IFA Technical Conference

Venice, Italy

2-4 October 1990

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ENERGY MANAGEMENT - A COMPREHENSIVE VIEW

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ABSTRACT

This paper describes how an efficient energy management programme can be successfully implemented by a fertilizer industry in particular and other industries viz. petrochemical, cement, steel, etc. in general.

The paper also describes the *modus operandi* of a regular energy monitoring system. Apart from this, various energy awareness programmes and some basic management concepts like management by objectives, management by survey, etc, are also discussed in brief.

PREFACE

The imbalance between demand and supply of energy can have grave repercussions on any ambitious developmental programme for an upcoming country like India. While the government is sparing no efforts in setting up new energy sectors viz. more power plants based on different fuels like atomic energy, hydro energy, gas based projects, etc. to augment the existing installed capacities, nevertheless, it is also a prime responsibility of energy consuming sectors to ensure a judicious use of energy in various forms. In India, there are ample growth opportunities both in agricultural and industrial sectors and since Indian economy, to a great extent, depends on agricultural sector output, a fertilizer industry assumes significant role in overall development for improving the Gross National Product (GNP).

The fertilizer industry is one of the largest energy consuming sectors and there is a lot of scope of each fertilizer complex to improve its energy efficiency, thereby making some significant contribution towards an overall outlay of energy projected by Planning Commisssion of India.

In an energy management programme; rather than taking a surface view or a lop-sided approach, a well drawn-out strategic planning, proper organising, followed by a dynamic action plan will ensure reasonable success. But, merely organising and planning is not enough. It has to be adequately supported by continuous monitoring systems, appropriate simulators in the form of motivational aspect and awareness programmes. The top management necessarily has to invest time and other resources to develop strategies which can trigger-off the thinking process in its managerial cadre and down below. Although, in India, we cannot afford the luxury of extensive experimentation, the time is ripe when we start producing specialist energy managers and set up comprehensive R & D programmes which can bring tangible results.

INTRODUCTION

Gujarat Narmada Valley Fertilizers Company Limited (GNFC) is the world's largest single stream Ammonia - Urea Complex located in the industrially backward district of Bharuch. The company was established in 1976 and trial runs of ammonia - urea plants were started in January 1982. Commercial production commenced from 1st July, 1982. From fertilizers, the company has diversified into chemical, electronic and engineering industries. The company has also put up a Captive Power Unit for uninterrupted power supply. The details of existing plants in operation as well as expansion projects are enclosed in Annex 1.

During the first three years of commercial production, there were a lot of teething problems and the capacity utilisation of the ammonia plant was limited to around 65% and that of the urea plant was around 75%. After improving the reliability and continuity of plant operations, the capacity utilisation of the ammonia and urea plants registered more than 100% and 110% respectively. The energy consumption per MT of ammonia was reduced from 14 MKCal to 12 MKCal and from 9 MKCal to 8 MKCal in urea plant. The reduction in energy consumption by about 14% has been possible due to the multi-pronged approach and strategies adopted, which are outlined in subsequent pages. The various statistics of production, capacity utilisation and energy consumption are enclosed in Annexes II and III.

The whole gamut of an energy management system revolves around the modalities adopted by the company. Using these modalities as a springboard, one can launch a successful energy conservation programme.

MODALITIES OF A ENERGY MANAGEMENT SYSTEM

Formulation of the Group

Energy management should be a top management function and necessary resources in terms of time, man-power and capital should be invested for this important function. The first and foremost task is to set up a group consisting of individuals who have attitude, aptitude and necessary skills to carry out this energy conservation function. This group should be accountable for the set targets of the energy consumption. The objectives and responsibilities should be crystal clear and a senior technical person should lead this group.

At G.N.F.C. such a group was formed in 1984 (group known as Performance Monitoring Group) and the responsibility has been assigned to this group. The group consists of the Chief Manager, two managers, three engineers and four operators.

Step By Step Approach

The group has to keep in mind the set targets for consumption of raw materials, utilities, power and has to strive hard for achieving those realistic targets for energy consumption. It is obvious that these targets will be very close to the design figures given by the licencer of the plant. A systematic approach will strengthen the functioning of this group. The following steps are important and may serve as guidelines to the fertilizer companies in general.

Check List: Based on the operating guidelines, operating experience and general rules of energy conservation, a detailed check list should be prepared which consists of basically two portions. The first one is general energy conservation points applicable to all plants and the second portion should be on plant to plant basis i.e. separate for ammonia, urea, boiler plants etc. The check list should be periodically filled (say weekly for all the plant areas of Fertilizer Complex). This will help the engineers get the primary information regarding energy losses. Such a check list recently designed at G.N.F.C is enclosed in Annex IV.

Data Collection: While the check list gives general and primary information, it is also equally important to locate areas of inefficiency, deficiency and hidden loss of energy. For this purpose, the group will have to design the various proformas for data collection. These proformas may either be in the form of section-wise important parameters and/or equipment-wise i.e. separate proforma for compressors, heat exchangers, cooling towers, pumps, etc. The various data should be collected independently by the operators of this group. Of course, the correctness of the data should be periodically cross checked with the standard instruments (standard pressure gauges, thermometers, infrared temperature guns and contact type RTDs, etc.).

Data Processing: The various data will have to be analysed and processed to calculate stage-wise efficiency of the compressors, heat transfer co-efficient and dirt factors in case of heat exchangers, performance evaluation of various sections, steam balance and ultimately specific energy consumption for each different product. A computer based system can greatly enhance the capability of data processing.

Feasibility Study: From the various analyses carried out, a clear picture will emerge as to what short term measures and what should be long term measures required to achieve the set objectives of the top management. A comprehensive report on energy conservation should be circulated to the top management as well as to the concerned plant managers. Also for each scheme, feasibility study should be carried out which should include the following:

- Title of the scheme.
- General information and background regarding the problem.
- Energy loss on account of present limitations.
- Various alternatives possible.
- Proposed scheme including schematic diagrams.
- Estimated cost and savings.
- Payout period of the energy conservation scheme.

Implementation: While short term measure will not pose many difficulties, the long term measures will have to be adequately discussed and proved to be economically viable before approval for implementation.

Review of the Scheme: After implementation, the scheme should be reviewed for its effectiveness and should be compared with the original proposal. This will not only serve as an history and feed back but also bring out the strengths and weaknesses in the system - which may be useful for future actions.

Other Techniques

Probing Questions: They should be asked in the following areas:

- Any pump developing higher than the required head?
- Any vent control valve remaining open?
- Is there any repetitive cause for shut-down?
- Are we getting design vacuum for condensing type turbine?
- Is cooling water supply temperature being maintained?
- Is flue gas outlet temperature in boiler chimney maintained?

Suggestion Scheme: This will ensure participation of many employees in energy conservation programme.

Awareness Programme: At least one day in a year should be celebrated as an Energy Conservation Day. Also energy seminars and quizes should be conducted periodically. The consciousness level rise with such awareness programmes.

ENERGY MANAGEMENT AT G.N.F.C. - A CASE STUDY

The G.N.F.C. Management has felt the importance and implications of a good Energy Management System right from the commissioning stage. We took a pragmatic approach and the following strategies were adopted to effectively manage the energy so as to minimise losses and increase production, productivity and hence profitability.

Regular Energy Monitoring

A special group called Performance Monitoring Group regularly carries out monitoring of various energy consuming equipments, such as compressors, heat exchangers, heaters, pumps, etc. The data are systematically analysed in computer and the necessary corrective actions are immediately initiated. Different programmes like steam balance, heat exchanger performance check, compressor calculations, shut-down decision etc. have been developed on a computer so as to facilitate better monitoring and quick review of energy balance.

Energy Audit

Based on regular monitoring, a fortnightly report is prepared and circulated to the concerned managers. The report contains energy losses, steam leakages and equipment performing with poor efficiency. Apart from this, insulation survey steam traps survey, lube oil survey are carried out periodically by this group.

Energy Awareness Programmes

To cultivate good habits and to inculcate creativity and innovation among the employees, the GNFC management took the following steps:

Suggestion Scheme: This was started in July 1982 and it invited suggestions from all the employees on the following areas:

- Improvement in Productivity
- Improvement in Energy Inputs
- Improvement in Safety
- Improvement in Morale

This scheme has been very successful in G.N.F.C. It has created an environment whereby every person in the company is motivated to think with ideas for better systems and procedures. Suggestion boxes have been kept in different parts of the complex and the suggestions are collected regularly every week. Suggestions are screened by a committee and every month awards are given to those whose suggestions have been accepted.

Management by Survey: As the fertilizer industry in the country is quite mature and there are several plants using similar technologies, it was felt that continuous scanning of the environment would help drawing from experiences of other companies. Hence, the concept of "Management by Survey" was evolved. Teams of officers with a healthy mix of both senior and junior engineers from various disciplines were organised to visit various plants in the country. After visiting plants, every team submits tour reports. As a result, many ideas picked up during the Management by Survey of various plants have been implemented or are under process of implementation for reducing energy consumption.

Management by Objectives: Setting up of long-term as well as short-term objectives have helped our company to a great extent in developing better methods, performance standards and minimum energy utilisation. This concept of management was first introduced in our Fertilizer Division wherein goals for higher production and productivity were set and later on, it was introduced in all the divisions wherein annual and monthly goals are set at the department level. All efforts are made to meet these objectives. Monthly and yearly reports from all the departments contain the status of achievement of objectives. This way of management has helped creating awareness towards productivity of each and every man and machine in all the plants including better energy utilisation.

On-line Maintenance: Our Organisation policy is to keep standby equipments always in a healthy position. Leakages of various fluids, gas and steam through flanges, pin-holes on pipelines or on valves are arrested by fixing clamps and injecting furmanite. Recently, we have also started cold welding in the running plant.

Energy Seminars: Concerned officers attend seminars on energy conservation. In-house seminars are also arranged by our Human Resource Development Group. We also utilise the services of outside experts available in the field.

ENERGY CONSERVATION SCHEMES IN AMMONIA PLANT

As a result of adopting various energy management strategies, a number of schemes have evolved and after due scrutiny most of these schemes have been implemented with good success.

Gasification Section

We have 2 units of Texaco's Gasification Trains operating at 85 bar pressure and each is having capacity equivalent to 80% of the plant load. The following energy conservation measures have been adopted.

Oxygen/Oil Ratio Controller

The ratio of liquid oxygen to feed oil is a very critical parameter and the combustion efficiency of gasification largely depends on this ratio. Earlier, we had only indication of this oxygen/oil ratio and the control was done manually.

Recently, we have provided the ratio controller and now we are able to smoothly maintain this oxygen/oil ratio to a constant figure of 1.08 (wt/wt). This has helped us in lowering down oxygen consumption by about 1% due to better combustion efficiency as reflected by better methane and CO2 control at Gasifier exit gas. The scheme is shown in the attached drawing N° 1. The scheme was implemented in both gasifiers at a cost of about US$ 8,000. Energy saving on account of this modification in terms of steam saving in A.S.U. (Air and Nitrogen Compressor) is about 1.4 MT steam/Hr which is equivalent to 0.35 MKCal/Hr. The annual saving works out to US$ 90,000 and hence, the payout period is hardly one month.

Use of LSHS alongwith FO

Earlier, we were using only furnace oil which contains 3.5% of sulphur. On account of high sulphur, we were consuming around 0.75 MT of oil/MT of Ammonia. After 1983, we started using LSHS (Sulphur Content is around 0.4%) alongwith F/O in the ratio of about 80 : 20. This reduced our specific oil consumption to 0.73 MT/MT, thus, a saving of 20 kg of Oil/MT of Ammonia. In energy terms, this works out to be 0.2 MKCal/MT of Ammonia. Apart from this energy saving, the pollution problem has also reduced to a considerable extent. The annual saving works out to be US$ 900,000.

Intermediate Burner for Gasifier

As indicated earlier, each gasifier is designed for 80% plant load and hence, we are operating both gasifiers. Thus, load on each gasifier will be around 55 to 60% only. Under this condition, we have noticed that, due to higher burner size, the combustion efficiency is somewhat poor resulting in higher CO_2 and methane content in the exit gas. There are small burners which are designed for 40% load of each gasifier. However, we cannot use the plant load limitation. If we use smaller burner, we can load up one gasifier only up to about 70% instead of 80%. To avoid these problems and for better energy efficiency, we have designed an intermediate burner having dimensions as per drawing N° 2. We expect an energy saving of 0.35 MKCal/Hr which works out to US$ 90,000 per annum.

Modification in Soot Water Coolers

During the gasification, about 2% soot is generated which is scrubbed by quench water. The soot water at 255° C is cooled down up to 150° C by heating grey water in 12 meter long horizontal heat exchanger. This heat exchanger (one for each gasifier train) having 2 shell pass and 6 tube pass, has not been performing since long due to by-passing on shell side through sealing strips of central baffle. This being a very long exchanger, it is difficult to pull out the tube baffle and attend the seal strips which will never be satisfactory. Due to this limitation, a modification has been carried out to convert this 2 shell pass exchanger into a single pass by external piping modification as shown in the drawing N° 3.

The soot water temperature has dropped to 180° C which was remaining at around 220° C earlier. Consequently, grey water temperature has increased up to 175° C which was remaining at around 155° C. This has resulted into an energy saving of 8 MT/Hr. LP steam which is equivalent to 4 MKCal/Hr and in monetary terms equal to US$ 200,000 per annum.

Higher Conversion in CO Shift Reactor by Water Injection

We have 3 units of reactors containing Sulphur active catalyst (Co-Mo) for carrying out CO-Shift reaction in the ammonia plant. The designed CO slippage through 3rd bed is 1.5%. Up to August 1983, we were getting 1.25% of CO at 3rd bed outlet. The 3rd bed inlet temperature was reduced from 322° C to 280° C in consultation with catalyst manufacturer - M/s BASF. In September 1983, CO slippage was reduced to 0.6% by water injection upstream of 3rd reactor. This resulted in reduction of 8 kg of Fuel Oil/MT of Ammonia, thus reducing energy by 0.08 MKCal/MT Ammonia. The annual saving due to this change in operation works out to US$ 300,000. The scheme is shown as per drawing N° 4.

Synthesis Loop Pressure Reduced

We have Haldor Topsoe Synthesis Loop with Series-100 radial convertor. Ever since the commissioning stage, the loop pressure used to remain higher by about 20 bar for a given load. The problem was studied in detail and we could notice that the overall temperature difference across the synthesis convertor was remaining at 200° C instead of the design value of 189° C. From this, we would analyse that the catalyst activity was very good and the real problem was due to less syn gas circulation rate through the convertor.

Thus, the innovative idea of increasing the capacity of the recirculator (3rd stage) of synthesis compressor came up. The compressor manufacturer - M/s. BHEL - was contacted and our requirement to increase the circulation flow rate by about 10% was indicated. A new impeller of recirculator having higher vane diameter was procured at a cost of US$ 30,000 and installed during September 1989 shut-down. Due to this inexpensive modification, the loop pressure came down from 240 Bar to 220 Bar and we would save about 2.5 MT/Hr of HP steam. Also the plant load limitation on account of high loop pressure was eliminated. The energy saving on account of this modification is 0.6 MKCal/Hr which works out to US$ 150,000 on annual basis. The modification is as per the drawing N° 5.

Bypassing in Gas - Gas Exchanger

In the synthesis loop, the synthesis gas after compressor discharge is heated up in the gas - gas exchanger, which is a 12 meter long vertical shell and tube exchanger. This exchanger is having fixed welded head at the top and floating head at the bottom. Earlier, we had carbon impregnated "O" rings which were failing often resulting into bypassing of synthesis gas through this heat exchanger, thereby reducing gas flow through convertor by about 10,000 NM3/Hr. This problem was noticed by measuring ammonia concentration at tube side inlet and outlet. Now, instead of "O" rings, furmanite has been filled up and this has worked well, reducing the bypassing through this exchanger. This has resulted in energy saving of synthesis gas compressor by 0.12 MKCal/Hr and on an annual basis, it works out to US$ 30,000.

High Pressure Drop Across Strainer

Earlier, during one of the studies to reduce loop pressure of synthesis section, it was observed that 3rd stage strainer was offering very high pressure drop of about 2 Bar instead of 0.2 Bar. During the available shut-down opportunity, we removed the strainer and found out that it was very clean. On calculation, it was revealed that the strainer was improperly designed and hence, we removed the strainer. This brought down the loop pressure by about 5 Bar resulting in saving of the steam consumption of about 0.5 MT/Hr which is equivalent to US$ 35,000.

Series-200 Catalyst Basket

M/s Haldor Topsoe have designed Series-200 basket which essentially brings down energy consumption of synthesis loop by about 1500 KW which is equivalent to 4.5 MT/Hr of HP steam. We have already procured this Series-200 basket and we shall retrofit in the synthesis convertor at a suitable opportunity, within the next one year. This is expected to reduce the specific energy consumption by 0.02 MKCal/MT of ammonia. On annual basis, it works out to US$ 300,000.

RELIABILITY EFFORTS TO REDUCE ENERGY CONSUMPTION

It is a proven fact that the shut-down costs are very high, as a lot of energy is wasted during start-ups and shut-downs. We experienced this during the first 3 years of operation when we faced a lot of teething problems in the ammonia plant. It was then, we decided to carry out various modifications for improving the design and material of construction aspects of various heat exchangers as well as turbine condensers. These modifications are as described below.

Failures in High Pressure Exchanger due to Vibration

There were repeated tube failures in high pressure heat exchangers of synthesis section during September 1982 to July 1984. The ammonia plant load was restricted to about 85%, resulting into huge loss of profit. Apart from this, the cooling water quality also got badly deteriorated due to ammonia leakages and subsequently affecting other exchangers of ammonia plant.

All the three exchangers having cooling water on shell side were suspected to have flow induced vibration problem. A computer programme was developed and most of the exchangers, having cooling water on shell side, were analysed for tube vibration problem. The result of programme revealed that the probability of flow induced vibrations was more in these high pressure exchangers of synthesis section.

A modified split flow design was given by the manufacturer for one heat exchanger (water cooled condenser) and we had designed new tube bundles for the other two exchangers with less baffle spacing and less baffle cuts which eliminates the probability of flow induced vibrations. No tube failures have been observed in these exchangers after the above modifications.

Heat Exchanger with Cooling Water Service

During the year 1983-84, we faced tube leakage problems in several CS heat exchangers, having cooling water service. The material of construction was recommended to be changed from CS to SS (after detailed study) for the following exchangers:

- Nitrogen Compressor Interstage Coolers
- Lube Oil Coolers for Compressor
- Synthesis Compressor Interstage Coolers
- BFW Heater in Synthesis Section
- Water Cooler in Synthesis Section
- Ammonia Heater
- Ammonia Condensers
- Surface Condensers of Turbines

Conversion of Ammonia Condensers (From 4 Tube Passes to 2 Tube Passes)

The ammonia condenser performance was not satisfactory and its cooling water temperature rise used to remain more than 12° C instead of design value of 10° C. This was one of the major bottlenecks to achieve 100% capacity utilisation during 1983-84.

These exchangers were having four tube passes on cooling water side. These exchangers were converted to two tube passes from four passes, thereby reducing the tube side pressure drop and increasing the cooling water flow rate. The heat transfer increased by about 25%.

The load limitation on account of these condensers was eliminated in July 1984. Apart from this, refrigeration compressor final discharge pressure came down by 2 kg/cm2 and hence, steam consumption also got reduced to a certain extent.

ENERGY CONSERVATION THROUGH INTEGRATION APPROACH

Use of Waste Water of Urea Plant in place of Boiler Feed Water

Between 20 to 25 tonnes boiler feed water was used as make-up water in our carbon recovery section as per design. We were looking for use of effluent waste water of urea plant which contains small quantities of ammonia and urea only. After detailed study, we could establish that this water can be used in place of BFW in carbon recovery section of ammonia plant. This has not only helped in reducing D.M. water consumption but also in reducing the steam energy required for heating D.M. Water in deaerator. The annual saving works out to US$ 35,000. The scheme is shown in attached drawing N° 6.

Utilisation of Flash Steam of Condensate Tank in Urea Plant

The condensate in urea plant flashes out about 5 MT/Hr of steam at atmospheric pressure and is condensed by cooling water exchanger. We decided to use this heat energy. We studied various alternatives and after removing heat exchanger, we are using this steam for heating D.M. Water before it goes to deaerator. The energy saving on account of this modification is 2.5 MKCal/Hr which on annual basis works out to US$ 80,000. This scheme is enclosed at drawing N° 7.

Use of Condenser of Urea Plant for Condensing Refrigeration Ammonia from Ammonia Plant

Refrigeration required in air Separation unit, rectisol wash unit, ammonia synthesis unit, storage tank section is provided by NH3 refrigeration unit. It consists of one turbo-compressor, condensers and collecting drums. The gas from the outlet of synthesis convertor is about 430° C in ammonia synthesis unit. The gas is cooled in BFW heater and one water cooler, where substantial part of ammonia product is condensed. The gas then passes to the cold exchanger and ammonia chiller where ammonia is used as refrigeration. The water cooler performance was poor due to scaling on water side, so extra heat load was transferred on ammonia chiller and ultimately refrigeration load remained high.

Apart from this, ammonia condensers of refrigeration unit were performing unsatisfactorily and so the plant load was limited to 75% due to this, during the year 1984.

A 4" dia line was provided to inter-connect ammonia collecting drum and urea plant ammonia condenser thereby transferring the condenser load of ammonia plant to urea plant. With this arrangement, ammonia production increased by 50 MT/Day. We operated this scheme for around two months producing additional 2000 MT of ammonia which is equivalent to US$ 200,000. The details of the scheme are shown in drawing N° 8.

Reduction in Power Consumption

We studied complete electrical network of GNFC Complex over the last few years and found out all the pumps delivering higher head than required. The high heads were often because of insufficient data during design stage or extra safety margin considered during design stage. We trimmed off these impellers and reduced power consumption. The details are given in Annex V.

In ammonia plant, we were supposed to run 6 nos. of cooling water pumps with 960 KW motor. The cooling water pressure was supposed to be maintained at 5 kg/cm^2 g. We studied this system and decided to run only 5 pumps at lower head and high flow to save electrical energy. For one exchanger located at very high elevation, we provided a booster pump. This has reduced our power consumption by about 500 KW.

In all, we reduced the electrical power consumption by 1,700 KW which works out to an annual saving of US$ 750,000.

FUTURE PLANNING AND CONCLUSIONS

We believe that a dynamic management system only can produce good results, whether its is a financial management, productivity management or energy management. To give a greater thrust towards the energy management, we have considered the following future plans:

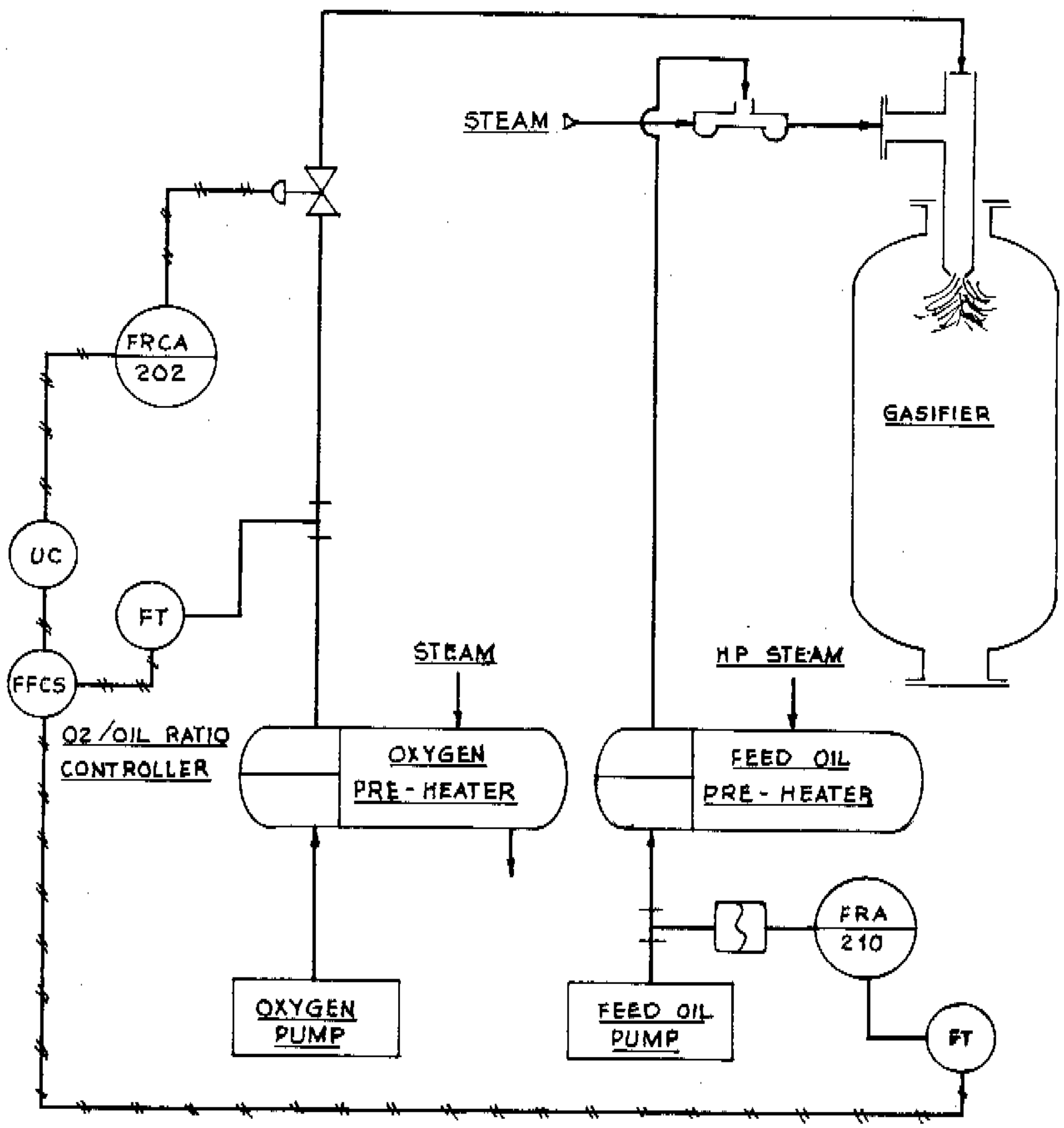
- Use of advance technology (Trapman instrument, Iso-Scan Technique)
- Micro-processor based control loops
- Use of non-conventional energy sources like windmills, solar energy, etc.
- Use of Co-generation principle
- Pinch technology and use of heat pumps
- Use of AC variable motors
- Feasability study of mist cooling and vapour recompressor

We are also planning to install Series-200 basket in ammonia synthesis convertor which will reduce steam consumption by about 4.5 MT/Hr.

It is needless to emphasize that a good energy management system is not merely an energy conservation programme, but, also includes some fundamental management principle, strategic planning followed by a dynamic action plan as well as a continuous monitoring system. A well drawn-out systematic approach and use of computer can substantially cut-down energy cost, thereby, improving overall productivity, performance and profits. The efforts for improving reliability and continuity of plant operation will significantly contribute to reducing energy consumption. Innovative ideas and adoption of new technologies will have to be encouraged so as to sustain growth rate even during the impending energy crunch looming large over the globe.

O2/OIL RATIO CONTROLLER IN GASIFIER

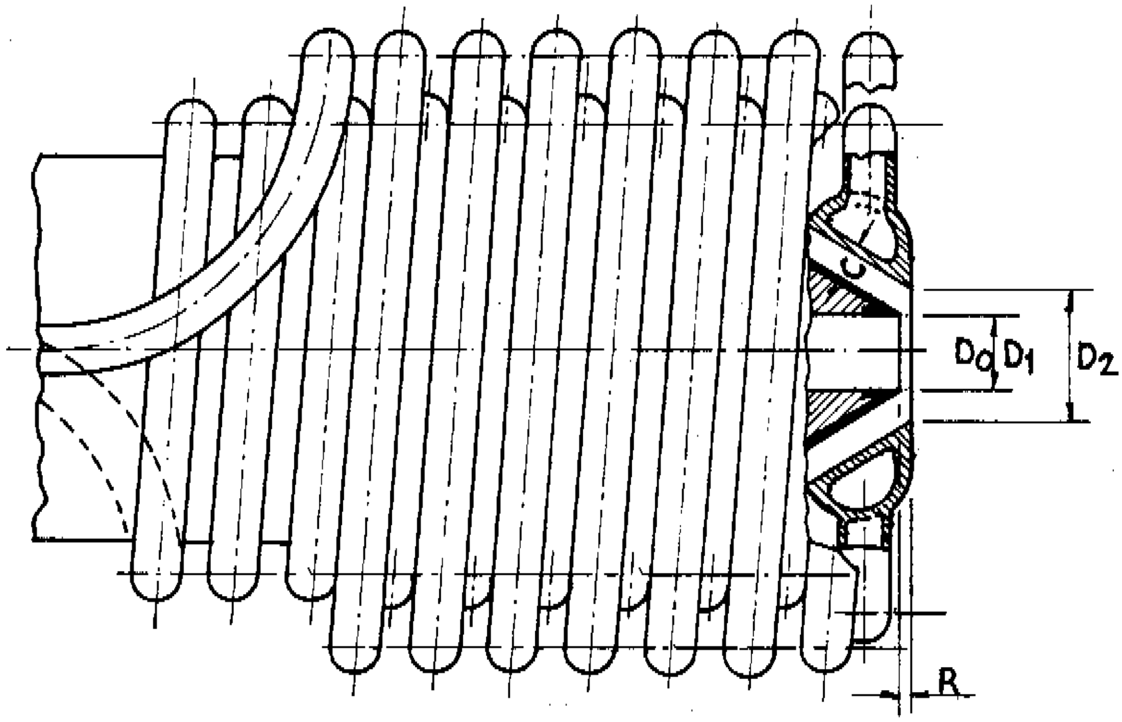
DRAWING NO. 1



ADVANTAGE	:	- BETTER COMBUSTION EFFICIENCY.
		- LOWER OXYGEN CONSUMPTION BY AROUND 1 %
SCHEME COST	:	US $ 8000
ENERGY SAVING	:	0·35 MKCAL / HR (1·4 MT STEAM / HR.)
BENEFIT	:	US $ 90000 / ANNUMN.
PAYOUT PERIOD	:	1 MONTH .

INTERMEDIATE BURNER FOR GASIFIER

DRAWING NO. 2



DIMENSIONS (IN M.M.) FOR INNER AND OUTER NOZZLE

SIZE	DO	D1	D2	C	R
SMALL	34·1	34·9	48	6·6	1·8
BIG	40·7	41·5	58	8·5	2·7
INTERMEDIATE	37·4	38·2	52	7·5	2·2

ADVANTAGE : - BETTER COMBUSTION EFFICIENCY.
- APPROX. 1% LOWER O2 CONSUMPTION.

SCHEME COST : US $ 60,000

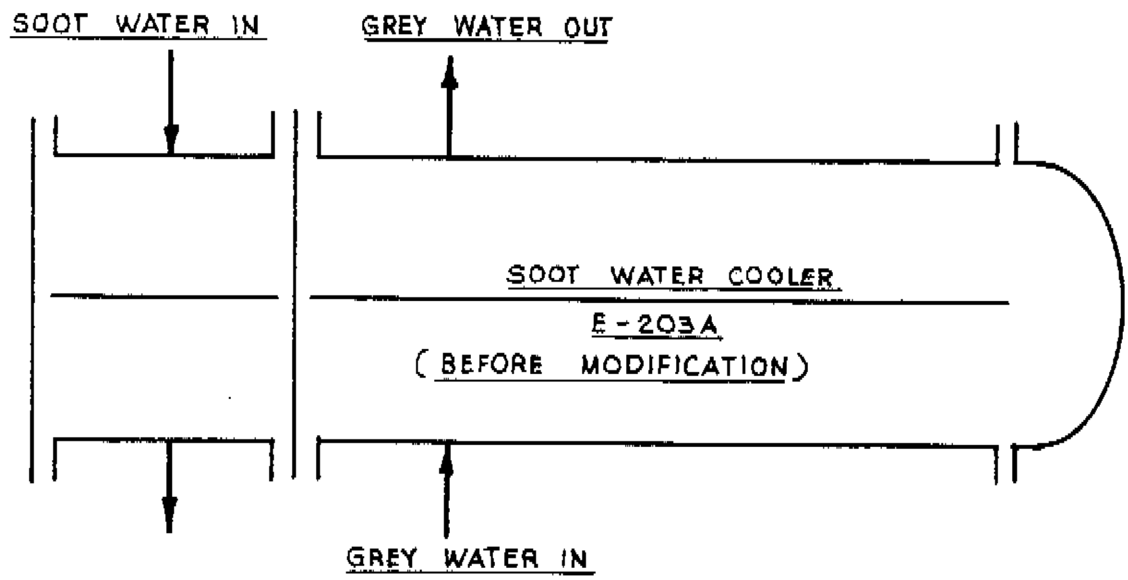
ENERGY SAVING : 0·35 MKCAL / HR.

BENEFIT : US $ 90,000/ ANNUMN

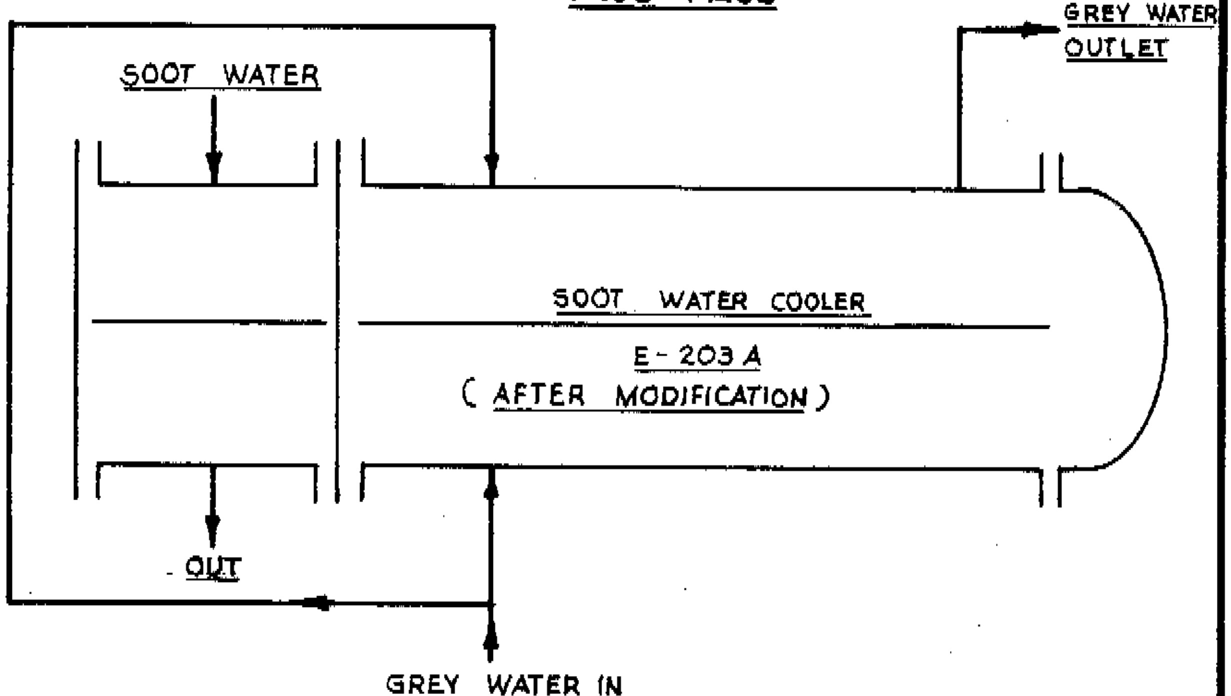
PAYOUT PERIOD : 8 MONTHS.

CONVERSION OF TWO PASS INTO SINGLE PASS OF SOOT WATER COOLER

DRAWING NO. 3



TWO PASS

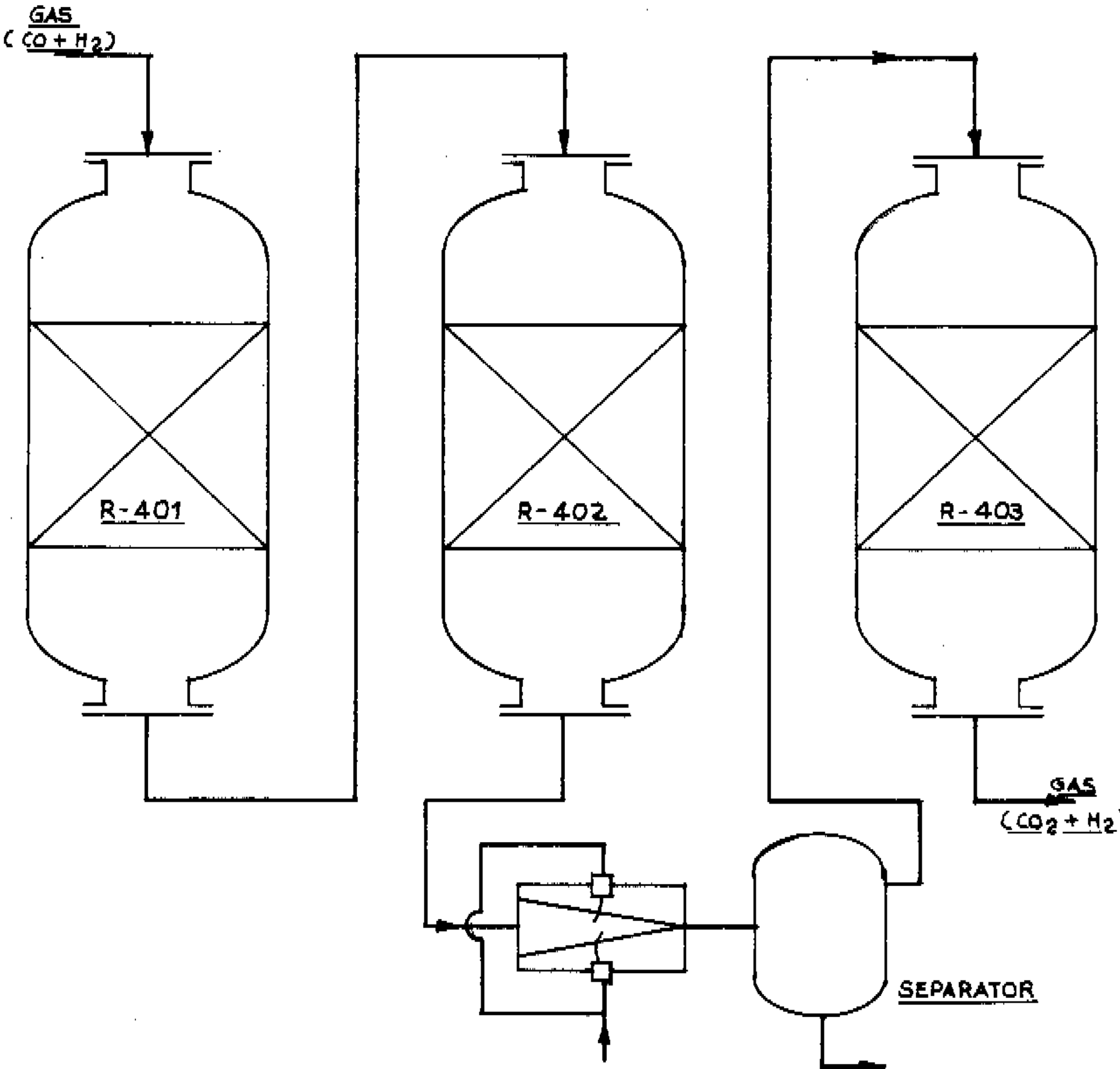


SINGLE PASS

ADVANTAGE	:	IMPROVEMENT IN HEAT TRANSFER BY AVOIDING BYPASSING ON SHELL SIDE.
SCHEME COST	:	US $ 15,000
ENERGY SAVING	:	8 MT / HR LP STEAM.
BENEFIT	:	US $ 200000 / ANNUMN.
PAYOUT PERIOD	:	1 MONTH.

HIGHER CONVERSION IN CO-SHIFT REACTOR BY WATER INJECTION

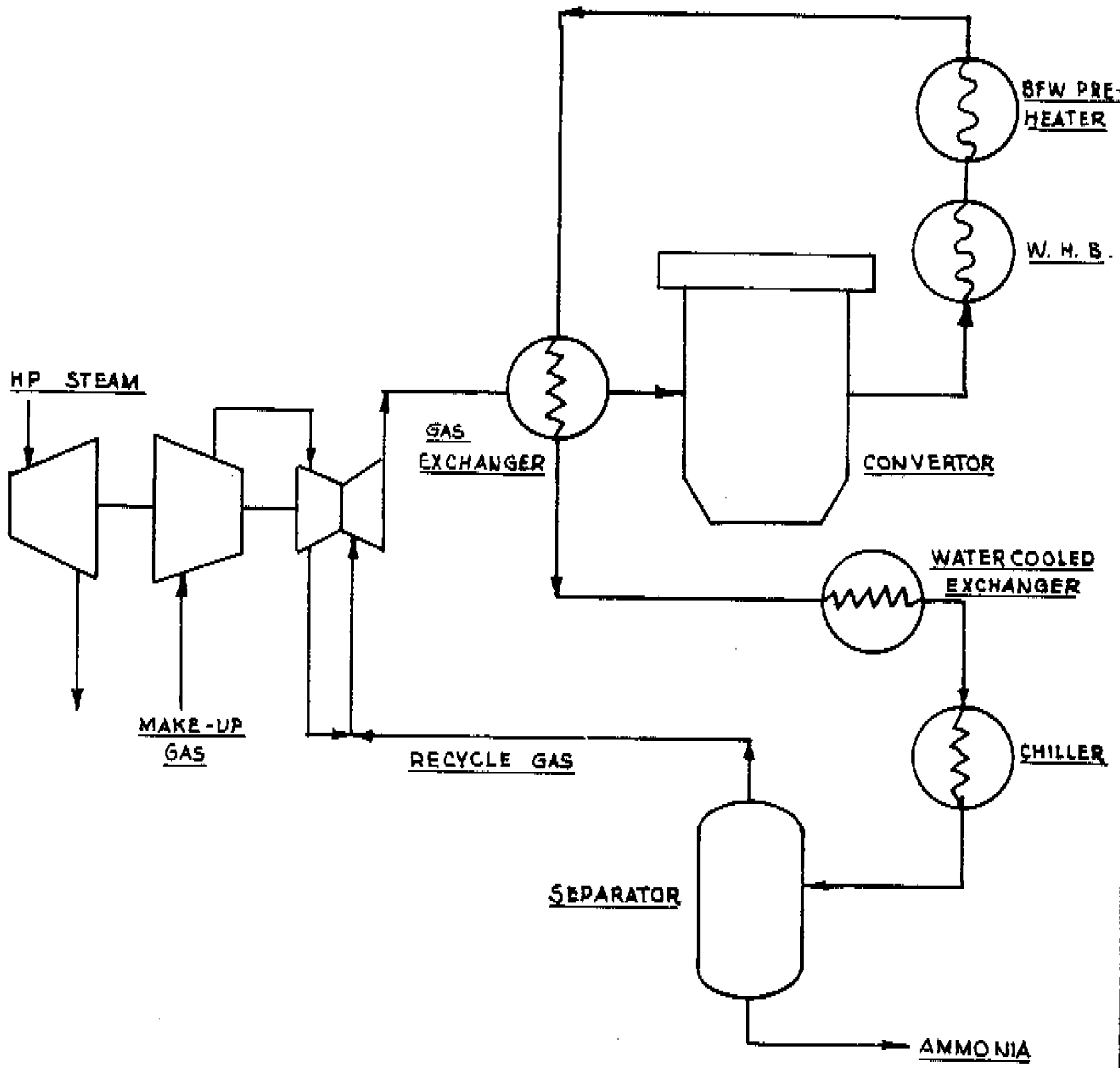
DRAWING NO. 4



ADVANTAGE	:	CO SLIPPAGE THROUGH 3rd CO-SHIFT BED IS REDUCED TO 0·6 % FROM EARLIER 1·25 %.
ENERGY SAVING	:	0·08 MKCAL / MT.
BENEFIT	:	US \$ 3,00,000 / ANNUMN.

MODIFIED IMPELLER IN RECIRCULATOR OF SYNGAS COMPRESSOR

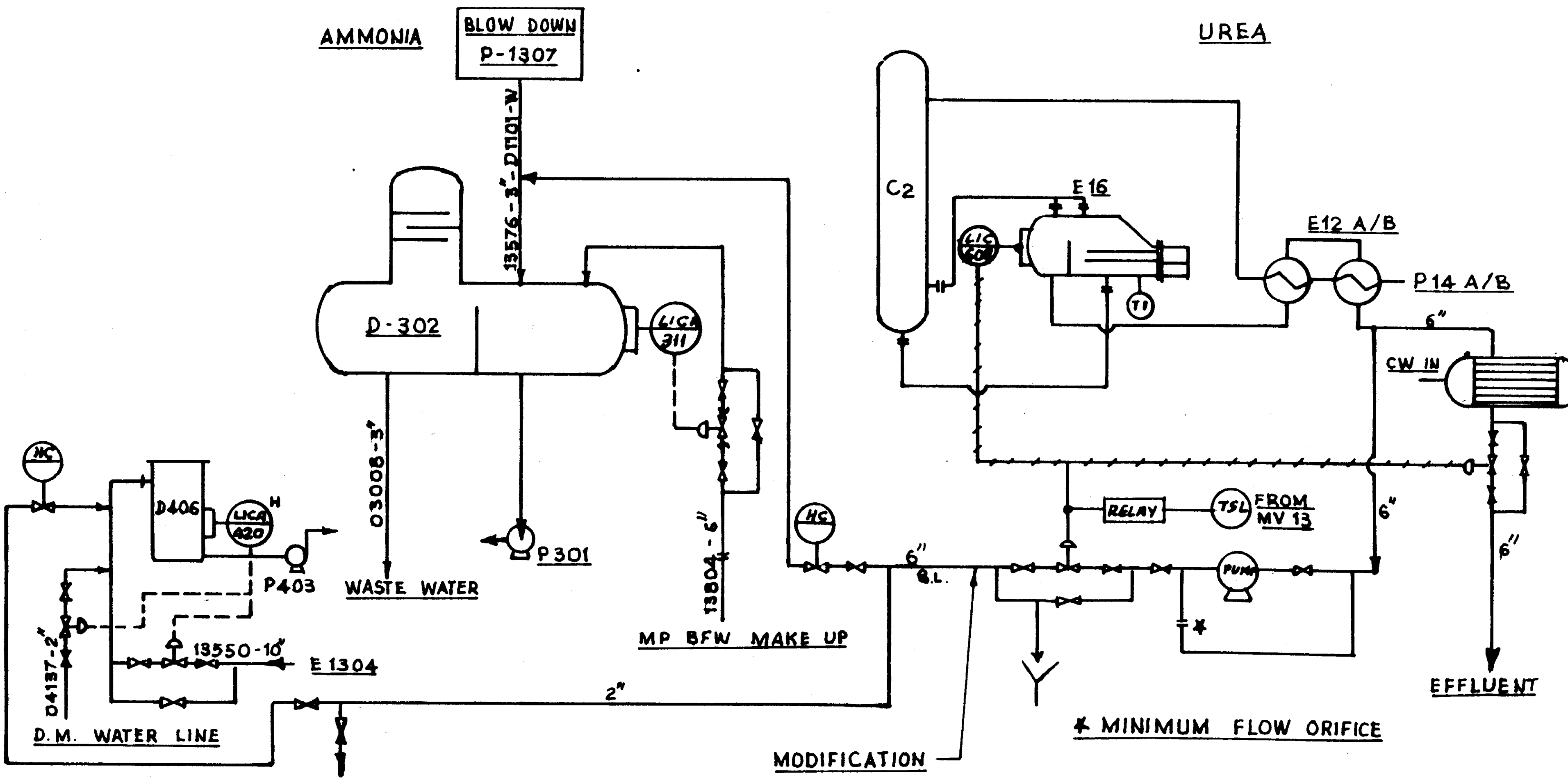
DRAWING NO. 5



MODIFICATION	:	VANE DIAMETER INCREASED BY 40 mm.
ADVANTAGE	:	- LOOP PRESSURE CAME DOWN FROM 240 BAR TO 220 BAR. - PLANT LOAD LIMITATION ELIMINATED.
SCHEME COST	:	US $ 30,000
ENERGY SAVING	:	700 KW = 0·6 MKCAL /HR.
BENEFIT	:	US $ 1,50,000 / ANNUMN.
PAYOUT PERIOD	:	3 MONTHS.

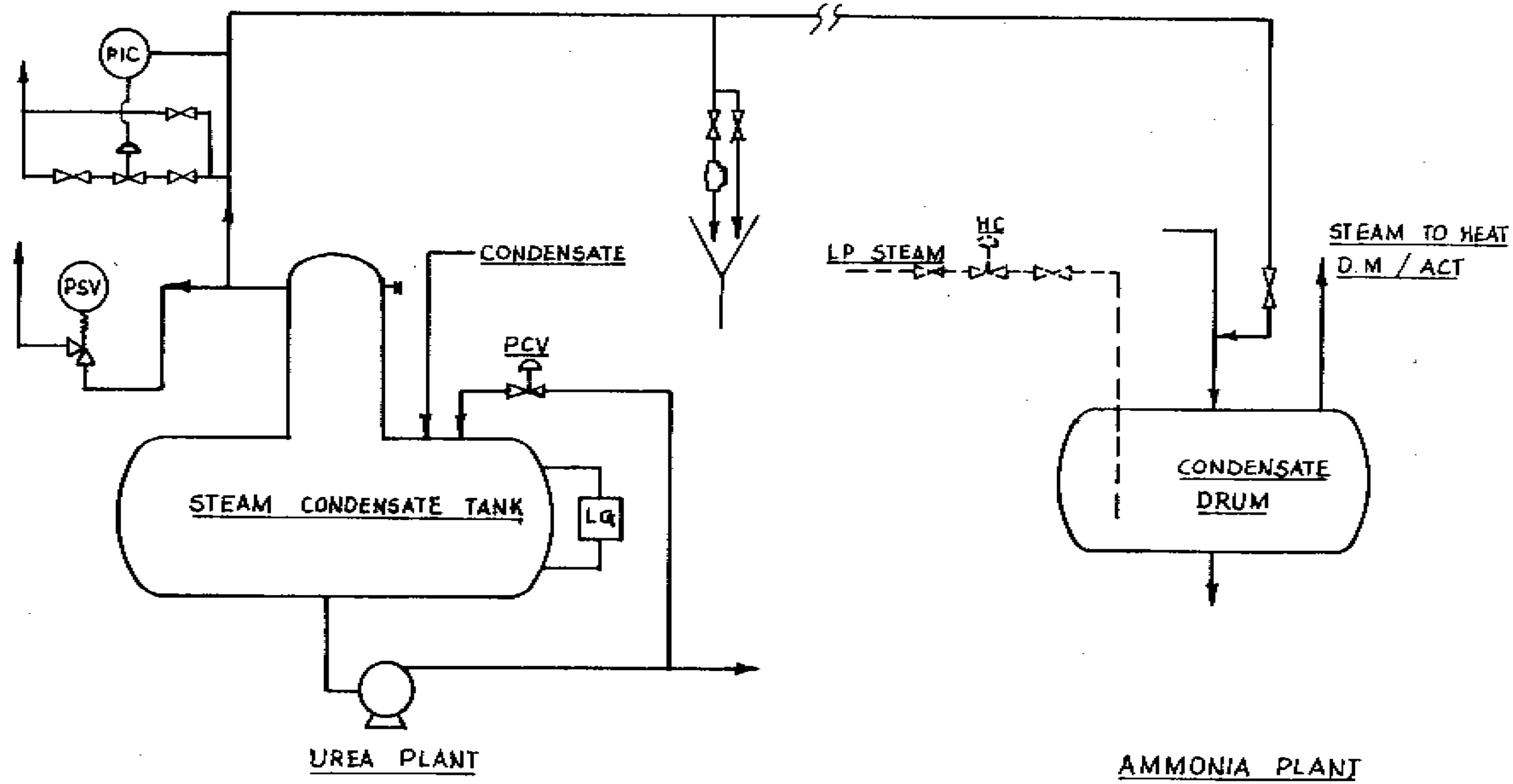
USE OF WASTE WATER IN SECTON - 300

DRAWING NO. 6



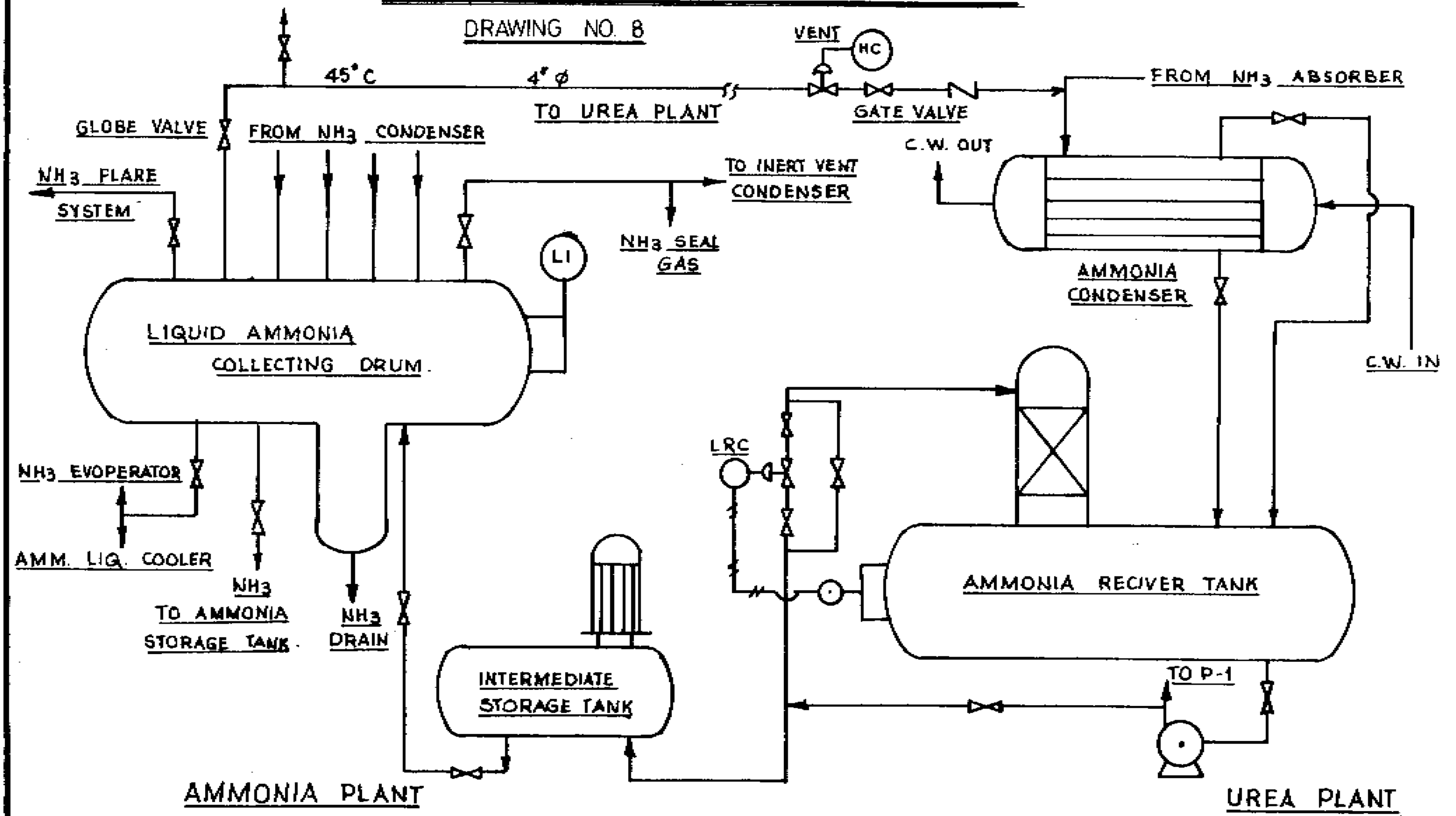
UTILISATION OF FLASH STEAM OF CONDENSATE TANK IN UREA PLANT

DRAWING NO. 7



USE OF UREA PLANT CONDENSER FOR INCREASING LOAD OF AMMONIA REFRIGERATION SYSTEM

DRAWING NO. 8



16 - 17