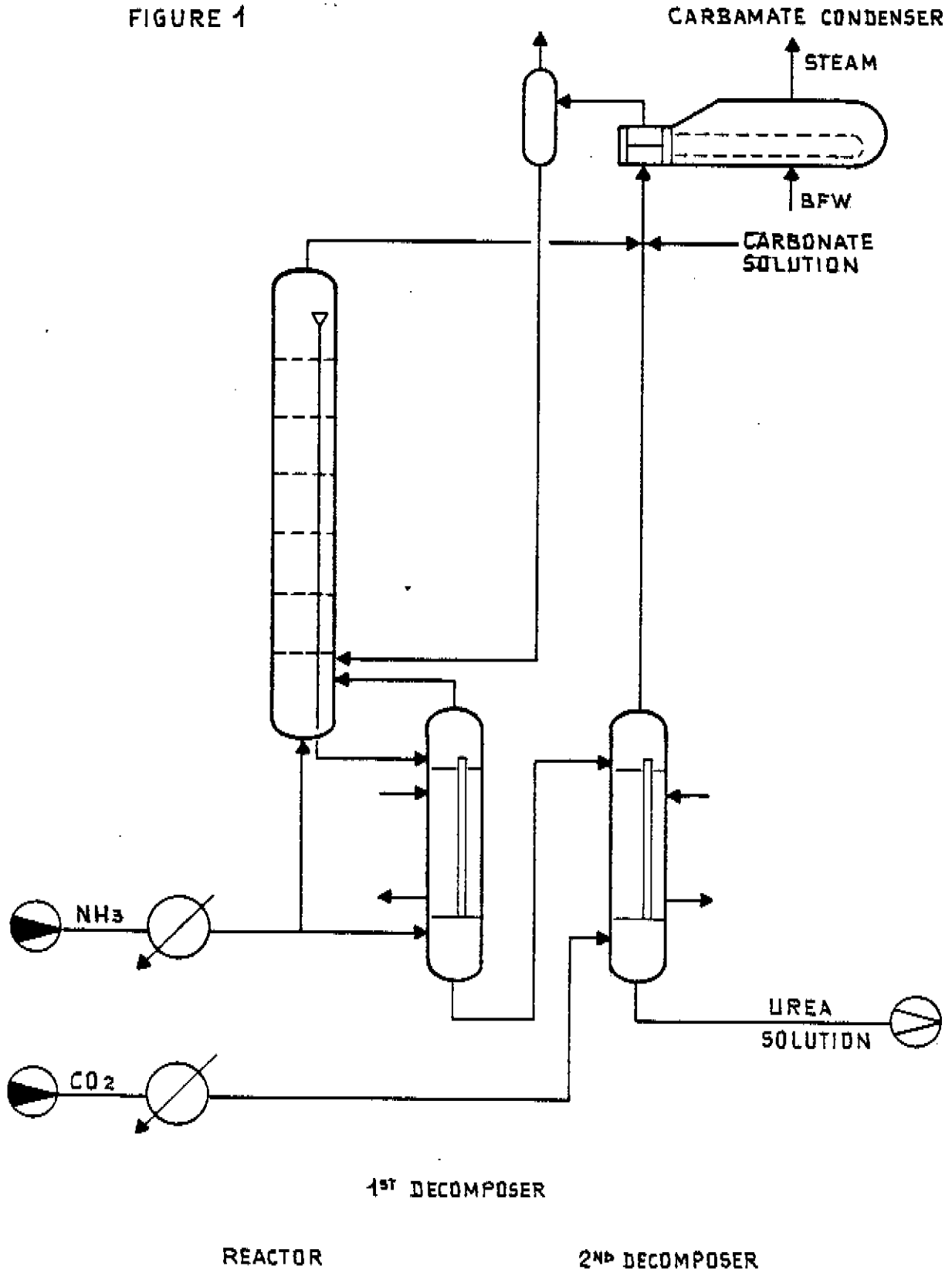
- operating pressure .....	180±220	kg/cm <sup>2</sup>
- steam consumption (30 kg/cm <sup>2</sup> ) .....	500±600	kg/t urea prilled
- steam recovery (6 kg/cm <sup>2</sup> ) .....	100±200	kg/t urea prilled
- NH <sub>3</sub> /CO <sub>2</sub> molar ratio in the reactor .....	4.5±5.6	
- carbamate conversion per pass .....	74±78	%

The steam consumption is roughly 40% less than the one of current plants.

Due to the significantly reduced overall heat duty, the total heat transfer surface of the two decomposers is lower than the one required by conventional strippers. The carbamate condenser, too, has a very reasonable size due to the favorable NH<sub>3</sub>/CO<sub>2</sub> ratio at the operating conditions.

The reduced size of the above mentioned equipment and the simplification of the finishing section allow a significant reduction of the investment required for the plant (in the range of 15 to 20% less than the best current plants).

FIGURE 1



## COMMERCIAL SCALE DEMONSTRATION

A program aimed to the demonstration on commercial scale of the new IDR process is under way.

The demonstration plant is being built by revamping a 300 MTPD urea plant located in our factory of S. Giuseppe di Cairo (Italy).

The demonstration is relevant to the performance of the high pressure synthesis loop (reactor, decomposers, condenser): therefore new equipment will be used for this section, whilst the urea solution will be finished in the existing facility.

We obtained a low interest loan of approximately 1.2 millions U.S. doll. for the construction of this plant from the European Economic Community, within the frame of financem<sup>e</sup>nt granted to "Energy Saving Demonstration Projects". This grant proves that our project is considered worthy and innovative.

We adopted for the construction of the new equipment materials widely used in present day urea plants and tested them at the foreseen operating conditions in a pilot reactor at our Research Institute G. Donegani, Novara (Italy).

The test program is aimed at the demonstration of the performances expected from the new process, to the optimization of the synthesis loop and of single equipment items.

The construction work is well advanced and we foresee the plant will start at the end of the current year, performing a 6 month experimental program. The process should be available for further adoption within Montedison Group and licensing to interested parties around mid 1981.

Fig. 2 shows the high pressure loop under erection at San Giuseppe di Cairo.

We would like to remind you that in developing the new process we made large use of our 30 year old experience in design and construction of urea plants.

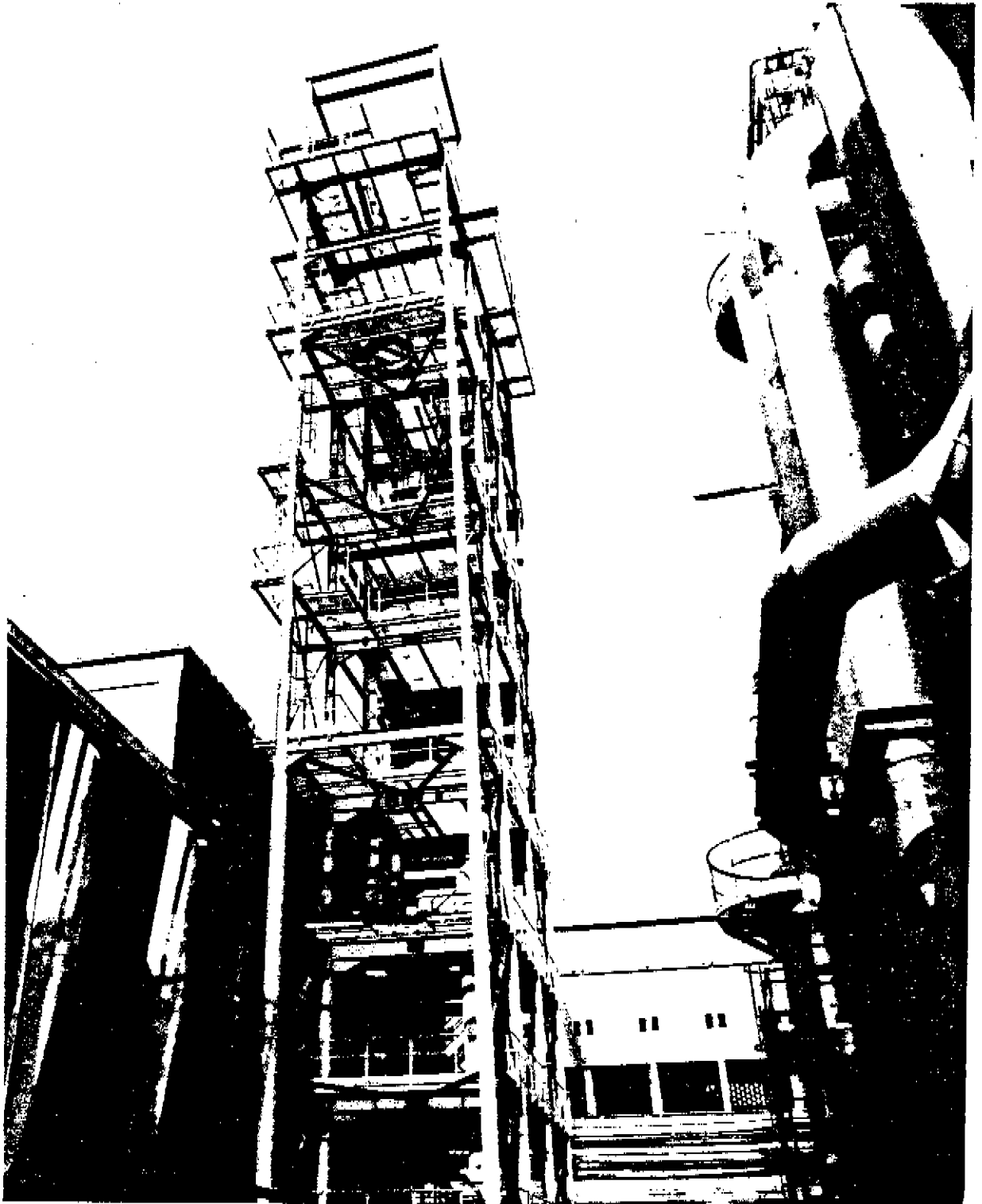
The enclosed table lists the urea plants built in the last 10 years using our process.

## CONCLUSION

The new IDR urea synthesis process is to be considered not only as a MONTEDISON contribution to the improvement of urea production technology but also a significant energy saving process with the relevant manufacturing cost reduction.

This development is the first achievement of a large MONTEDISON plan aimed at saving energy by modifying the chemical process. This plan will obviously affect several different processes in the near future.

Figure 2 - High pressure loop under erection at S. Giuseppe di Cairo.



PLANTS BASED ON MONTEDISON UREA PROCESS BUILT SINCE 1968

<u>Country</u>	<u>Location</u>	<u>Company</u>	<u>Year</u>	<u>Capacity</u>	<u>Product</u>
Netherlands	Sluiskil	Compagnie Néerlandaise de l'Azote	1968	700	Prills
Netherlands	Sluiskil	Compagnie Néerlandaise de l'Azote	1970	1100	Coated Prills
U.S.S.R.	Kirovakan	Kirovanskii Chimcombinat	1973	54	Urea solution
India	Durgapur	The Fertilizer Corp. of India Ltd.	1973	1000	Prills
India	Cochin	The Fertilizer & Chemicals, Travancore Ltd.	1973	1000	Prills
India	Namrup	The Fertilizer Corp. of India Ltd.	1976	1000	Prills
India	Barauni	The Fertilizer Corp. of India Ltd.	1976	1000	Prills
India	Talcher	The Fertilizer Corp. of India Ltd.	(°)	1500	Prills
India	Ramagundam	The Fertilizer Corp. of India Ltd.	(°)	1500	Prills
India	Haldis	The Fertilizer Corp. of India Ltd.	(°)	500	Prills
India	Nangal	The Fertilizer Corp. of India Ltd.	(Planned)	1000	Prills
India	Korba	The Fertilizer Corp. of India Ltd.	1979	1500	Prills
India	Sindri	The Fertilizer Corp. of India Ltd.	1977	1000	Prills
Italy	Ferrara	MONTEDISON	1980	1500	Coated Prills
U.S.S.R.	Gorlovka	Techmashimport	(°)	1500	Coated Prills
U.S.S.R.	Berezniki	Techmashimport	(°)	1500	Coated Prills
U.S.S.R.	Kemerovo	Techmashimport		1500	Coated Prills

(°) Under construction



TA/80/17 A contribution to energy saving: a new process for urea production by G. PAGANI, Montedison SpA, Italy (Rapporteur K.C. Knudsen, Superfos, Denmark)

Q - Mr. F.G. MEMBRILLERA, S.A. Cros, Spain

Do you add in your new urea process any oxygen or air to maintain passivation? In case you do it, where do you feed it? Is there any critical point at the synthesis equipment from the corrosion point of view?

A - We adopted, for the construction of the main equipment the up-to-date, well proven, austenitic stainless steel urea grade. We tested these materials from a corrosion point of view in a pilot reactor simulating the operating conditions of the new process. We have found that no corrosion problems occur if a good passivation of the surfaces is realized, and we have not found critical parts of equipment from this point of view. We have carefully studied the air passivation of the loop in order to avoid lacking of oxygen in some parts of the plant. We add a small quantity of air to the CO<sub>2</sub> and send other small quantities to the bottom of the reactor and the first decomposer.

Q - Is the first decomposer or stripper located physically above the second one? I mean, is the liquid flow of the first stripper flowing by gravity to the second one? In case it is, what is approximately the height of your demonstration urea plant?

A - As you have seen from the slides, the reactor and the two decomposers are not superelevated. In reality, the 2nd decomposer and the carbamate condenser work at a lower pressure with respect to the system reactor - 1st decomposer (roughly 0.5 atmosphere). We recover this loss of pressure by superelevating the carbamate condenser and utilizing the specific gravity difference between condensed carbamate and vapors to be condensed. In this way, it is possible to feed the condensed carbamate to the reactor by gravity. It is sufficient to superelevate the condenser 6-8 meters with respect to the top of the reactor for obtaining a good circulation. Of course, this superlevation may be avoided using a suitable injector.

Q - Mr. V. VANECEK, RIIC, Czechoslovakia

On the page 17-7 coated prills are mentioned. How and with what are the prills coated?

A - The question is not related to our new urea process. In any case, prilled urea is coated by spraying a urea-formaldehyde solution on the prills in a rotating drum. In this way, it is possible to obtain free-flowing urea suitable for transportation in bulk without caking problems. The proprietary firm of the process is NSM of Holland and we have a full licence for this treatment.

Q - Mr. B.K. JAIN, F.A.I., India

What are the limitations in installing the modified facility for re-vamping an existing plant with regard to size of the plant or process?

A - No limitation regarding size because we are only operating within a section of the existing plant.

Q - Mr. P. MORAILLON, Générale des Engrais, France

Is the vapor consumption used partially or totally for CO<sub>2</sub> compression?

A - No, we spoke in our report of the middle pressure steam consumption for recycling the unreacted matter to the reactor. This is the main energy consumption we have in a urea plant. No change is foreseen for the compression of CO<sub>2</sub> with respect to to-day's proven technology. In any case, the energy requirement for the CO<sub>2</sub> compression depends upon the machine driven system.

Q - What is the kWh consumption per ton of prilled urea?

A - With a reciprocating compressor driven by electric motor, the energy requirement ranges between 100-130 kWh/t urea.

Q - What is the pressure in the synthesis loop ?

A - The design pressure of our new loop is 240 atm. We will do experiments in the pressure field ranging from 150 to 220 atm. We expect to obtain the best results at 180-200 atm.

Q - Reference 1 does not appear in the French text.

A - Reference 1 is "Make urea with less energy" Hydrocarbon Processing, May 1979.