OVERVIEW ON KAFCO

Karnafuli Fertilizer Company (KAFCO) is one of the supreme Chemical Engineering oriented factories in Bangladesh. It is a joint venture factory of Japan and Bangladesh and the plant is constructed at Chittagong. It was first incorporated as a public limited company in 1988. After six years in 1994 the plant was commissioned and went for its first test run. At preliminary stage of production they had encountered several problems and had to shut down the plant frequently. From 1994 to 2000, the company goes on and off. In October 2000, the plant acceptance is effective. After a few years of cost over run, in financial year 2004-2005, KAFCO achieved their record production of 685214 MT Urea. From then they have been able to run the plant with a good margin of profit.

The whole production process of Urea consists of three plants- The Ammonia Plant, The Urea Plant and The Utility Plant. At present Ammonia Plant is running at 109% capacity and Urea Plant is running at 118% capacity. KAFCO exported the excess ammonia in abroad by Cryogenic Ship. After every two years KAFCO is shut down and attend overhauling. The next overhauling is on March, 2008. During turn around a few changes is made suggested by the technical department. This year, they are going to replace the CO_2 cooler and install a rich flash drum to prevent carbamate carry over.

Bangladesh is an agricultural land and therefore it has immense demand of fertilizer. Though KAFCO is an export oriented company, currently it does not export urea in abroad more than 30 % due to Government regulation. Due to higher demand in domestic market, Bangladesh Government buys fertilizer from KAFCO at international price.

From the beginning of KAFCO, its prime concern is about the safety matters. This company never compromise in the question of safety and now it has achieved the five star marks from British Safety Council in 2007 that is the highest level of safety for a company. In Asia, only TATA of India has such level of safety.

KAFCO: AT A GLANCE

Stakeholders of KAFCO

Owners/Stakeholders	Percentage of ownership
Bangladesh government	44%
KAFCO Japan	31%
Haldor Topsoe	15%
Stami Carbon	16%
IFU	9%

Process licensors of KAFCO

Plant	Process licensor
Ammonia plant	Haldor Topsoe (Denmark)
Urea plant	Stami Carbon (Netherlands)
CO_2 removal	UOP (USA)
Granulation unit	Hydro Gari (Norway)

* General contractor of the whole plant was ‘CHIYODA’.

Design and current capacity of the plant

Plant	Design capacity, MT/day	Current capacity, MT/day
Ammonia plant	1500	1625
Urea plant	1725	2039

AMMONIA PLANT

Purpose of ammonia plant:

The purpose of ammonia plant is to produce the anhydrous liquid ammonia which will be mainly consumed as the feed of Urea plant and/or will be sent to the liquid ammonia storage facility in accordance with situation. This plant also produce the gaseous carbon dioxide as a by product which will be also consumed as the feed stock of Urea plant.

Normal capacity of ammonia plant:

The normal capacity of ammonia plant is 1500 metric tons per day (MPTD) of anhydrous liquid ammonia.

Process configuration and adopted process:

The major part of ammonia plant is designed based on Haldor Topsoe Ammonia Process owned by Haldor Topsoe A/S.

Brief description of process and catalyst:

Ammonia is produced from a mixture of hydrogen (H_2) and nitrogen (N_2) where the ratio of H_2 and N_2 should be 3 to 1. Besides these two compounds, the mixture will contain inert gases to a limited degree, such as argon (Ar) and methane (CH_4).

For ammonia plant, the source of H_2 is hydrocarbon in the form of Natural Gas. The source of N_2 is atmospheric air.

The process which are necessary for producing ammonia from the abovementioned raw materials are as follows:

- ✓ Sulphur contained in the hydrocarbon feed is completely removed in the desulphurization section.

- ✓ The desulphurization hydrocarbon is reformed together with steam and air to raw synthesis gas. This gas contains hydrogen and nitrogen as well as carbon monoxide (CO), carbon dioxide (CO_2), methane (CH_4), argon (Ar). The reforming takes place at about 35 kg/cm^2g.

- ✓ In the gas purification section CO is first converted into CO_2 and H_2 with steam in order to increase the H_2 yield. CO_2 is then removed in the CO_2 removal section and the remaining CO and CO_2 are converted to methane afterwards in the Methanation section.

- ✓ In the ammonia synthesis section the purified synthesis gas is, after compression to a pressure about 130 kg/cm^2g, converted into ammonia by a catalyst reaction.

- ✓ The ammonia plant is designed to produce 1500 MPTD ammonia. Most 9s the ammonia produce is sent to the Urea Plant for urea production. The remaining is sent to the atmospheric storage tank.

Block diagram of ammonia plant

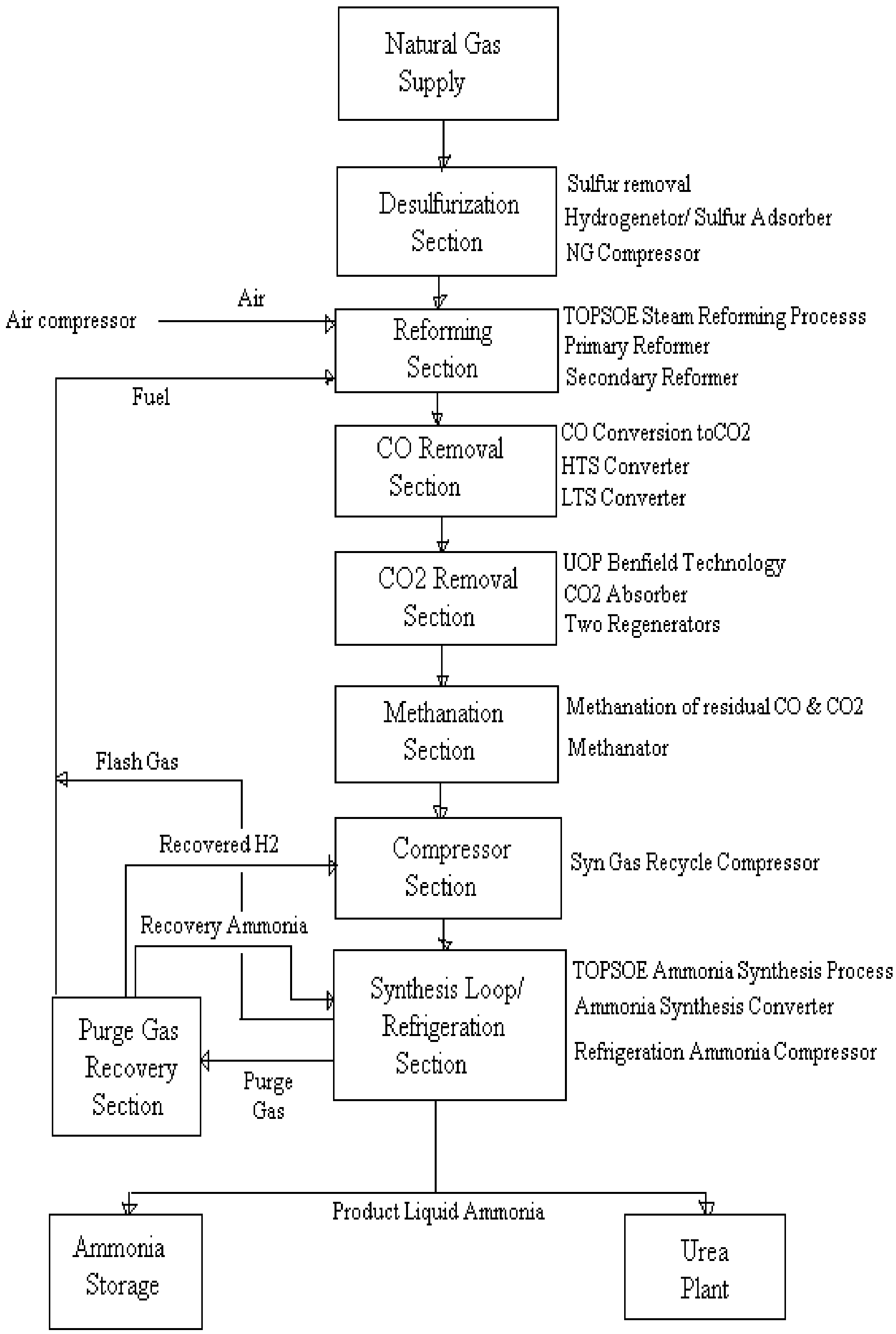

Figure 01: Block diagram of ammonia plant

PNG PURIFICATION SECTION

Desulphurization vessel

The process natural gas is first purified to remove sulfur (S). If S is present, it may be condensed as Sulfuric Acid (H_2SO_4) which is hazardous for the process. At first organic sulfur is converted to inorganic Hydrogen Sulfide (H_2S) because ZnO is used to remove H_2S as Zinc Sulphide (ZnS) can not absorb organic S.

The second purpose of purification section is to convert the unsaturated hydrocarbon to saturated hydrocarbon. For this purpose Co-Mo catalyst is used.

A natural gas compressor is before the DSV to reduce the volume of gases and for effective adsorption of CO_2.

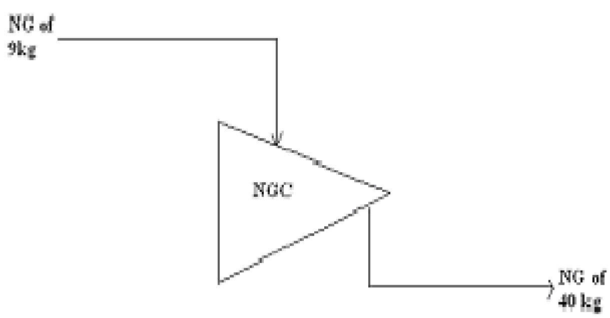

Figure 02: Process Natural Gas (PNG) compressor

STEAM REFORMING

Primary Reformer (PRF)

Primary reformer has two sections-

- ✓ Furnace
- ✓ Convection Zone

Furnace

The furnace zone is used to convert the unsaturated hydrocarbon mainly Methane (CH_4) to CO, CO_2 and H_2. For this purpose Nickel (Ni) catalyst is used. This is an endothermic reaction. So heat is required for quick reaction. In KAFCO side firing is used in the furnace. A part of PNG is used as fuel in the furnace. Other part is used for steam reforming. Fuels are supplied using tubes. There are 100 tubes in each side, so in total 200 tubes are used in the primary reformer. Tubes are designed to absorb certain temperature (T) and pressure (P). In primary reformer vacuum is maintained. A logic system is used to maintain vacuum. 480 burners are used in KAFCO. The height of the furnace is 12m. In the upper 3m there are pre reformed catalysts. In the PRF N_2 blanket is used to protect reduced catalyst from being oxidized.

Heat recovery in Convection Zone

There is a convection zone in the upper part of the furnace. Huge heat energy is produced in the furnace section. Only 50-65% of the energy is used for reforming reaction. To recover the rest of the energy this convection zone is required. This energy is used for various purposes such as heating the process streams, process steam, process air, boiler feed water etc. Around 35-40% energy can be recovered. Two induced draft fans (IDF) are used to emit the exhausts of the PRF. The exhaust temperature is generally 185ºC. The temperature of these gases should not be less than 100ºC. If temperature is less than 100ºC mist can form which can damage the IDF coil.

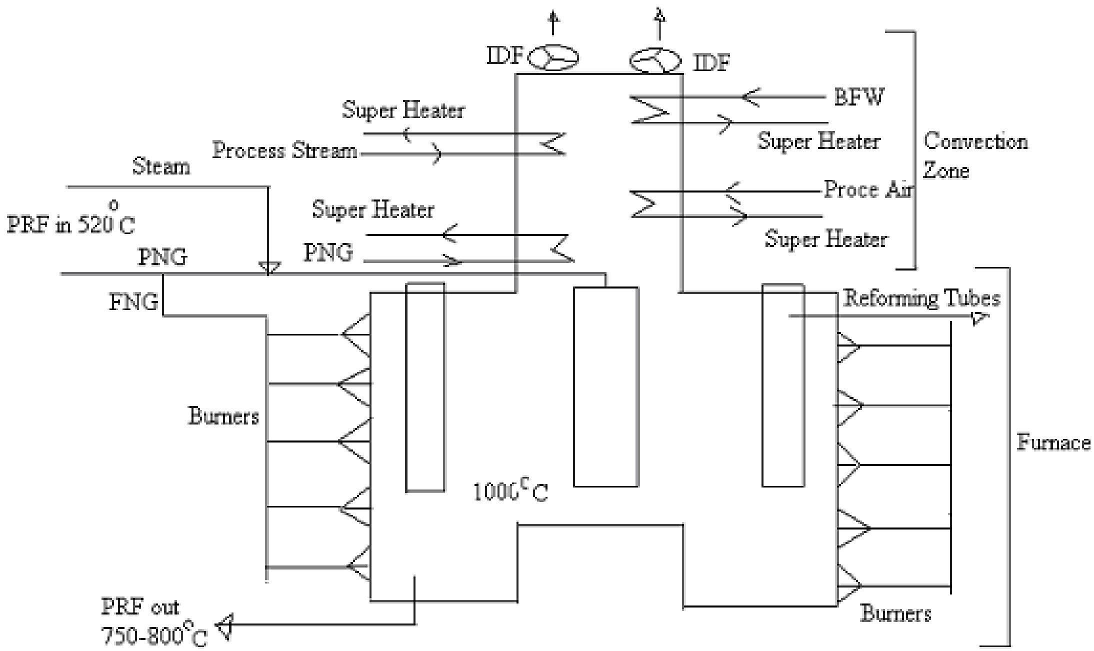

Figure 03: Primary Reformer

Secondary Reformer (SRF):

In PRF 100% conversion is not achieved. So another reformer is used to convert the rest of the saturated hydrocarbon. Ni catalyst is also used in this section. Here an additional reaction takes place. This additional reaction is combustion reaction of H_2 and O_2. This reaction is highly exothermic. Heat generated in this reaction used in the reforming reaction. There is a large space in the upper part of the secondary reformer where this highly explosive reaction takes place. In this section process air is also injected.

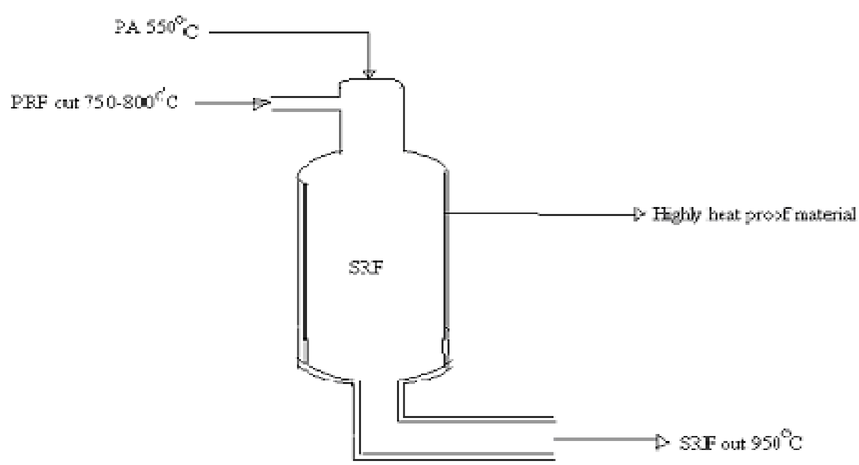

Figure 04: Secondary Reformer

SHIFT CONVERSION

High Temperature Shift Converter (HTS)

CO is undesired element for this process. CO is converted to CO_2 in this converter. The inlet and outlet temperature of this converter are respectively 360ºC and 420ºC. SRF out contains 30% CO and HTS out contains 3% CO.Fe_2O_3 is used as catalyst. The reaction in the HTS is exothermic reaction. At high temperature rate of reaction increases and complete combustion is not achieved.

Low Temperature Shift Converter (LTS)

This converter is used two convert the rest of the CO to CO_2. The outlet of the LTS contains around 0.3% CO. The outlet temperate is 230ºC. ZnO, Cr_2O_3/CuO are used as catalysts in this converter.

CARBON DI OXIDE REMOVAL

Benfield process

The objective of using this section is to get rid of the CO_2 obtained from the conversion of the CO in the shift converters since it is undesired in the next steps. In order to achieve this removal, Benfield process is carried out. Here hot potassium carbonate solution is used to absorb CO_2. Various additives are used with this solution to promote absorption and inhibit corrosion. The composition of this solution is 29% K_2CO_3, 2.9% DEA and 0.9% V_2O_5 with remaining water.

The CO_2 is absorbed chemically by the conversion of potassium carbonate to bicarbonate. As the solution pressure is reduced to about atmospheric pressure part of the CO_2 and water vapor escape. So an absorber and a regenerator are operated at 28 kg and 1 kg pressure respectively.

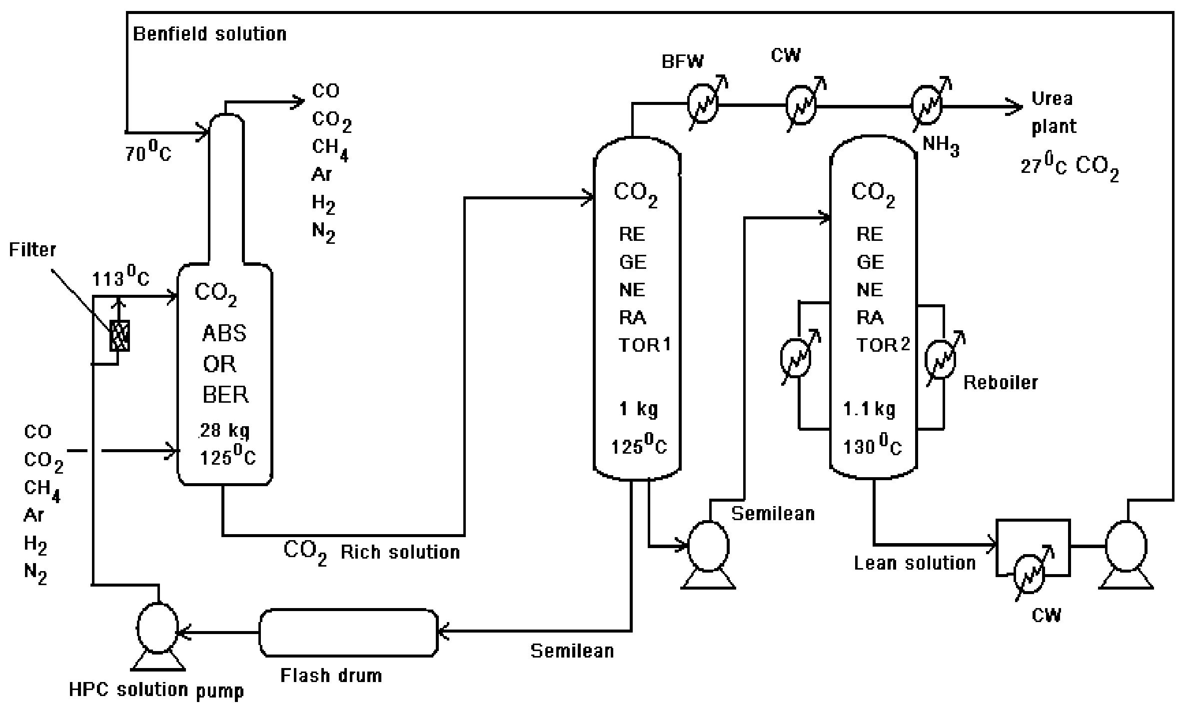

Figure 05: Carbon-di-oxide Removal Section

Here reboilers are used for better regeneration. Reboilers always supply latent heat and the solution is preheated so it is such named. The regenerator is operated at high temperature and the

113^{0}C hot potassium carbamate solution enters into the absorber through a flash drum and this solution is semi lean. The temperature is maintained so that an optimum absorption is maintained. A side stream filter is used before the solution is entering the absorber since some dirt is present in the solution which must be scrubbed.

A split ratio is maintained at about 3.5 which mean that the flow rate of the solution entering the absorber at the lower level than that of another solution entering the upper portion is about 3.5 times. The removed CO_2 is cooled by some cooling steps to get the cooled CO_2 which is very important to produce more urea.

Methanation

After the removal of the CO_2 the remaining CO and CO_2 are converted to methane in this section. Methanator is used to ensure the removal of CO_2 and CO. In the methanator a packing of catalyst is used. Here operation at lower temperature is advantageous due to thermal degradation at high temperature. In the methanator 75% of the feed is converted. So recirculation is used for reuse. In the methanator nozzles are used as distributor so that no channeling occurs and the full conversion is occurred. PSV is used to keep the vessel safe and to operate at other than design value.

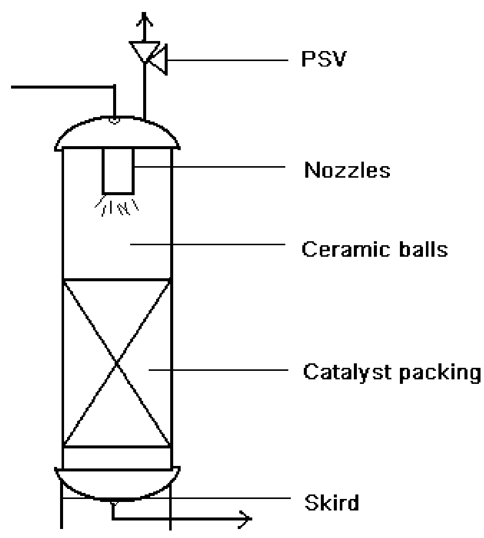

Figure 06: Methanator

AMMONIA SYNTHESIS

The methanator outlet is cooled to 42^0C before compressor since the volume will be less if a low temperature stream is compressed. As a result power consumption will be lower. The gas is compressed to 130 kg and send to the ammonia converter. In the converter hydrogen and nitrogen reacted in presence of Iron (Fe) catalyst and converted to Ammonia.

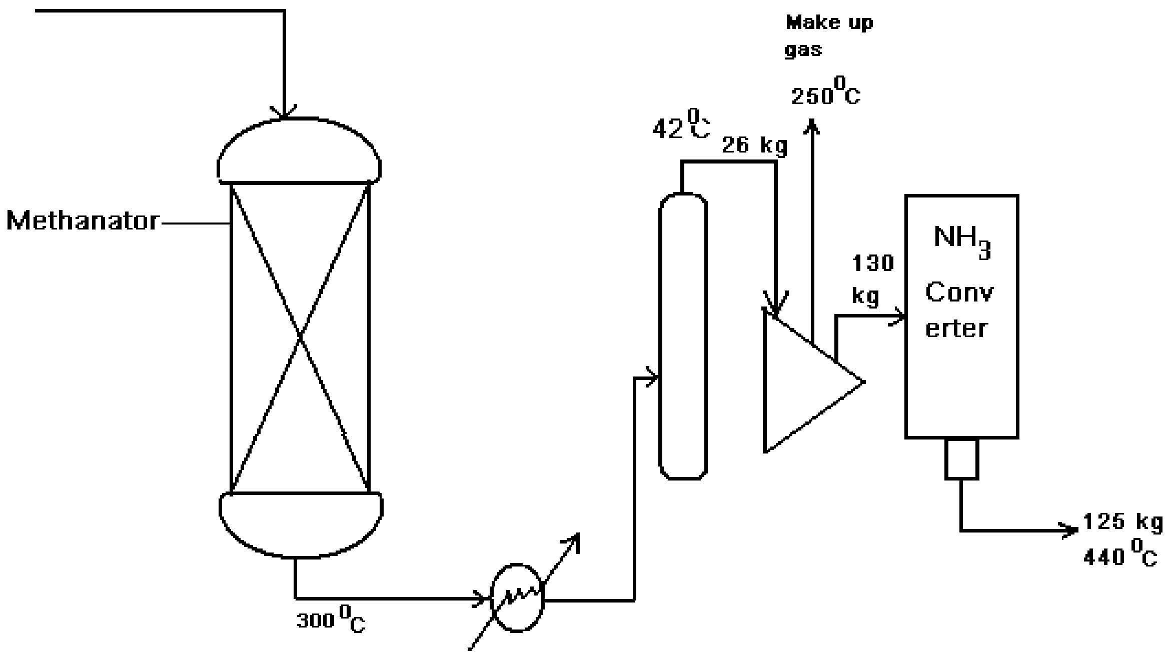

Figure 07: Ammonia synthesis

AMMONIA AND HYDROGEN RECOVERY UNIT

Ammonia recovery

Ammonia is absorbed in the absorber at high pressure and low temperature. The absorbing agent is water. Water is regenerated at low pressure and high temperature in the regenerator and recycled back to the absorber. Ammonia and a trace amount of water are cooled in the condenser where water is condensed and separated from ammonia. About 99% pure ammonia is found by this process. Reflux is done for better purification and also to avoid thermal degradation.

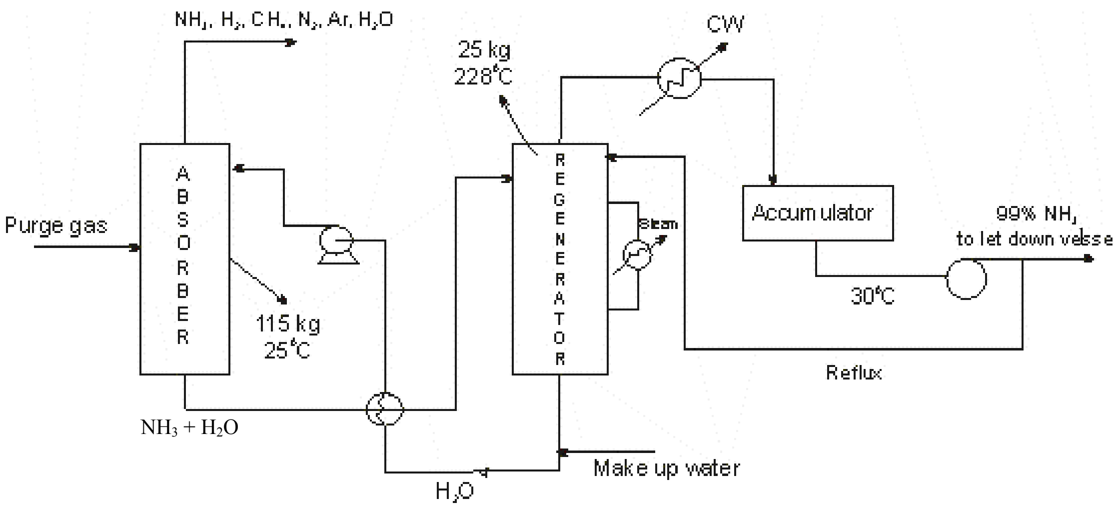

Figure 08: Ammonia recovery unit

Hydrogen recovery

In KAFCO, there are two adsorbers to adsorb the little amount of ammonia and water as they may block the path because of ice formation at lower temperature. One adsorber remains in service and another one is in regeneration. After six hours operation one adsorber may exhausted and need regeneration. Regeneration is done by recycled nitrogen. There are three heat exchangers inside a large vessel which is called cold box. Start up temperature of the cold box was ambient temperature. There are 13 valves, through which the stream passes. Because of sudden expansion after passing the throttle valves a mixture of liquid and vapor form.

Temperature low down as it uses its internal energy to get expanded. This is called Joule-Thomson effect. The rate of temperature reduction is maintained at $10^0C/15^0C$ per hour to avoid thermal shock. About 10/12 hours are required to achieve temperature of -187^0C. At this temperature nitrogen become liquefied and gaseous hydrogen is separated and comes out from the top of the vessel.

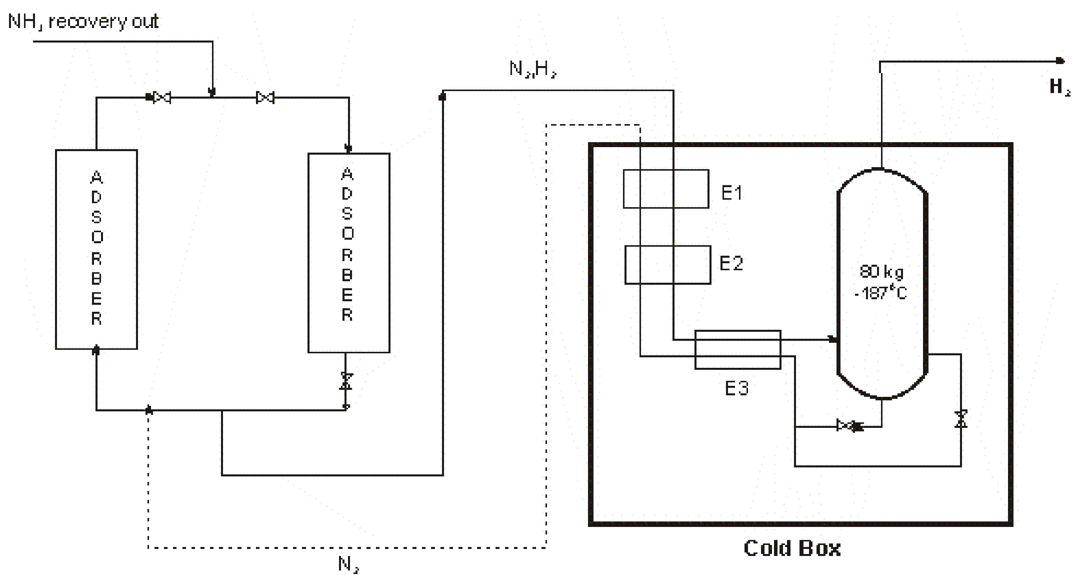

Figure 09: Hydrogen recovery unit

REFRIGERATION AND STORAGE OF AMMONIA

Refrigeration unit

In ammonia refrigeration unit, there are eight heat exchangers in KAFCO. Ammonia comes out from the converter at about 440^0C that passes through the eight heat exchangers to lower down the temperature up to the boiling point of NH_3 (-33^0C) at atmospheric pressure. Heat is first exchanged in the waste heat boiler and then in the BFW preheater. There are cooler where cold water is used as a cooling agent. Two chillers are used to lower the temperature less than the ambient temperature. Ammonia is used as a refrigerating agent in the chillers. The NH_3 separator is used since some H_2 and other gases may be entrapped and the CH_4 and N_2, H_2 are removed for product purification so that in the let down vessel flushing occurs. Demister is used since some liquids are present. Pressure is reduced by using the let down vessel (25 kg) and by the flash drum (0.03 kg).

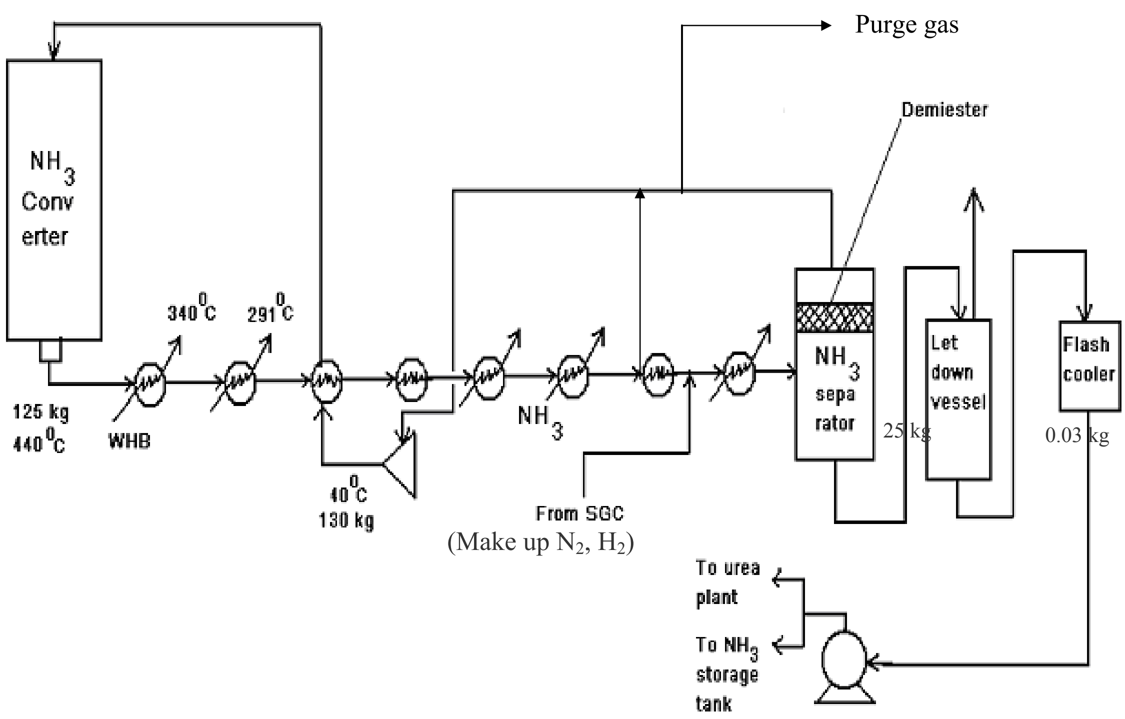

Figure 10: Ammonia cooling and refrigeration

Ammonia storage at atmospheric pressure

A vessel can not be perfectly insulated. As a result some molecule of ammonia become gas and eventually increases the pressure of the vessel. At high pressure some ammonia may condensed and create a vacuum inside the storage tank. Ultimately the vessel may squeeze and undesired situation may occur. In KAFCO ammonia is stored in a vessel of 20,000 ton capacity and pressure is maintained at atmospheric pressure by using a Boil of Gas (BOG) compressor. There are two BOG compressors in KAFCO. One is running and another one is stand by. Compressor compresses the gas and then it give up latent heat by exchanging with cooling water. Thus, pressure reduces and nearly atmospheric pressure is maintained in the storage tank. There is an accumulator which act as a damping device and vent inert (mostly nitrogen) to the atmosphere. Otherwise it will increase the partial pressure.

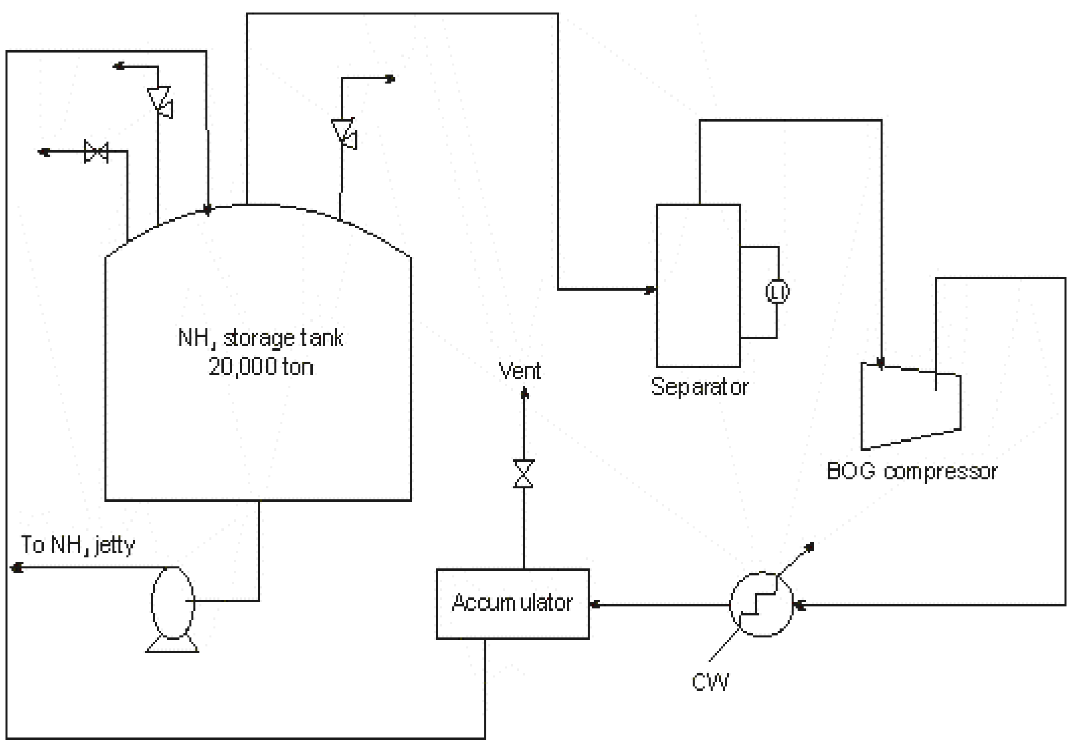

Figure 11: Pressure control in NH_3 storage tank

AMMONIA (NH_3) PRODUCTION REACTIONS

- ✓ **DESULPHURIZATION SECTION**

a. Hydrosulfurization reaction

$RSH + H_2 = RH + H_2S$

$R_1SSR_1 + 3H_2 = R_1H + R_2H + 2H_2S$

$R_1SR_2 + H_2 = R_1H + R_2H + H_2S$

$RSH + H_2 = RH + H_2S$

$C_4H_4S + 4H_2 = C_4H_{10} + H_2S$

b. Absorption reaction

$ZnO + H_2S = ZnS + H_2O$

- ✓ **REFORMING SECTION**

$C_nH_m + 2H_2O = C_{n-1}H_{m-2} + CO_2 + 3H_2 + HEAT$

$CH_4 + H_2O = CO + 3H_2 + HEAT$

$CO + H_2O = CO_2 + H_2 + HEAT$

$2CO = CO_2 + C$ (SOOT)

- ✓ **SYNTHESIS GAS PURIFICATION SECTION**

CO shift conversion

$CO + H_2O = CO_2 + H_2 + HEAT$

- ✓ **CO_2 REMOVAL SECTION**

$K_2CO_3 + CO_2 + H_2O = 2KHCO_3$

- ✓ **METHANATION SECTION**

$CO + 3H_2 = CH_4 + H_2O + HEAT$

$CO_2 + 4H_2 = CH_4 + 2H_2O + HEAT$

- ✓ **AMMONIA SYNTHESIS SECTION**

$3H_2 + N_2 = 2NH_3 + HEAT$

UREA PLANT

Raw materials:

1. Ammonia (NH_3)
2. Carbon di oxide (CO_2)
3. Formaldehyde (HCHO)

Chemical reaction:

$NH_3 + CO_2 \longleftrightarrow NH_4COONH_2$ $\Delta H = -28.5$ kcal/mol

$NH_4COONH_2 \longrightarrow NH_2\text{-}CO\text{-}NH_2 + H_2O$ $\Delta H = 3\text{-}6$ kcal/mol

Product Quality:

- Crushing strength
- Uniformity index
- Size distribution

Processes

1. Once through
2. Partial recycle –CO2 & NH3 both in liquid form
3. Total recycle
    - Conventional
    - CO2 stripping
    - NH3 stripping

Sections

1. Compression section
2. Synthesis section
3. Purification/Decomposition section
4. Recovery section
5. Evaporation section
6. Granulation section

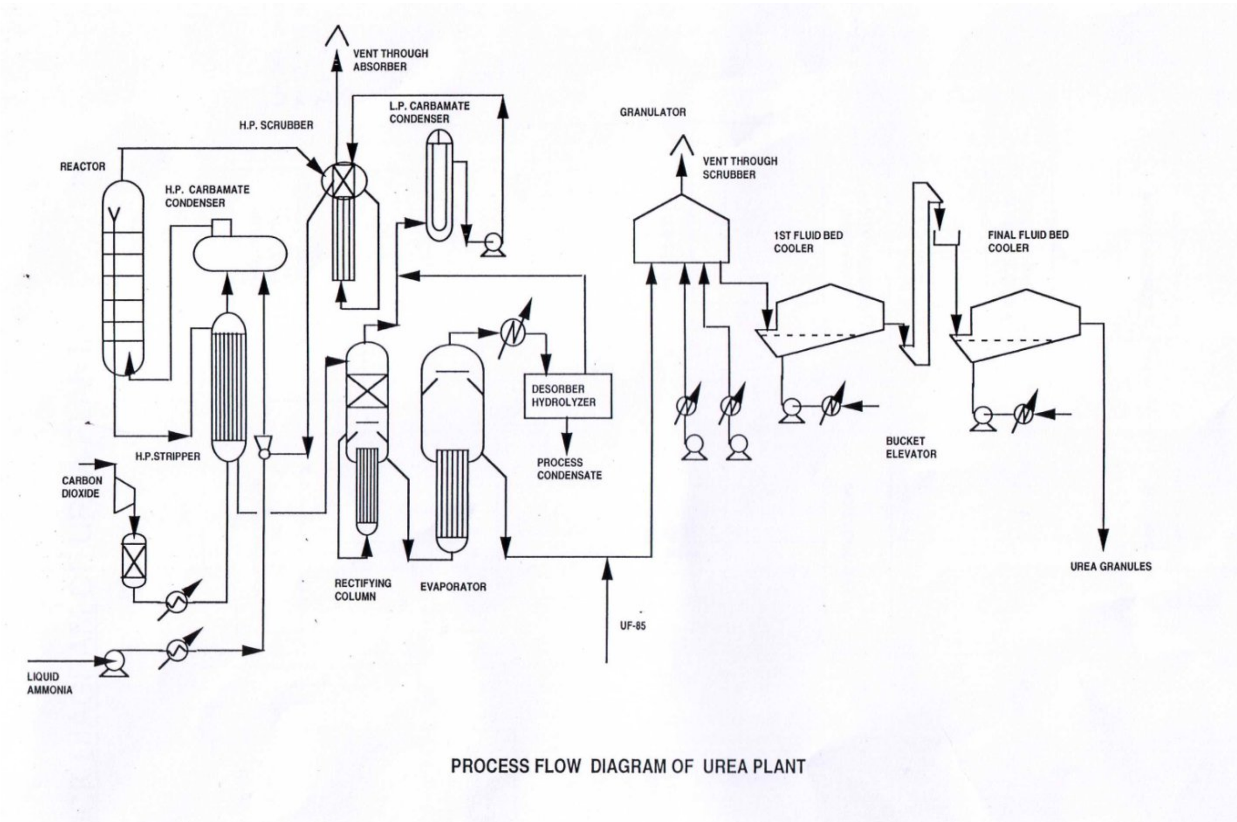

Figure 12: Process flow diagram of Urea plant

COMPRESSION SECTION

CO_2 from NH_3 plant is used. This CO_2 is not pure. It contains 99% CO_2, H_2 0.8% and N_2 0.2%.. Impure CO_2 is mixed with air and send to compressor where the pressure develops from 12 kg to 152 kg. This is a 4 stage compressor with intercooler and separator in every stage. Intercooler reduces the temperature and the separator for moisture removal. Extraction admission condensing turbine is used to drive the compressor. H_2 converter is used to convert H_2 in water. The following reaction takes place

$$H_2 + O_2 = H_2O$$

Pt catalyst is used. Also excess air is introduced for safety of equipment.

SYNTHESIS SECTION

There are 3 parts in synthesis section-

Reactor:

Reactor contains sieve trays. The liquid (urea solution) is introduced at the bottom of the reactor which moves upward through trays. After reaching a particular level it flows through a funnel again in the downward direction to the stripper. Normal carbon cannot be used as the construction material as urea solution is corrosive. The process body consists of three layers. Inner layer is made of sufforex, the middle part of high grade steel and the outer layer is of carbon steel.

HPCC (High pressure carbamate condenser)

For the first time horizontal condenser was introduced in spite of a vertical one, which is termed as pool condenser. It is a shell and tube heat exchanger. Liquid is in shell side where as water in tube side

Stripper

Here carbamate is stripped off using carbon di-oxide.

$C0_2$ gas received from ammonia plant is compressed to 145 kg/cm^{2}G pressure and charged to high pressure $C0_2$ stripper. Ammonia received from ammonia plant is pumped to high pressure Carbamate condenser at 162 kg/cm2G and part of the ammonia is also supplied to low pressure carbamate condenser. The recycle solution mostly ammonia, $C0_2$ in water received through rectification and low pressure carbamate condenser enriched with ammonia from low pressure recovery section is also pumped to H. P. carbamate condenser through H.P. scrubber. Most of the reaction between $C0_2$ and NH_3 is performed in high pressure carbamate condenser where low pressure steam is produced by utilizing heat of reactions.

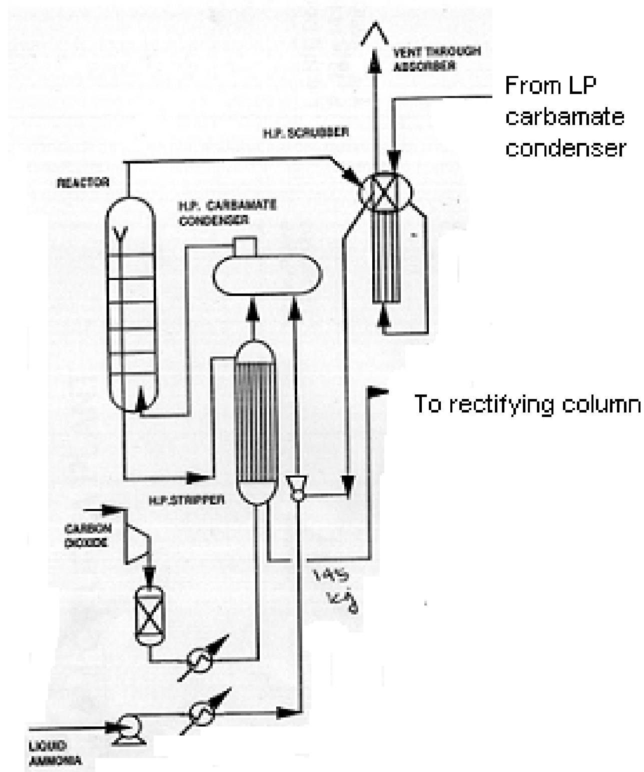

Figure 13: Synthesis loop

The solution from H.P. carbamate condenser is passed to urea rector and then to stripper. After the stripper the pressure is reduced where upon almost all the carbamate is converted to urea and $C0_2$, ammonia in the gas phase is passed to L.P. carbamate condenser.

The major part of non-converted NH_3 and $C0_2$ in the urea solution from the reactor is stripped off in the H.P. stripper. The gas phase from H.P. stripper is led to H.P. carbamate condenser, the liquid phase to the recirculation.

Recirculation stage

In the recirculation stage, the major part of the remaining non-converted NH3 and C02 is removed from the urea solution in the recirculation heater and led via rectifying column to the L.P. carbamate condenser. From the level tank for L.P. carbamate condenser the carbamate solution is recycled to the H.P. scrubber by means of the HP carbamate pump.At the outlet of this section urea is concentrated to 68%.

Evaporation section:

The urea solution from the rectifying column is discharged to the urea storage tank via the atm. flash separator. About 80% urea solution from the urea storage tank is concentrated to about 96% in one evaporation stage. There is a pre-evaporator (P=-0.55 Kg). An ejector is used to create vacuum.

Flash separator (71% urea) → Pre evaporator (76% urea) → Evaporator (96-97%urea)

96% urea melt from the evaporation is processed into a solid final product in the granulation section.

GRANULATION UNIT

The urea solution at 96% concentration is delivered to the Granulation unit battery limits at a pressure of about 7 kg/cm^{2}G and a temperature of 132 - 135 °C.The feed solution is sprayed via nozzles. In the unit there are 198 nozzles within 9 headers. The whole unit has been devided into 6 chambers. Three of which are termed as cooling chamber. The headers are equally distributed among the other three chambers.

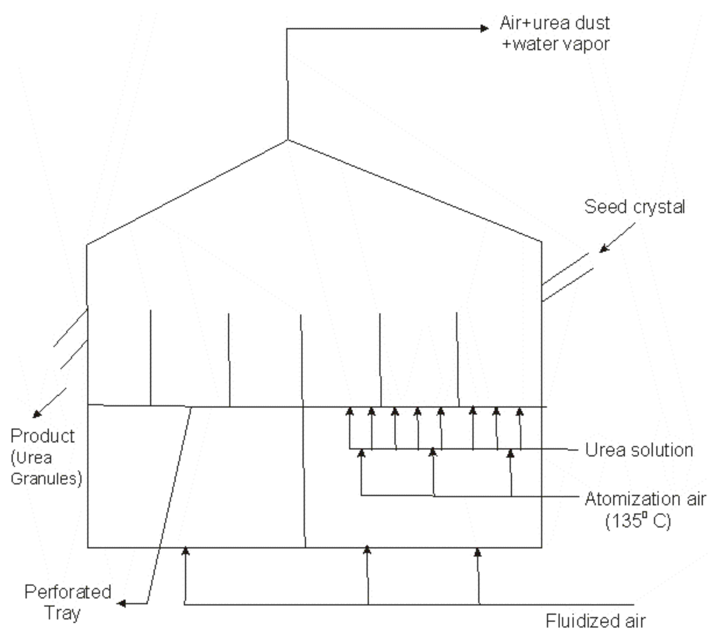

Figure 14: Granulator

UF 85 (in the form of urea/formaldehyde precondensate) is metered into the urea feed solution as a process aid and anti-caking agent.

The formaldehyde containing urea solution, at 96% concentration is dispensed to the injection heads and sprayed by atomization air, compressed by the atomization air blower on the fluidized bed Granulator. Atomized air is heated with steam before injection to avoid solidification of urea at the nozzle.

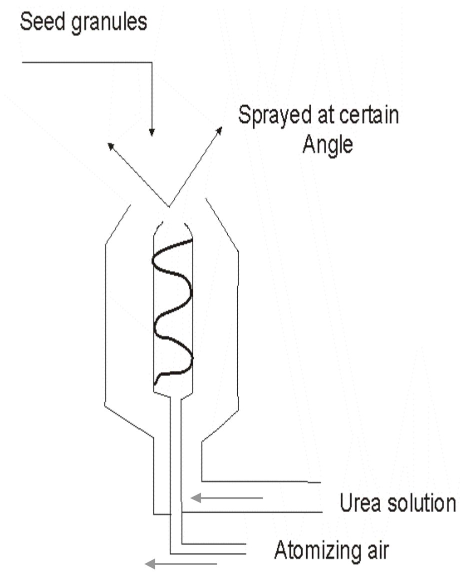

Figure 15: Urea spraying nozzle

In this process particle size grows by continuous evaporation and solidification of a large number of minutes drops of the solution into the initial particle called seed or nucleus (accretion process).

The granulated product from the granulator is down in the first fluid bed cooler and thereafter is taken up to the screening section by the bucket elevator.

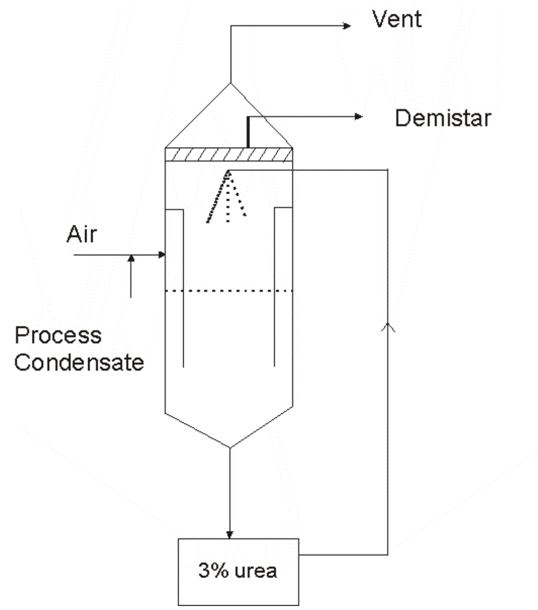

Figure 16: Cooler scrubber

In the screening section urea granules are separated into three fractions; on-size (2-4 mm,end product), undersize (below 2 mm,fine), oversize (coarse).

Undersize fraction is recycled directly and oversize fraction is recycled after crushing into the granulator and used as a seed or nucleus.

Block diagram of Granulation unit

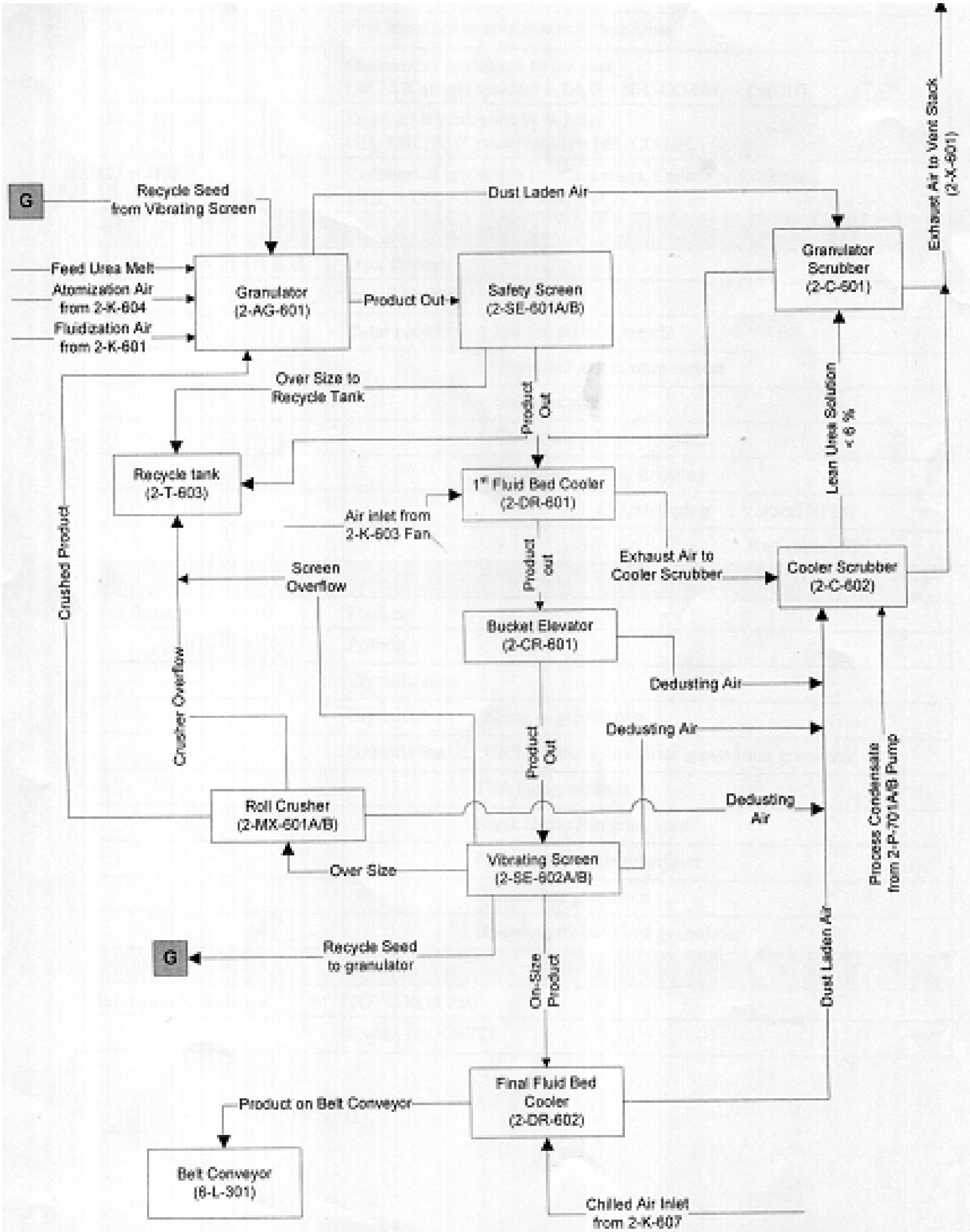

Figure 17: Block diagram of Granulation unit

WATER TREATMENT FACILITIES

In KAFCO the water requirement is varied about 700 m^3/hr. Source of the raw water is the under ground water. There are 8 deep tube wells .each has a capacity of 200m^3/hr of these 6 are always working, one is standby and the remaining one is recently introduced to meet the increasing water requirement in the plant. The water level is under continuous monitoring as after a certain level of water the pump will trip. Then the water goes into the clarifier.

Clarifier

Before the clarifier water is stored in a pond some turbid materials are separated. Then along with small turbid, bacteria, iron and some manganese this water moves to clarifier. KAFCO has two clarifiers of slurry blanket type. Normal capacity of these clarifiers is 970m^3/hr. conical bottom is at 45^0 with the surface. Maximum angle can 60^0 according to design. One by one chlorine, alum, sodium hydroxide, coagulant is added.

Chlorine is added

- To remove Mn2+
- To remove Fe2+ by oxidation
- To kill bacteria
- To maintain pH; for better coagulation

Purpose of using **alum** is

- To maintain pH near about 6.85
- To remove $Ca(HCO_3)_2$

Sodium hydroxide is used

- To increase pH for reducing corrosion
- To dissolve O_2
- To remove CO_2

Coagulant increases the suspended solid size. KAFCO uses a polymer commercially known as kurifloc (trade code PA 322)

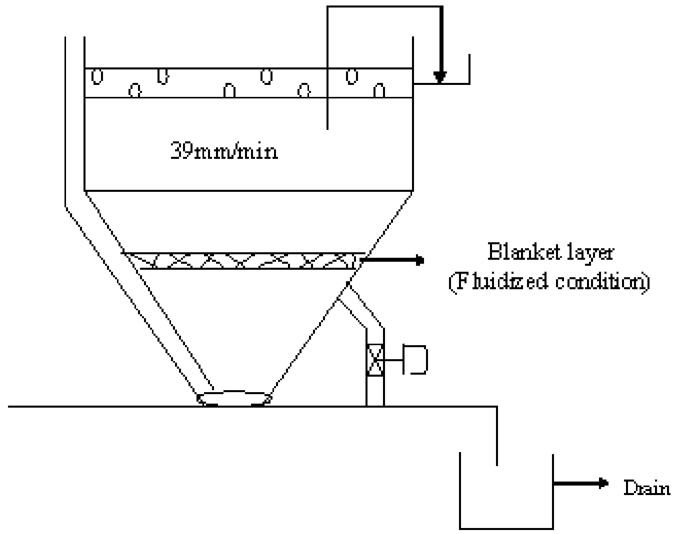

Figure 18: Schematic diagram of clarifier

Sand filter

Clarified water is passed through sand filter and thus remaining suspension is removed. Gravels are used to support the sand .Maximum size of the solid that can be trapped is 30 μ mm. Water passes though an arrangement of 8 banks of gravel-sand combination. Next water is stored in a 14000 m^3 water tank.

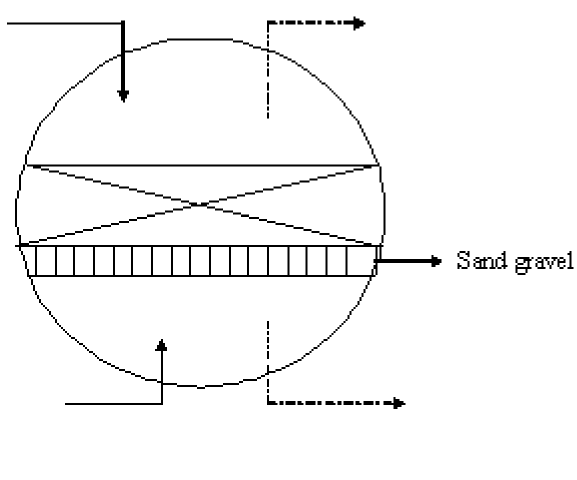

Figure 19: Schematic diagram of sand filter

Cooling tower

In the cooling tower air cools process water and they flow countercurrently. It is a mechanically draft cooling tower. Induced draft fans are used to suck air. KAFCO has 10 cells in the tower. Cooling water may be cooled by 10 to 15^0C using cooling tower. There is a side stream which is 2% of raw water. Some chemicals are used:

Sulphuric acid: To control pH

Chlorine: To kill bacteria and other such type of micro organisms. Poly cream is used every month to remove slime.

Dispersant: A Zn based phosphate polymer which is used to prevent scale formation.

Corrosion inhibitor: A Zn based phosphate polymer is used that forms a layer on the inner pipe surface to resist corrosion.

Demineralization unit

Dissolved ions are removed in the demineralization unit. Different types of resin are used according to necessity. The major contents of this unit are –

Cation exchanger

- To remove Na , Mg, Ca, etc

Anion exchanger

- To remove So_4^{2-}, Cl^-, $CO_3^{2- -}$

Degasifier

- To remove dissolved CO_2 in water

Mixed bed polisher

It is used to obtain highest purities in the treatment of feed water and condensate for high-pressure steam boiler. Both cation and anionic resins are used in the polisher.

STEAM GENERATION UNIT

BOILERS

KAFCO has two natural circulation natural gas fired package boilers of MACCHI, Italy. The boiler furnaces operate under positive pressure and in completely water cooled condition of furnace floors, walls and roofs consisting of membrane wall construction. The furnace is completely enclosed by water walls. The space between the tubes is closed by the fins, which overlaps each other. Thereby forming a completely gas tight seal enclosure. The water walls are-rear wall, intermediate wall and front wall. There are D-tubes forming the floor, side and roof walls. These tubes are continuous construction entering directly into the steam and water drums. Suitable excess door are provided on the front wall, intermediate wall and side wall in order to inspect furnace, superheater and boiler bank tubes during boiler overhaul.

Supplies for steam production:

- ✓ Water
- ✓ Fuel NG
- ✓ Air

Design capacity of each boiler: 95 ton/hr at 100% Maximum Continuous Rating (MCR)

Production: 85 ton/hr

Feed water temperature: 135^0C

Product steam temperature and pressure: 110kg/cm^2; 510^0C

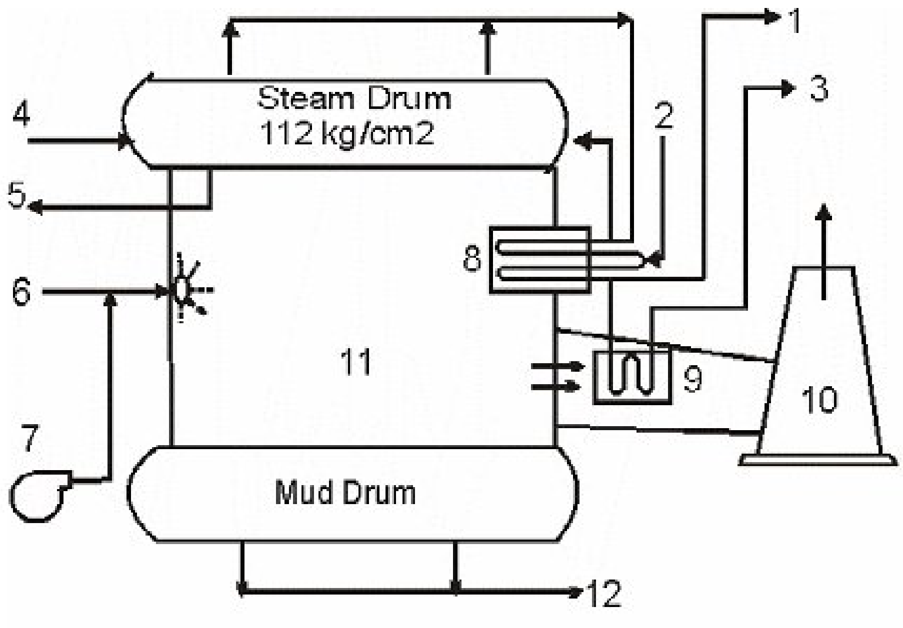

Figure 20: Boiler and its input output

Table 1. Parts of a boiler and their description

Number	Name	Description
1	Boiler production	High pressure (HP) steam to header,85 ton/hr at 510^0C
2	Desuperheater	BFW added to maintain HP steam temperature at 510 ^{0}C
3	Boiler feed water	BFW, 87ton/hr to steam drum at 140^0C gaining temperature through economizer up to 190^0C
4	Chemical dodging	Phosphate solution to create passive layer inside steam drum
5	Continuous blow down	Keep impurities such as silica concentration constant in the loop
6	Natural gas	At a rate of 6.5 KNm^3/hr as source of heat energy
7	Forced draft fan	Supply combustion air at 80 T/hr. Motor and steam driven
8	Superheater	Increase saturated steam temperature from 323^0C to 510^0C

9	Economizer	Preheat BFW by extracting heat from flue gas , looses temperature from 360^0C to 195^0C
10	Vent stack	Release flue gas to atmosphere
11	Boiler house	Ignition happens in a positive pressure, 320 mm H_2O
12	Intermittent blow down	Controls sudden increase of impurities

Problem in the boiler

Though preparation of boiler feed water undergoes various treatments, a trace amount of undesired substance may cause some problems. This are-

- ✓ Corrosion due to improper pH and dissolved gases
- ✓ Scale formation because of hardness and silica content
- ✓ Carry over by entrainment and vaporization

These problems can be controlled by different chemical dodging in the boiler and by level controlling.

STEAM SYSTEM

Steam in KAFCO plant has five different pressure levels which are used in utility, ammonia and urea plant. In **utility and urea plant**, the three different pressure levels are as follows:

High Pressure (HP) Steam

- ✓ Pressure: 109 kg
- ✓ Temperature: 510^0C
- ✓ Design pressure/temperature: 122 kg, 548^0C

Medium Pressure (MP) Steam

- ✓ Pressure: 38.1 kg
- ✓ Temperature: 380^0C
- ✓ Design pressure/temperature: 46 kg, 410^0C
- ✓

Low Pressure (LP) Steam

- ✓ Pressure: 4.2 kg
- ✓ Temperature: 220^0C
- ✓ Design pressure/temperature: 7 kg, 260^0C

Besides in **Urea plant**

- ✓ 20 kg steam is used in stripper & hydrolyser
- ✓ 8 kg steam is used in heating purpose in granulation unit, ejector, steam jacketing and tracing

STEAM HEADER CONTROL SYSTEM

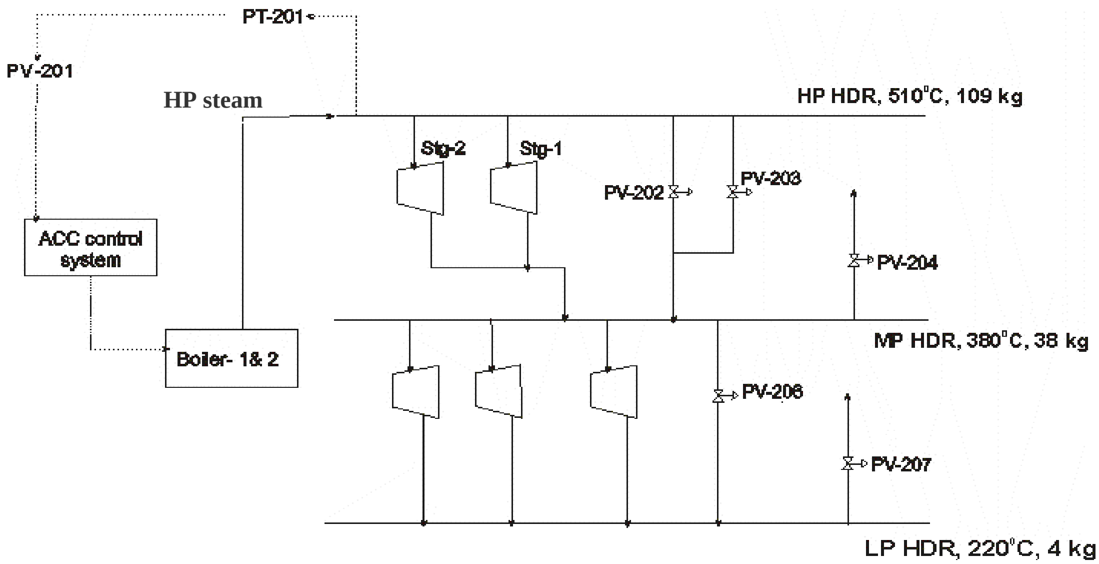

Figure 21: Steam header control system

HP steam header

HP steam generated in number 1& 2 boilers is first come to the HP steam header and supplied to the Steam Turbine Generators (STG) for power generation. HP header pressure is controlled by two ways-

- ✓ During normal operation, the pressure is controlled by the Automatic Combustion Control (ACC) system. PV-201 is the master controller. It gets sense from the PT-201 and increase or decrease ignition as per requirement and maintains pressure at the set pressure of 109 kg.
- ✓ If the pressure exceeds the set point, HP steam will undergo letdown to the MP steam through PV-202 to maintain HP steam pressure.

MP steam header

MP steam is produced as extraction steam from the STG-1 & 2 and supplied to different users. MP header pressure is controlled by the following ways-

- ✓ During normal operation, the pressure is controlled by the extraction steam governor valves and by the controller PV-203. MP steam pressure is maintained at 38 kg.
- ✓ If the pressure exceeds the set point, then two actions will execute automatically-
  - i) HP steam letdown will decrease by PV-203
  - ii) Extraction steam from STG will decrease
- ✓ If the pressure of the MP steam header is extremely high and exceeds the set point of MP vent controller PV-204 (40.5 kg), then it will actuate automatically to maintain the pressure of the MP steam header by venting of excess MP steam to the atmosphere.
- ✓ If the pressure decreases down the set point, then two actions will execute automatically-
  - iii) HP steam letdown will increase by PV-203
  - iv) Extraction steam from STG will increase accordingly

LP steam header

LP steam is produced as exhaust steam from different steam turbines i.e. Utility cooling water pump, FDF boiler no-2 and BFW pump. LP header pressure is controlled by the following ways-

- ✓ During normal operation, the pressure is controlled by the controller PV-206. LP steam pressure is maintained at 4.05 kg.
- ✓ If the pressure decreases down the set point, then pressure control will be done by opening or increasing letdown automatically.
- ✓ If the pressure of the MP steam header is extremely high and exceeds the set point of MP vent controller PV-207 (4.2 kg), then it will actuate automatically to maintain the pressure of the LP steam header by venting of excess LP steam to the atmosphere.

POWER GENERATION UNIT

There are two types of power generator in KAFCO-

✓ **Steam Turbine Generator (STG)**

HP steam generated in number 1& 2 boilers is supplied to the STG for power generation. There are two steam turbine generators (G-1 & G-2) in KAFCO with 10 MW capacities each. They are extraction-condensing type turbines. Steam comes through Turbine Throttle (TT) and HP control valve which control the steam pressure. STG runs about 10,000 rpm. There is a gear box that acts as a reducer to reduce the speed up to 1500 rpm in the generator. The voltage generated is 6.6 KV and frequency of 50 Hz as the Motors that are used run at 6.6 KV.

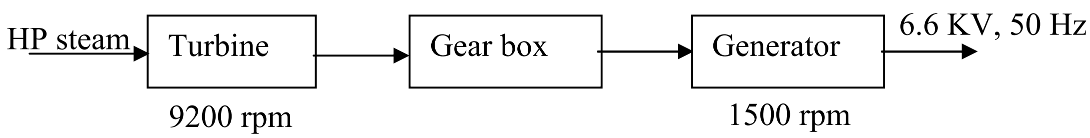

Figure 22: Units of power generation

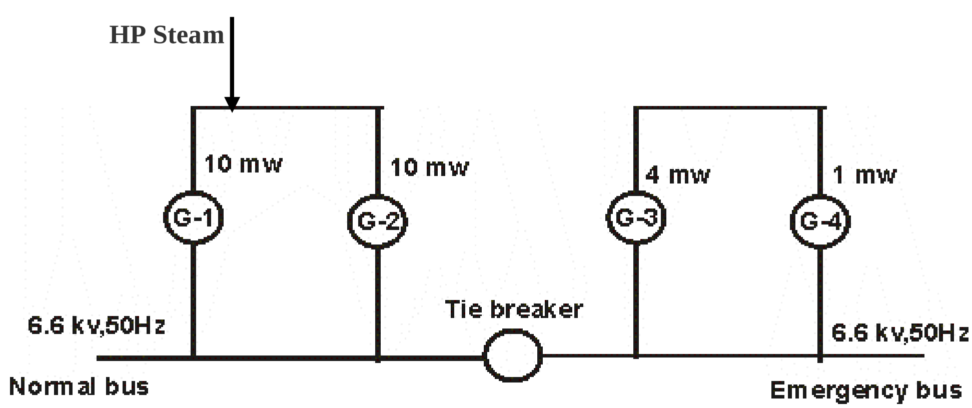

Figure 23: Electrical load management system

- ✓ **Diesel Engine Generator**

There are two other standby generators (4 MW and 1 MW) which are used in case of any emergency. G-3 (4 MW) starts to start up STG. G-4 starts manually if G-3 fails to start up.

All power lines meet in a common line which is called BUS. There are two BUS-one is normal bus, another one is emergency bus. There is a tie breaker between two buses which is always in charge up condition. In case of failure in STG, the emergency bus will come on track to supply current in the most essential part of the plant.

PRODUCT HANDELNG (PH) AND STORAGE

Activities of PH and storage

Product handling and storage section is responsible to maintain the stock of urea by controlling the product quality within the specified condition & dispatch the materials for abroad and domestic purposes. Granulated urea is transported at a rate of 83 tons/hr to urea bulk storage by the conveyor system. The flow rate and total capacity carried by the conveyor line is measured by a weighing scale which is installed on receiving conveyor line. The bulk product is distributed and pilled up on the storage area in urea bulk storage by a tripper. It is controlled the maximum height and distance of piles are 16,500 mm and 700 mm respectively. The temperature of the receiving urea is maintained 35-40^{0}C and relative humidity is maintained 55-60% inside the bulk storage. There are 56 unit heaters for heating the inside air of bulk storage for dehumidification.

Urea transfer system

Dispatch of urea is usually carried out in three modes-

- ✓ Bulk product into ship (for abroad)
- ✓ Bagged urea into ship (for abroad or local market)
- ✓ Bagged urea into truck (for abroad or local market)

Urea conveyor system

- ✓ Manual- By means of local commands
- ✓ Automatic- sequence control from control room

Unit capacity

- ✓ Urea bulk storage capacity: 80,000 MT
- ✓ Reclaimer capacity : 50-500 MT/hr
- ✓ Bag loading capacity : 80-85 MT/hr
- ✓ Bulk ship loading capacity: 450-500 MT/hr
- ✓ Bagging hopper capacity : 18 m^3 at high level & 3.5 m^3 at low level

MAINTENANCE DEPARTMENT

Maintenance is such an important division of a plant which gives continuous and sustainable support to the production department to avoid undesired and unplanned interruption. This is an essential department of each plant and the efficient performance of this department contributes to the efficiency and stability of a plant after start up. The Maintenance department of KAFCO seemed to be very strong-based, well equipped and very efficient in respect of manpower. In fact it can be said that KAFCO is the most well maintained plant among the government owned as well as multinational plants in Bangladesh. The total strength of the maintenance department here is 150 people and dedicated and systematic works helped KAFCO to reach such a position.

The main objectives of the Maintenance dept. are:

- ✓ To provide support to the production dept. for uninterrupted production
- ✓ To avoid catastrophic failure
- ✓ To prolong the life of equipments and machineries
- ✓ To optimize spare parts consumption
- ✓ To save production downtime

To fulfill these objectives all the branches of the maintenance dept. run scheduled check ups and tests at a definite interval like a 15 days or 1 month cycles.

Now there are four branches of the Maintenance division:

- ✓ Mechanical Maintenance
- ✓ Electrical maintenance
- ✓ Civil Maintenance
- ✓ Instrumentation Maintenance