International Fertilizer Industry Association

IFA Technical Conference

Edmonton, Canada

12-15 September 1988

International Fertilizer Industry Association - Secretariat: 28 rue Marbeuf - 75008 Paris - France
Tel. +33 1 53 93 05 00 - Fax +33 1 53 93 05 45/47 - ifa@fertilizer.org - www.fertilizer.org

MONTEDISON IDR (ISOBARIC DOUBLE RECYCLE) PROCESS - PROCESS IMPROVEMENTS AND APPLICATIONS IN THE UREA PLANT RETROFITTING/REVAMPING

S. Bardi, G. Brusasco

(Agrimont, ITALY)

FOREWORD

Despite a certain revival in the urea market during the first half of 1988, mostly due to the effect of the agricultural policy recently adopted in P.R. China, the overall demand for this fertilizer is still far lower than the world-wide installed capacity.

If we compare the expected future trend in urea demand (increasing by 1.5/2% p.a.) with the actual growth of the installed capacity, the gap between demand and production capacity is destined to continue for many more years.

The 1987 world-wide installed capacity was about 95 million tons/year. An idea of installed capacity growth is given by the number of plants under construction, which will be started-up during the 1988-90 period. These are not less than 20, for a total capacity of about 9 million tons/year, and distributed among planned economy countries (60%), India (25%) South America, the Middle East and Asia.

A further 30 plants are planned/proposed for the following 2-3 years with an anticipated increase in production of 11-12 million tons/year.

If this situation, as well as the commercial policy followed in some geographic areas, does not justify significant activities in the field of new investments, especially in the more industrialized countries, it contributes, however, towards weakening the market further and making the existing plants less and less competitive.

As things stand, the IDR technology plays a privileged role in securing an all-time low energy consumption among the urea processes available on the market today.

THE IDR PROCESS TODAY

The process was first exploited on commercial scale in 1981, shortly before the inversion of the energy cost trend.

It was used for the revamping of an old Montedison urea plant, which had been in operation at San Giuseppe di Cairo (Italy) since 1967.

Revamped, the plant has played a double role of plant for research and for commercial production (for process description and details, see IFA Technical conference 1980 and 1984).

Today, despite its 20 years' working life, this plant continues to carry out its double task more than satisfactorily. In fact, the IDR technology has progressed considerably since it was applied for the first time.

Process improvements, which are the outcome of exploration of the operating opportunities offered by the process and by the exploitation of the best, have led to:
- a further reduction in energy consumption;
- simplifications and size reduction of the main items of equipment.

The performance given today by the IDR urea process is as per table 1. Here figures include requirements for the treatment of plant liquid effluents. Requirements commparison, "prilling" versus "granulation", is also given.

The urea plant can, in fact, be equipped either with prilling tower or granulation section, as well as with effluents treatment system, all processes backed by long-experimented Montedison/Agrimont technologies.

PROCESS RELIABILITY

The reliability of the IDR urea process, considerable from the very first months of commercial use, has proved sufficient to guarantee really high stream factor values, in the order of 96% or higher, regardless of plant size.

This appears evident if the stream efficiency factors recorded in the IDR urea plant at San Giuseppe di Cairo (shown in table 3) are properly extrapolated. When doing so, due consideration should be given to the fact that said plant is very old and that, like other European plants, it is facing an unfavorable commercial situation. Moreover, the complete absence of corrosion, the good equipment design and the flowsheet simplicity characterizing the IDR urea technology should be taken into account.

RETROFITTING/REVAMPING OF OLD PLANT

If, at present energy costs, the advantage offered by the IDR process is not always sufficient to justify substitutive investments, it ensures more than interesting prospects in the field of plant retrofitting/revamping, due to other process features.

The IDR technology, in fact, can be "grafted" on to any type of existing plant with the following results:
- reduced steam consumption (down to 30%);
- improved operating conditions (no corrosion, reduction in circulating volumes to 70%);
- maximum re-use of existing equipment (up to 70% in terms of cost);
- minimal interference with production continuity (the new equipment can be installed during the running of the plant and easily linked during a routine maintenance period).

To understand more clearly how these advantages are achieved, as well as the versatility of the IDR technology for old plant revamping, the following factors should be considered:

A) The IDR H.P. section (reaction and stripping), representing the actual subject of the IDR know-how, may be assimilated to a distinct "reaction and partial purification loop" which ensures:
   - an M.P. steam consumption of 500 kg/t urea, due to its high reaction efficiency;
   - the production of a recovery steam whose pressure (7 bar) and amount (900 kg/t urea) can meet the heat demand for the purification and concentration of the urea solution leaving the IDR HP section (so that the whole plant steam consumption remains 500 kg/t urea);
   - a product, the urea solution leaving the second stripper, which contains the optimal quantities of unreacted NH_3 and CO_2 to cause such conditions, in the downstream purification sections, to permit use of the H.P. section recovery steam whenever heat is required;
   - a total amount of unreacted substances (NH_3 and CO_2) in the above

solution, corresponding to about 35% of those contained in the solutions feeding the purification sections of most of the plant of the previous generation.

B) All urea plants built during the Sixties and most of those built during the Seventies, are equipped with two purification stages. Design conditions of these stages are always compatible with those caused by the purification of the solution produced by the IDR H.P. section.

We thus come to the following conclusion:

1. The IDR technology can be used to retrofit/revamp any type of plant since it completely transfers its low energy consumption advantages to them.

2. In case of retrofitting only, the sole operation needed is the installation of an H.P. IDR section. It may be possible to re-use the old reactor and also the stripper and H.P. condenser when these are present. The purification and concentration sections do not need any modifications or additions worthy of note. In this case, the investment is modest: steam consumption is reduced to 500-600 kg/t urea, depending on the type of plant to be converted, whilst the existing equipment re-utilized, thus subjected to less exacting operating conditions, can be expected to have a longer working span.

3. In case of revamping, the capacity of the plant can be economically increased by up to 50%, with steam consumption ranging from 500 to 700 kg/t urea, depending on the capacity increase and the type of plant to be converted.
In this case, modifications of existing sections for the purification, concentration and pumping of raw materials increase with the increased capacity required.
Nonetheless, the total investment still accounts for less than 30% of the investment needed for a new plant of equal capacity and equal energy requirements.

4. In both retrofitting and revamping, production losses are limited to the period of time needed to make the switch from the old process to the new one, which takes place during routine maintenance shut-down.

The advantages which the IDR technology offers in revamping/retrofitting obsolete plants have already been understood by numerous fertilizer producers.

Following the retrofitting of the San Giuseppe di Cairo Plant there was the retrofitting of a 1700 t/d plant at Ferrara, Italy and the revamping of the Luzhou plant (Luzhou Natural Gas, P.R. of China) bringing it from 500 to 750 t/d.

Moreover, many feasibility studies on other countries are under way.

Agrimont's 1700 t/d plant at Ferrara, which had operated with the Montedison "total recycle with heat recovery" process since 1978, achieved a steam saving per ton of product of over 40% after convertion to the IDR technology.

The plant at Luzhou, in operation since 1965 and based on a conventional "total recycle" process, will be revamped from 500 to 750 t/d with a steam saving per ton of product of over 50%. The project is under completion and the revamped plant is expected to be started up by the first half of 1989.

Complete details of the effect of the convertion to the IDR technology on the two abovementioned plants are given in table 4 and sheets 2 and 3, whilst the results of feasibility studies commissioned by some urea producers, who plan to modernize their plants, can be found on sheets 4, 5 and 6.

CONCLUSIONS

We can summarize the main points of the above report as follows:

- at least 50% of plants installed world-wide are obsolete and their production cost is not competitive;
- total renewal with the installation of a modern technological plant means heavy investment, which cannot be justified since the urea market is weak;
- the only possible alternative to this total renewal is the adoption of the IDR technology. With a modest investment, production costs are reduced even below those incurred with new, high-tech plants, and production increases of up to 50% can be achieved.
  Moreover, the revamped plant offers exactly the same degree of reliability and working life-span as a new plant.

TABLE 1 - IDR Plant - Requirements per Metric Ton of Urea

CO2 compressor drive:		Steam Turbine		Motor	
		Prilling	Granulation	Prilling	Granulation
- Ammonia	kg	568	568	568	568
- Carbon dioxide	kg	735	735	735	735
- Steam (105 bar, 500°C)	kg	710	710	-	-
- Steam (25 bar, sat.)	kg			530	530
- Electric power	kWh	18	41	113	136
- Cooling water (10°C temperature rise)	m3	75	75	60	60

TABLE 2 - IDR Plant - Characteristics of effluents

Liquid Effluents (process water)

- Flow rate : 0.5 m3/mt urea
- Ammonia content : 5 ppm
- Urea content : down to 0 ppm (or higher values, depending on customer's requirements)

Gaseous Effluents

- Ammonia from inert gas scrubbing: 25 g/mt urea
- Urea dust from prilling tower : . with de-dusting: < 30 mg/m3 air
  . without de-dusting:<50 mg/m3 air

TABLE 3 - MONTEDISON's IDR Urea Plant at San Giuseppe di Cairo, Italy

YEARS	Design Yearly Capacity (A) (1)	Actual Yearly Output (B)	Halt due Upstream /Related Units (F)	Remaining Available Days per Year (C)	Downtime due to Internal Causes (2)	Actual On-stream Days per Year (D)	Operating Stream Efficiency $E = \frac{D}{C} . 100$	Production Stream Efficiency $E1 = \frac{B}{A} . \frac{334}{D} . 100$
	MT	MT	days	days	days	days	%	%
1985	100,000	90,860	30	335	26	309	92	98.2
1986	100,000	102,689	12	353	22	331	93.7	103.6

(1) Based on 334 on-stream days per year.

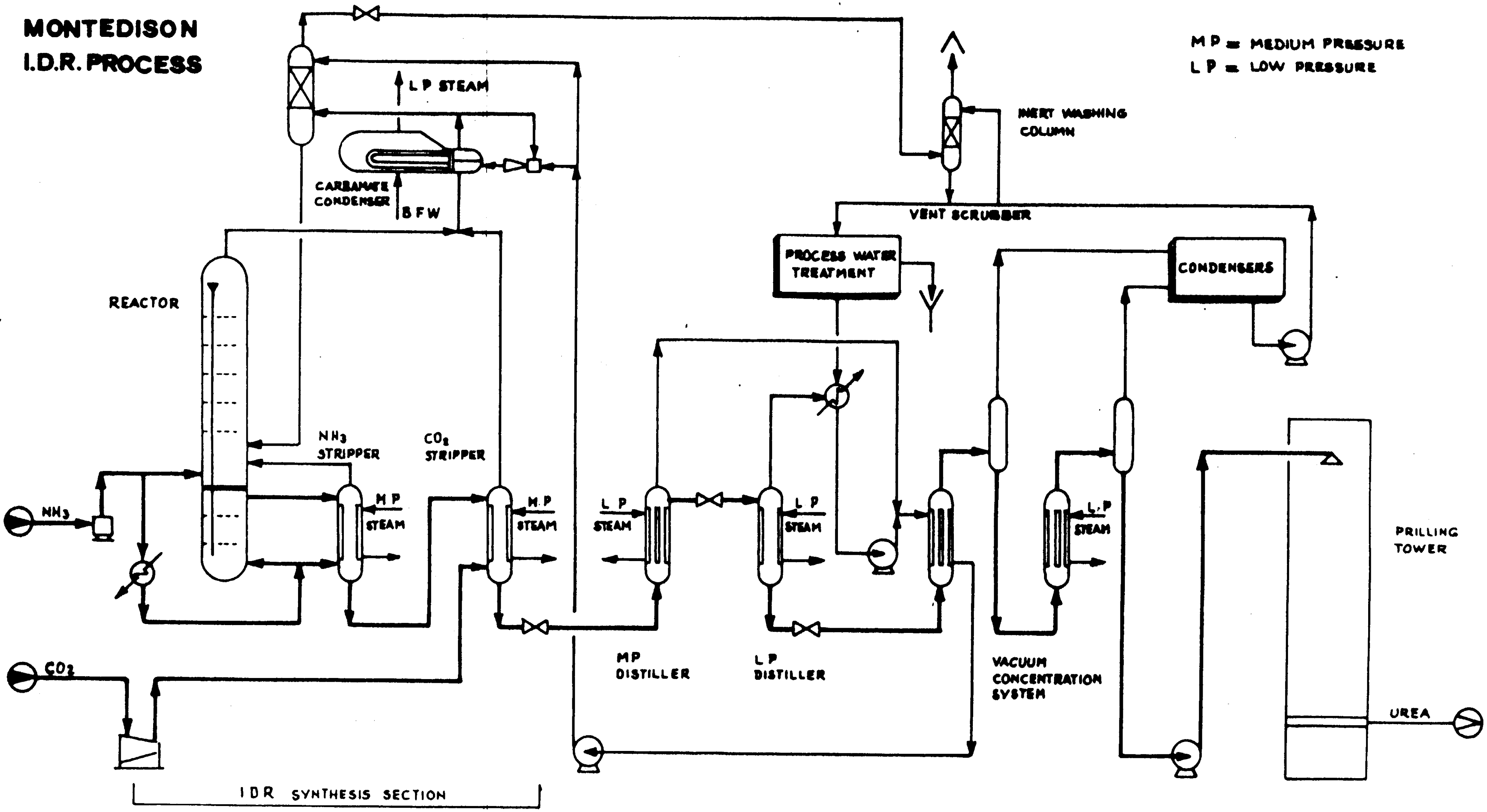
(2) Including the downtime needed for yearly scheduled maintenance, market situation, etc.

TABLE 4 - Effects of IDR Revamping

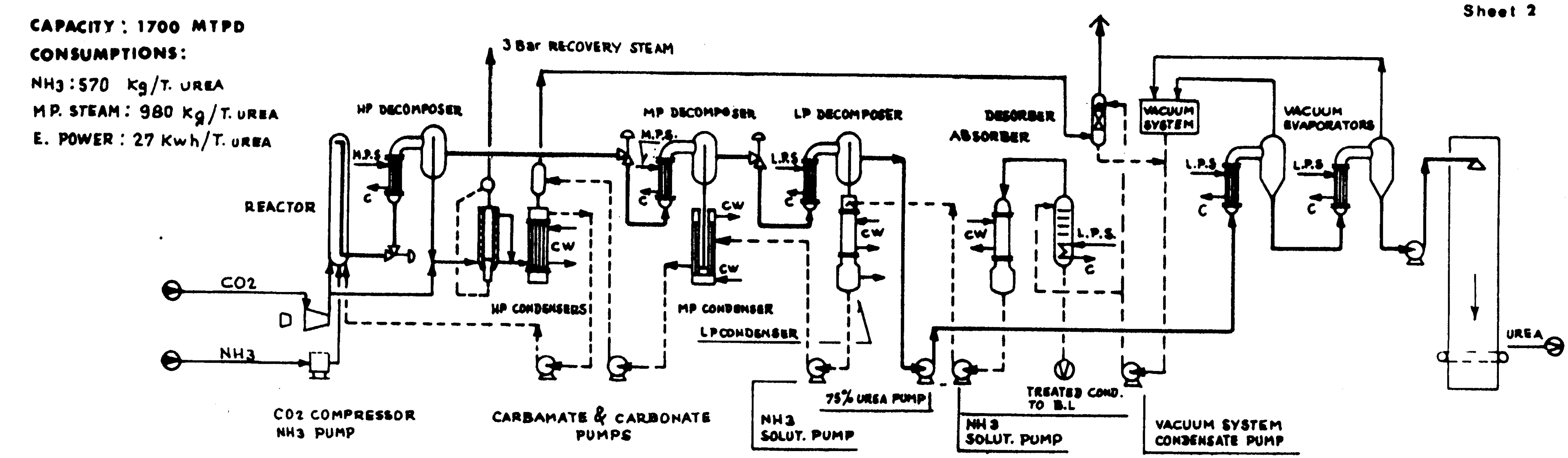
PLANT		Luzhou (1) P.R.C.	Ferrara Italy
Former capacity	(mt/d)	500	1,700
New capacity	(mt/d)	750 (2)	1,700 (2)
Former live steam consumption	(mt/mt urea)	1.46	0.98
New live steam consumption	(mt/mt urea)	0.72 (2)	0.58 (2)
Former ammonia consumption	(mt/mt urea)	0.585	0.57
New ammonia consumption	(mt/mt urea)	0.57 (2)	0.57 (2)
Former electric power consumption	(kWh/mt urea)	140	27 (4)
New electric power	(kWh/mt urea)	127 (2)	22 (2) (4)
Former cooling water circulation	(m3/mt urea)	110	130
New cooling water circulation	(m3/mt urea)	70 (2)	80 (2)
Former liquid effluents			
ammonia content	(ppm)	700	20
urea content	(ppm)	6,000	200
New liquid effluents			
ammonia content	(ppm)	<20 (3)	20
urea content	(ppm)	<20 (3)	200
Investment cost	(1987 M US$)	7.7 (5)	10
Yearly savings			
increased urea production	(mt)	83,500	-
steam	(mt)	190,000	227,000
ammonia	(mt)	3,760	-
electric power	(kWh)	3,255,000	2,840,000
C.W. circulation	(kWh)	925,000	2,600,000

(1) Project under compilation.
(2) Guaranteed figures.
(3) With effluent treatment section according to Tecnimont's technology. Guaranteed figures.
(4) CO2 Compressor driven by steam turbine.
(5) At European conditions.

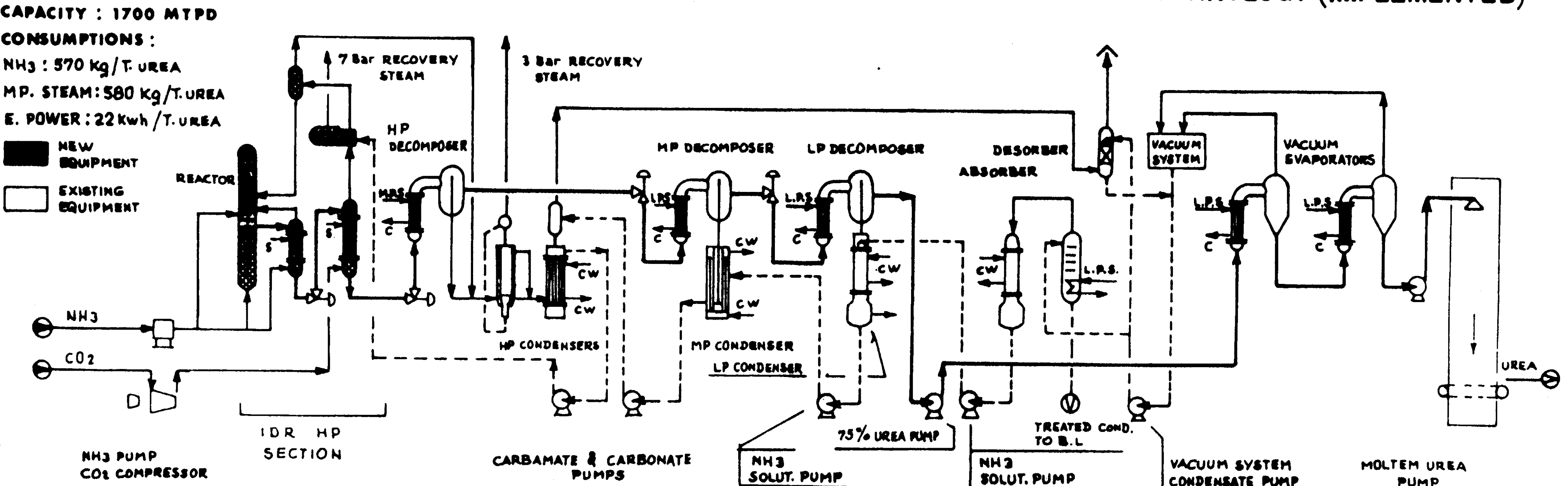
MONTEDISON I.D.R. PROCESS



ORIGINAL FLOW-SHEET OF A 1700 MTPD UREA PLANT BASED ON MONTEDISON 'TOTAL RECYCLE' PROCESS



FLOW-SHEET OF THE ABOVE PLANT RETROFITTED ACCORDING TO I.D.R. MONTEDISON TECHNOLOGY (IMPLEMENTED)



ORIGINAL FLOW-SHEET OF 500 MTPD UREA PLANT BASED ON A 'TOTAL RECYCLE' TECHNOLOGY

Sheet 3

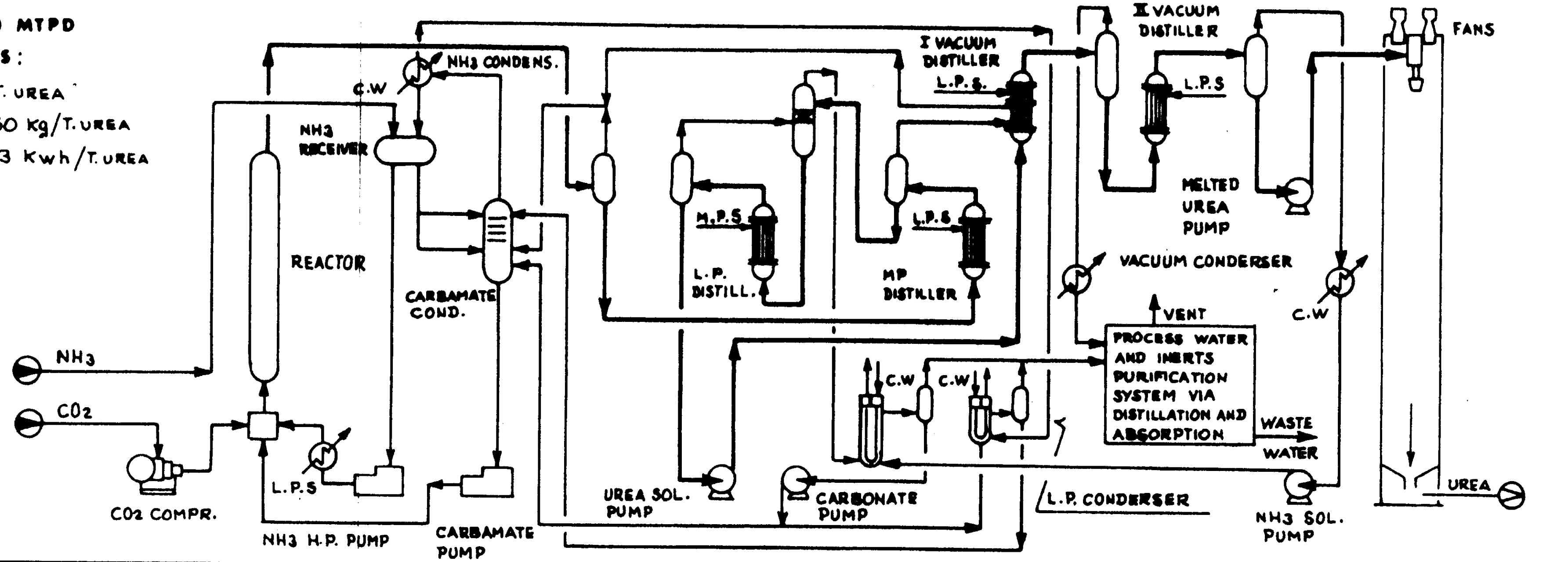
CAPACITY : 500 MTPD

CONSUMPTIONS :

NH_3 : 585 Kg/T. UREA

M. P. STEAM : 1450 Kg/T. UREA

E. POWER : 133 Kwh/T. UREA



FLOW-SHEET OF THE ABOVE PLANT REVAMPED TO 750 MTPD ACCORDING TO I.D.R. MONTEDISON TECHNOLOGY (IMPLEMENTED)

CAPACITY : 750 MTPD

CONSUMPTIONS :

NH_3 : 570 Kg./T. UREA

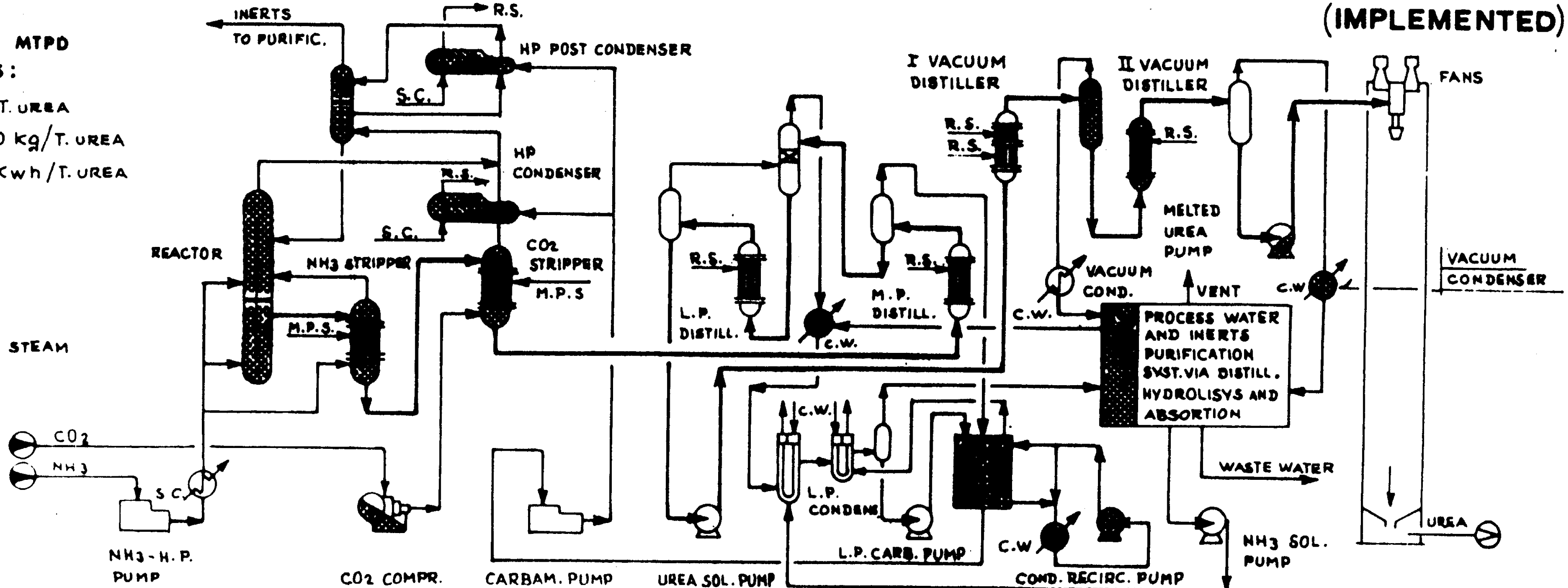
M. P. STEAM : 700 Kg/T. UREA

E. POWER : 123 Kwh/T. UREA

NEW EQUIPMENT

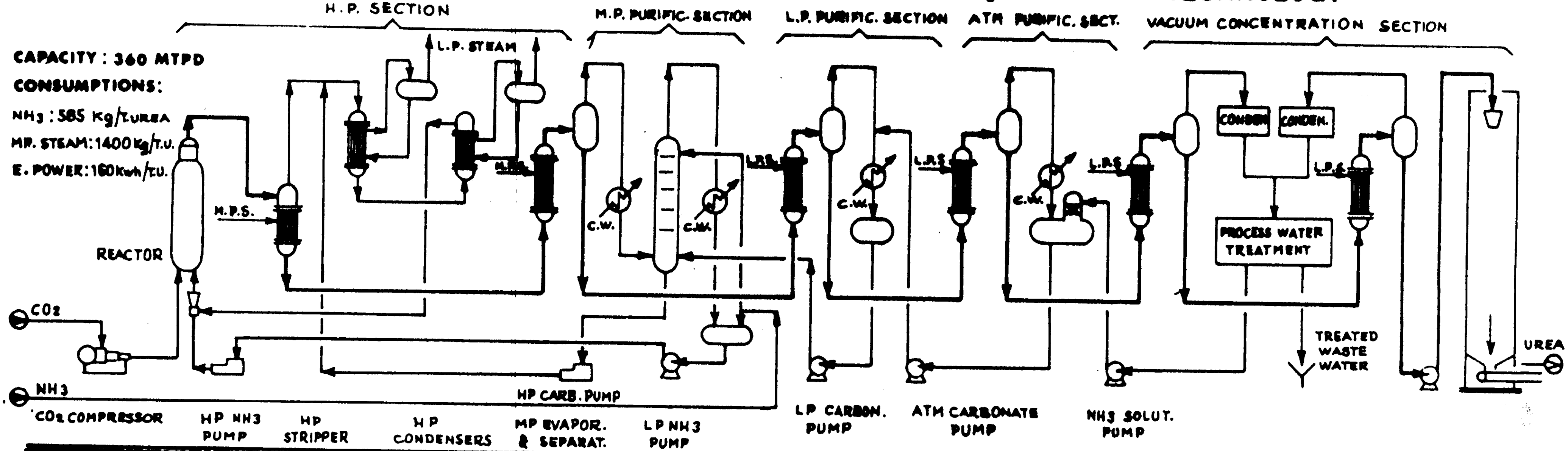
EXISTING EQUIPMENT

R. S. = RECOVERY STEAM

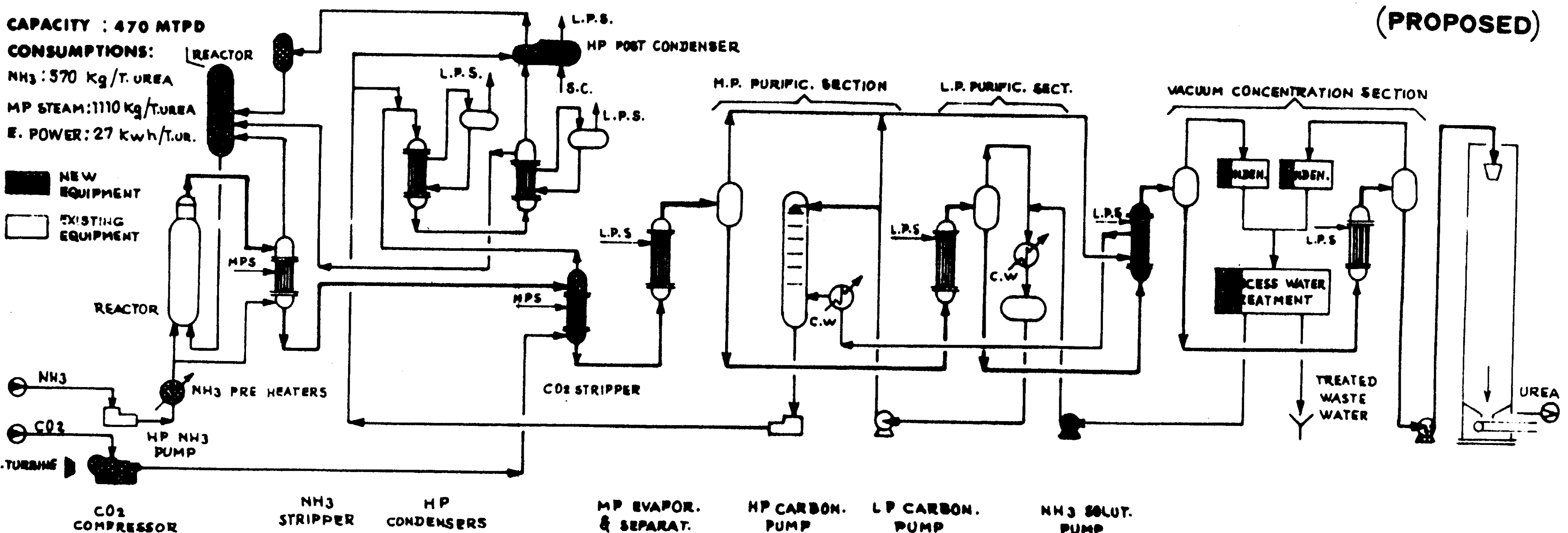


ORIGINAL FLOW-SHEET OF AN OLD 360 MTPD UREA PLANT BASED ON 'NH₃ STRIPPING' TECHNOLOGY

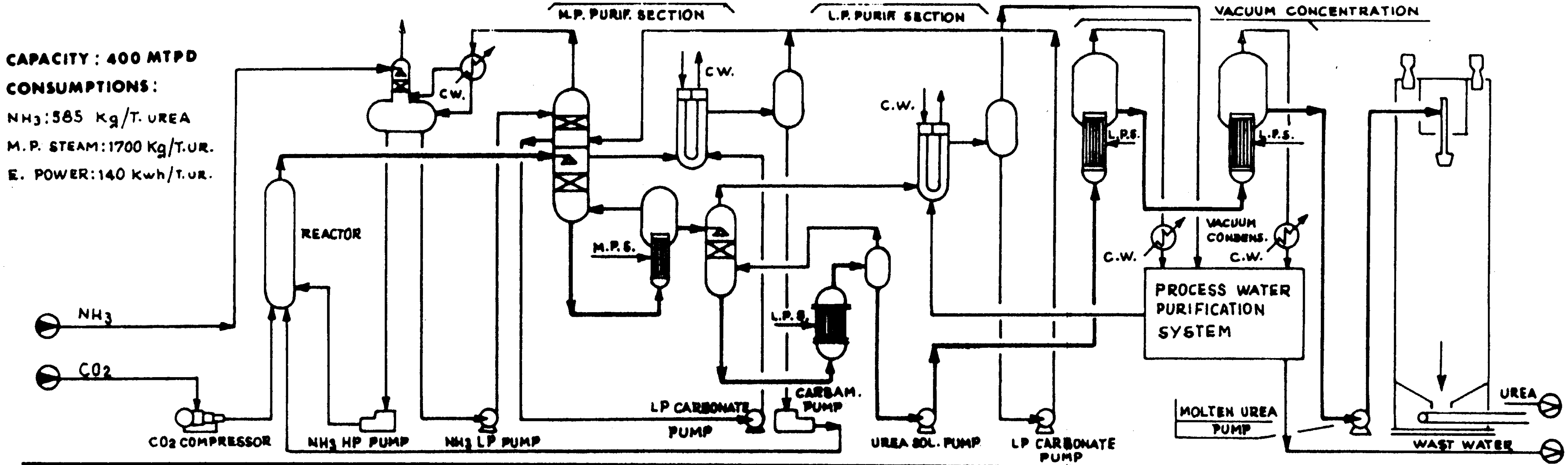
Sheet 4



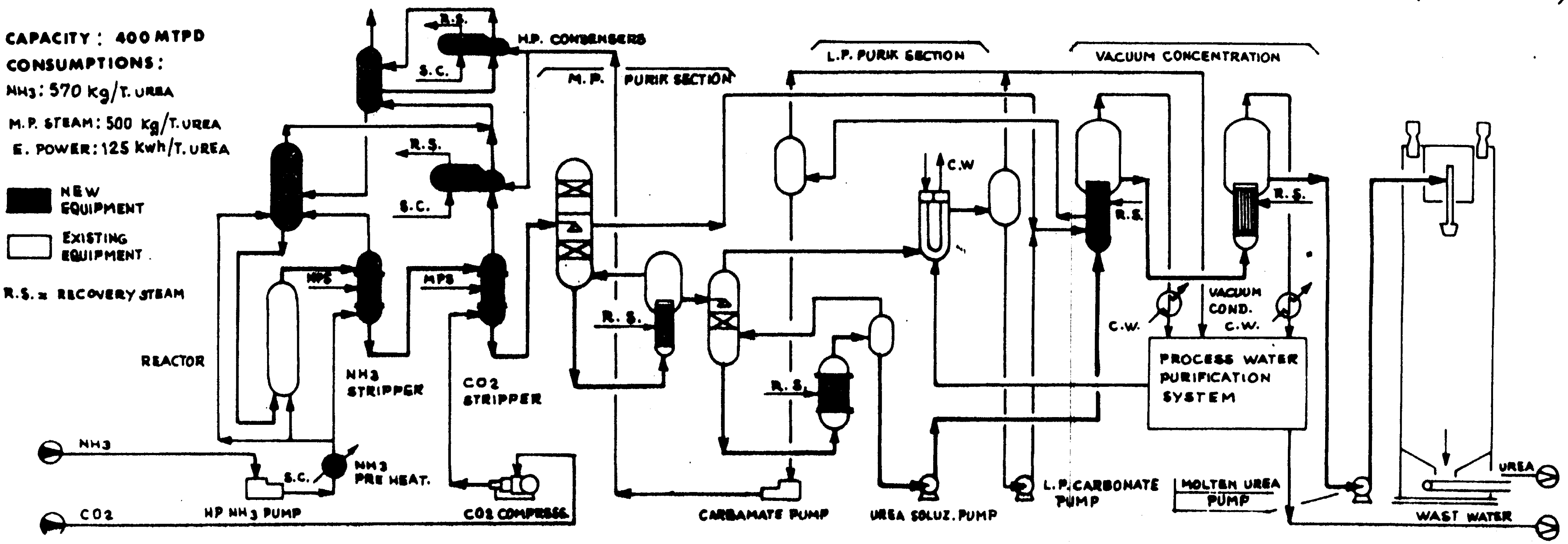
FLOW-SHEET OF THE ABOVE PLANT REVAMPED TO 470 MTPD ACCORDING TO I.D.R. MONTEDISON TECHNOLOGY (PROPOSED)



ORIGINAL FLOW-SHEET OF 400 MTPD UREA PLANT BASED ON A 'TOTAL RECYCLE' TECHNOLOGY



FLOW-SHEET OF THE ABOVE PLANT RETROFITTED ACCORDING TO I.D.R. MONTEDISON TECHNOLOGY (PROPOSED)



ORIGINAL FLOW-SHEET OF 300 MTPD (AS 80% W SOLUT.) UREA PLANT BASED ON A 'TOTAL RECYCLE' PROCESS

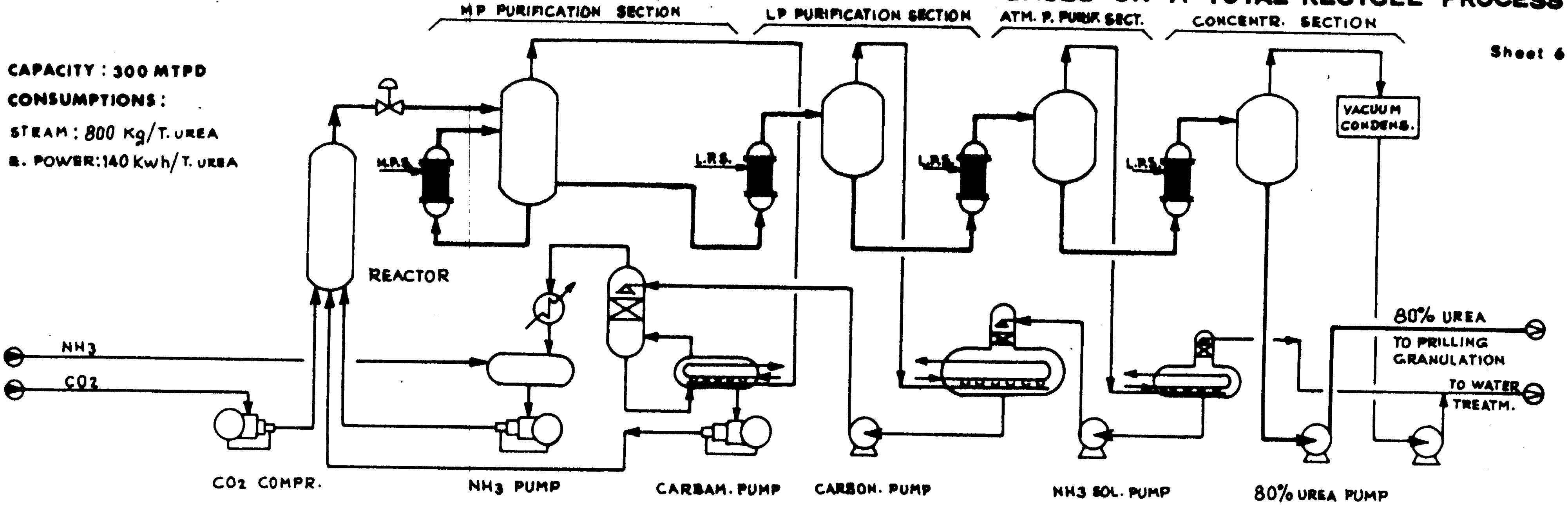
Sheet 6

CAPACITY : 300 MTPD

CONSUMPTIONS :

STEAM : 800 Kg/T. UREA

E. POWER : 140 Kwh/T. UREA



FLOW-SHEET OF ABOVE PLANT REVAMPED TO 650 MTPD (AS 80% W. SOLUT.) BY I.D.R. MONTEDISON TECHNOLOGY (PROPOSED)

CAPACITY : 650 MTPD

CONSUMPTIONS

HP. STEAM : 580 Kg/T. UREA

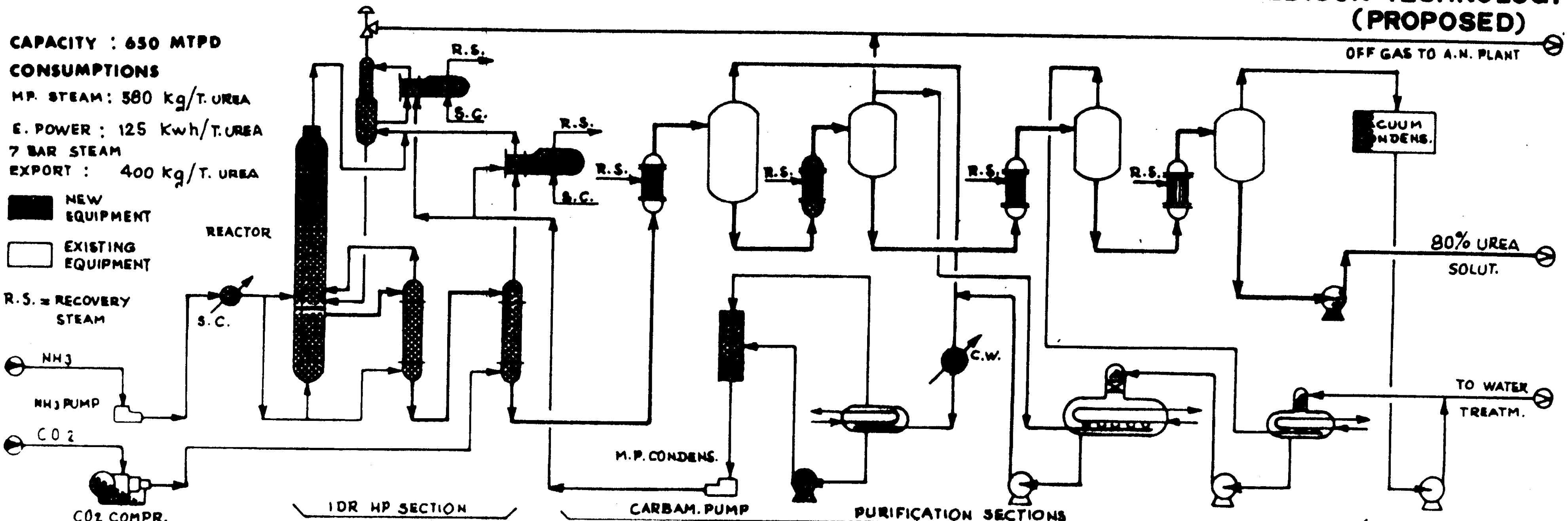
E. POWER : 125 Kwh/T. UREA

7 BAR STEAM EXPORT : 400 Kg/T. UREA

NEW EQUIPMENT

EXISTING EQUIPMENT

R.S. = RECOVERY STEAM



TA/88/7 Montedison's IDR (Isobaric double recycle) process - Process inprovements and applications in the urea plant retrofitting/revamping by G. Brusasco and L. Mariani, Agrimont, Italy

DISCUSSION (Rapporteur K. Farmery, ICI Fertilizers, UK)

Q - Mr. P. ORPHANIDES (Duetag, France)

For an urea plant operating on the basis of a conventional CO2 stripping process, do you think there are incentives to revamp (in order to improve capacity and/or energy consumption) by applying the IDR process ?

What could the expected results be ?

A - The lower limit for revamp is when the steam consumption is around 1.2 te steam/te urea. As most CO2 strippers consume around 1000 kg steam/te urea, the process is not likely to be beneficial for steam saving.

Thus, this approach is best thought of for capacity increases, not energy improvement.

For ammonia stripping processes, we have looked at revamping for urea capacity increase of up to 50% with moderate investment. In this case, most of the HP equipment can be re-used (eg the reactor, the strippers and the condensers), and the large size of the medium and low pressure purification sections can be profitably used also to give significantly higher output.

Q - Dr. S.K MUKHERJEE (KRIBHCO, India).

1/ How do you reduce energy consumption in the IDR process ? What are the key steps ?

2/ What is the ammonia conversion per pass in the IDR process ?

3/ What has been your experience of "on-stream time" for the IDR process ?

4/ What are the effluent specifications in the IDR process in terms of both free ammonia and total N in the effluent ?

A - 1/ It is easy to see how the steam consumption is reduced.

a/ Because of the very high CO2 conversion efficiency in the reactor, there is less unconverted product to be converted by steam later downstream of the reactor.

b/ Steam produced in the medium pressure purification stages is utilised by condensation to heat the urea solution sent to the vacuum section. This means that all the surplus heat from the first decomposer and the medium pressure decomposer is used in two stages.

2/ Normally, the ammonia conversion efficiency is not so important. I do not remember the numbers but, roughly, the heat consumed is 430 kilocals/kg CO2 (as carbamate) against 150-170 kilocals to evaporate each kg of free ammonia. Thus, we have established a limit, roughly ,

.../.../...

of 4 moles of ammonia for 1 mole of CO2 beyond which it is not beneficial to increase the ratio between ammonia and CO2.

3/ The only plant using this technology is the one near Genoa in Italy, which has been running since 1981. There, the on-stream factor is similar to the best others I know, and is around 8000 hours per year. We have found no corrosion or other unusual problems preventing achievement of such on-line time.

4/ The liquids from this plant are not different from those from any other process (e.g. Snam, Stamicarbon). The most frequently used procedures are ammonia stripping and urea hydrolysing. Thus, the liquid effluent from the vacuum section is sent to a rectification column to recover ammonia and then sent to a urea hydrolyser. This method can give 2 ppm NH3 and 2 ppm urea of 30 ppm NH3/30 ppm urea depending on operating conditions or client requirements. This is all well-known technology. We have installed 3 such effluent systems, one of which is in India and is well known to Dr. Mukherjee.