A PROJECT REPORT

ON

HEAT INTEGRATION STUDIES IN SULPHURIC ACID MANUFACTURING PROCESS

A project report submitted in partial fulfillment for the award of the degree of

**BACHELOR OF TECHNOLOGY IN CHEMICAL ENGINEERING**

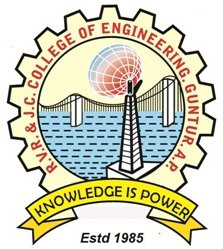
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2021 - 2025

**CERTIFICATE**

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During the above period their conductance and performance was found to be ----------------------

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Sulphuric acid plant Coromandel international ltd

Coromandel international ltd

**ACKNOWLEDGMENT**

The success and final outcome of this project required a lot of guidance and assistance from many people and I am extremely fortunate to have got this all along the completion of my project work. Whatever I have done is only due to such guidance and assistance and I would not forget to thank them.

I respect and thank Mr.N.Sridhar,Sr.Manager-HR(L&D), for giving me an opportunity to do the project work at COROMANDEL INTERNATIONAL LIMITED and providing us all such support and guidance which made me complete the project on time. I am extremely grateful to all of the Managers, Engineers, operators and all for providing such guidance.

Also, we would like to extend my sincere gratitude and regards to the non-teaching staff for their timely support.

**ABSTRACT**

This report is a contribution to the waste heat recovery in a sulphuric acid production plant. Energy efficient processes with maximized heat recovery and efficient operation have moved more and more into focus in the sulfuric acid business. The production of sulfuric acid by the contact process rejects about 150 t/h of gas at a temperature of 70°C and about 30 MW of heat in sea water. This work is a contribution to the valorization of this energy wasted. It deals with the opportunity of its recovery by providing some of the hot utility requirements. The present work is especially interested in the heat wasted in the sulfuric acid production unit. This unit uses the double absorption contact process.

**OBJECTIVES:**

* To study the process of manufacturing of sulphuric acid by contact process.
* To study heat integration in sulphuric acid manufacturing process (contact process).
* To know about applications of sulphuric acid.

**Problem statement:**

* Heat integration studies in sulphuric acid plant.

**INDEX**

**Contents page no.**

1. **INTRODUCTION 01 - 02**
   1. Intoduction to sulphuric acid plant in Coromandal 02
2. **LITERATURE SURVEY/THEORY 03 - 35**
   1. Raw material’s 03
   2. Product acid quality 03
   3. Steam generation 03
   4. Equipment’s involved 03 – 04
   5. Chemicals required 04
   6. Steps involved in production of sulphuric acid 05
   7. Chemistry of the process 06
   8. Process description 07 – 09
   9. Equipment description in brief 10

2.9.1 Melting section 10 - 14

2.9.2 Combustion section 14 – 19

2.9.3 Conversion section 19 - 28

2.9.4 Absorption section 28 - 35

1. **INTRODUCTION**

Process heat integration means heat that was previously cooled off is recovered and reused in another unit operation with direct process heat integration, heat is transferred directly from one process stream to the other in a single heat exchanger.

There exist today worldwide concerns about the excessive use of fossil fuels and the pollution problems that come with it [1, 2]. The process industries are responsible for 27% of global energy consumption, and annual demand for heat and electricity is expected to grow by 1.9% and 2.4%, respectively [3, 4]. Despite the increasing demand, depleting reserves of fossil fuels and increasing energy prices, energy in the form of low-grade heat is still being wasted. Using energy more efficiently could reduce demand for fuel; thereby conserving resources, reducing operating costs and reducing CO2 emissions [4]. Some recent control methods are discussed in [12-16]. Heat recovery systems can significantly increase the efficiency of industrial plants thereby contributing to the reduction of energy consumption. This study investigates the feasibility of utilizing waste heat from a sulfuric acid production unit for the purpose of heat recovery.

Example: In refineries, the heat from several waste streams can be used to preheat crude oil upstream of a fired heater.

Here we are going to explain heat integration in sulphuric acid manufacturing process. where, **Sulphuric acid (H2SO4)** is a colorless dense oily corrosive liquid produced by the reaction of Sulphur trioxide with water and used in accumulators and in the manufacture of fertilizers, dyes, and explosives. It is also called as king of compounds.

For the further studies on this project, we have considered sulphuric acid plant in coromandel, Visakhapatnam.

**1.1 INTODUCTION TO SULPHURIC ACID PLANT IN COROMANDAL:**

, adopting single contact single absorption technology using solid Sulphur as raw material. Initially the plant starting with a combustion furnace, two waste heat boilers, converter, economizer, drying tower and single absorption tower.

In 1975 the plant was revamped to 900 MTPD to eliminate the problems in acid coolers, to reduce stack emission and to improve the conversion efficiency.

Simon craves India limited adopting double contact double absorption process, design this process. In this plant convertor section has 5 beds are arranged to increase the production rate to 1400MTPD.

In October 2005, another sulphuric plant is constructed. it is also based on DCDA process. this plant was set by “MONSANTO PROCESS”. this was set to meet the excess requirements of the sulphuric acid in the production of fertilisers.in this plant production capacity is 300MTPD.

**PLANT CAPACITY:**

**S.A.P.-1 - 1400MTPD - 94%conc. - 68 T/Hr steam complex**

**S.A.P.-2. - 300MTPD - 98%conc - 32 T/Hr steam - pap**

1. **LITERATURE SURVEY/THEORY**

**2.1 RAW MATERIALS:**

1.Molten Sulphur with following specifications:

Sulphur content - 98.5% by weight

Moisture content max. - 0.5% by weight

Ash max. – <50PPM

2.Raw sulphur

3.Air

**2.2 PRODUCT ACID QUALITY:**

The sulphuric acid produced should be a commercial acid.

Total acidity as H2SO4  - 98.5% Iron as FE - 500PPm

**2.3 STEAM GENERATION:**

The total steam generated for 1T of acid is about 1.3T of steam, (390oc,39kgf/cm2).

Steam production per hour at the following:

S.A.P-1 - 68T/hr

S.A.P-2 - 32 T/hr

**2.4 EQUIPMENTS INVOLVED:**

1. Melting compartments with an agitator
2. Pressure leaf filter
3. Sulphur pumps
4. Sulphur burner (Furnace)
5. Waste heat boiler
6. Hot gas filters
7. Convertor
8. Super heater
9. Heat exchangers
10. Economizers
11. Absorption towers
12. Blink mist eliminators
13. Alkali scrubber
14. Acid circulation tanks, pumps & coolers
15. Cooling tower
16. Blower
17. Drying tower

**2.5 Chemicals required:**

* **Decolite:**

It is used for the removal of ash & mud content which precoating on the filter leaves in the precoating compartment.

* **Tri sodium phosphate:**

It is a corrosion inhibitor and to increase the flow of fluid simultaneously in steam.

A 1.92 sp.gr : 1922kg/m3 Liquid - 1.79 sp.gr : 1794 kg/m3

* Ignition temp - 248 0 C to 266 0 C in air
* heat of fusion - 13.2 k cal / 121 0 c
* viscosity - 8.0 cp @135 0C
* **Properties of sulphuric acid:**
* Molecular weight - 98.08 kg/kg mole
* Physical state - oily liquid
* Color - color less
* Odor - odorless
* Melting point - 10.4 0 c
* Boiling point - 370 0c
* Corrosivity - high corrosive
* Hygroscopicity - hygroscopic
* Solubility - highly soluble in water
* **Properties of catalyst: V2O5**
* Vanadium pentoxide is an odorless, yellow, red, crystalline solid slightly soluble in water at 250 c and more soluble in acid
* Specific gravity - 3.36 at 21.7 0 c
* Vapor pressure - app. 0 mmHg at 68 0 F
* Boiling point - 1750 0 c
* Melting point - 681 0 c
* Molecular weight - 181.878 g/mol
* Solubility in water at - 25 0 c
* **Advantages of V2O5:**
* Increased % conversion
* No toxic in nature
* Can resist high temp
* Less fragile in nature
* Only 5% V2O5 of is replaced per year & highly economical

**2.6 Steps involved in production of sulphuric acid**

* Sulphur melting
* Filtration
* Combustion
* Conversion
* Absorption
* Cooling

**2.7 CHEMISTRY OF THE PROCESS:**

**Mainly the production of sulphuric acid is carried in three stages:**

* **First stage:** Combustion of Sulphur in excess air to form Sulphur dioxide. The reaction is exothermic. This reaction carried out in furnace.

S + O2 SO2  + 70.9 Kcal/Kg mol

(Sulphur) (Oxygen) (Sulphur Dioxide)

* **Second stage:** Oxidation of SO2 to SO3 in the presence of vanadium pentoxide catalyst. This reaction is carried in converter.

SO2 + 1/2 O2 SO3 + 23.4 Kcal/Kg mol

(Sulphur Dioxide) (oxygen) (Sulphur trioxide)

The two above reactions are exothermic. The heat generated is used to reheat the gases to the desired temperature for the converter passes, produce steam in high pressure boilers and superheat the steam generated for various utilities

* **Third stage:** Absorption of so3 in sulphuric acid forms oleum and the formed oleum is diluted with water to form 2 moles of sulphuric acid. The reaction is carried out in absorbers.

S03 + H2SO4  H2S2O7

(Sulphur Trioxide) (sulphuric acid) (Oleum)

H2S2O7 + H2O 2H2SO4

(Oleum) (water) (sulphuric acid)

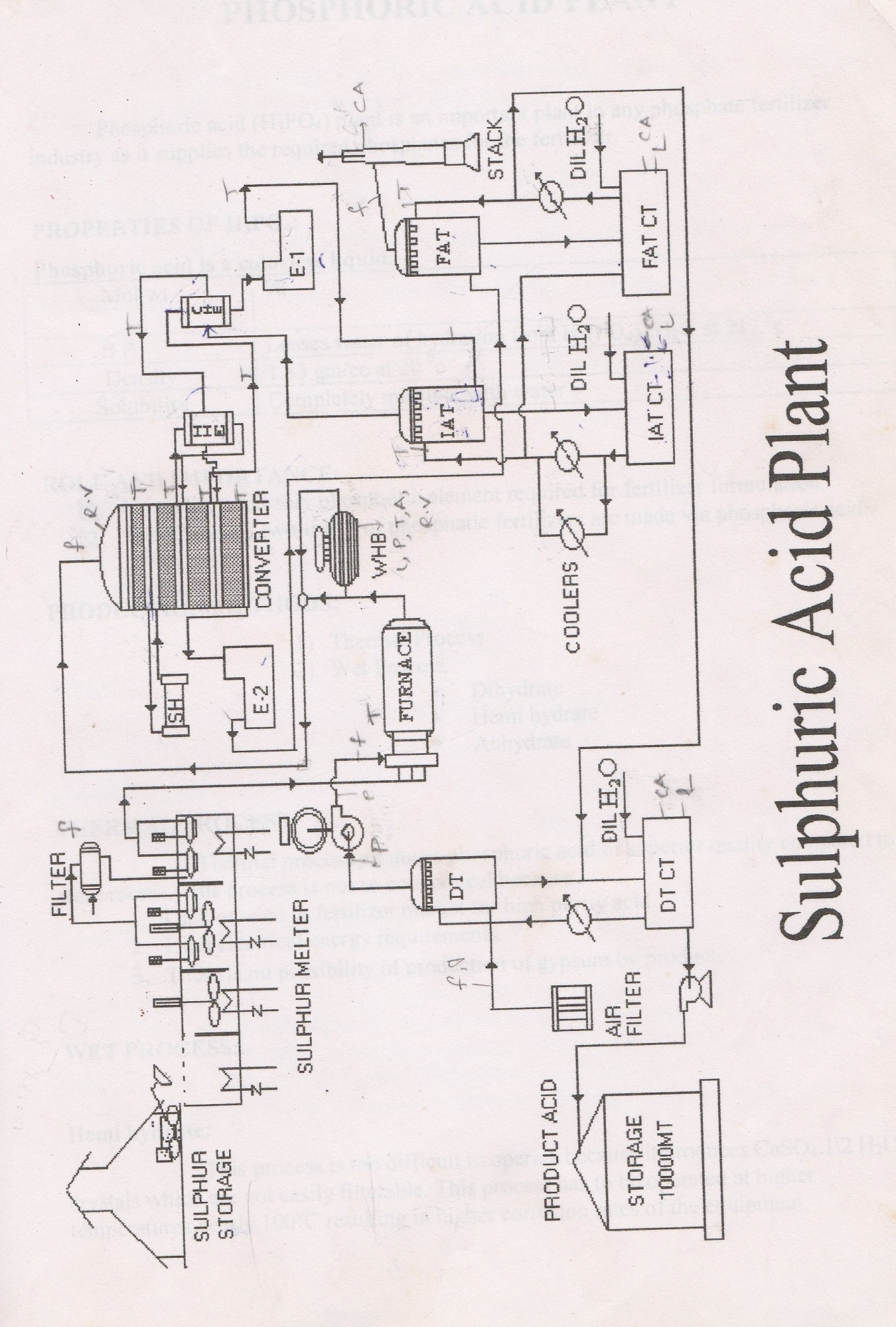
These two reactions are exothermic and most of the heat generated is removed by cooling water in acid coolers

**2.8 PROCESS DESCRIPTION:**

The raw Sulphur from gulf countries is imported and stored in Sulphur storage silos at wharf. From there it is transferred to Sulphur godowns of large capacity of 25000 MT. Then the Sulphur is fed into the melting compartment by pay loaders. Steam is used as a heating media in melting compartment where the Sulphur melts at 1190c temp only, but we generally maintain 1350c for its free flowing and also decomposition of ash results at that particular temp 1350c only. The obtained molten Sulphur of pressure 7 kg/cm2 and temp of 1750c is fed into the pressure leaf filters for filtration from precoating Sulphur pit.decolite powder is added in the precoating compartment which makes the filtration easy by foaming a cake layer on the leaves of the filter. Then the filtered molten Sulphur is stored in the clean Sulphur pit it is provided with a set of molten Sulphur to the Sulphur for combustion.

All the Sulphur piping’s are steam jacketed and the low-pressure saturated steam tapings are provided at regular intervals for maintaining the Sulphur in molten form during its flow. The filtered molten Sulphur along with the imported molten Sulphur of 99.9 % purity with an acidity of <0.02 % and ash content of < 100 ppm is pumped into the furnace by Sulphur pumps.

Combustion of molten Sulphur is carried out in Sulphur furnace in the presence of dry air to produce Sulphur dioxide gas containing 10.5-11.5% of SO2. The air required for the combustion is supplied by the blower. The steam turbine driven main air flower provides the mean for moving all the process gas through plant. The blower sucks the air from atmosphere and filters the air via. the air filters. The drying tower removes water vapor from the air stream before it passes to the Sulphur furnace. Drying eliminates the possibility of corrosion by wet gas in subsequent gas ducts reduces possible damage conditions could condense in the convertor and reduces subsequent formation of acid mist most of which would not be absorbed. Drying tower removes atmospheric moisture by counter current contact of strong 98.5% H2SO4 in air. The acid gets diluted because of the moisture absorbed from air and flows into the drying tower circulation tank. Two number of mist eliminators are mounted on the top of the drying tower to avoid the mist carryover.



Sulphur furnace is a combustion chamber where Sulphur undergoes atomization with air at a temperature of 1100oc to form SO2.Due to the high temperature of gas leaving the furnace effects the proper conversion in the further process they are fed to the waste heat recovery boiler for steam production .The gases leaving the boiler is passed to though the hot gas filter which is provided between the waste heat boiler and convertor pass 1 to clean the gases going to convertor. The SO2 gases are with at a temperature of 4200c is fed to the convertor. The conversion of SO2 to SO3 takes place in the convertor in the presence of V2O5 catalyst and potassium oxide as a promoter. In a five pass DCDA Convertor a quench air line to the 4th pass is provided so as to provide air for the combustion in the 4th and 5th passes. The reaction is exothermic, so the temperature is raised the presence of O2 not only raises the equilibrium conversion of SO2 but also is essential for maintaining the activity of vanadium catalyst.

The heat generated due to the conversion of SO2 to SO3 in the first pass is brought down to a desired level in the super heater. In the super heater saturated steam is used a cooling media, so the gas passes through the tubes and the saturated steam passes through the shell side the steam gets converted into the super saturated steam where the process gases from the super heater are sent to the second pass of the converter. The heat generated in the second pass is removed in the hot heat exchanger the heat generated in the third pass is removed in the cold heat exchanger and the gases from the cold heat exchanger are taken into economizer IB to recover heat into the steam circuit by heating boiler feed Water and the gases cooled in the economizer flow to the IAT i.e., intermediate absorption tower so3 is absorbed by circulating 98.5% sulphuric acid in counter current direction.

It is normal practice to absorb SO3 gases in absorption in water produces acid must which is difficult to separate from the gas steam and damages downstream equipments. Gases from the IAT are reheated to the reaction temperature required if the 4th pass inlet, in the shell side of the CHE followed by HHE.The gases from the 4th pass on to the 5th pass without cooling. Gases from 5th pass flow through economizer to recover the heat before going to fat to absorb so3 generator in the fourth pass by the circulating 98.5% sulphuric acid in the tower.

The unreacted SO2 to SO3 gases leaving the IAT & FAT absorptions towers are passing through alkali scrubber to reduce stack emission. In the alkali scrubber the unreacted gases are scrubbed by using alkaline solution called NaOH as a scrubbing agent. And exit gases from the alkali scrubber are vented to atmosphere through plant stack. Hot acids form the absorption tower is returned to their respective pump tanks. Acid circulations pump this hot acid from the acid pump tanks through the circulating acid coolers in order to cool the acid. There coolers is an anodically protected shell & tube heat exchanger which utilizes cooling water for cooling the acid. Cooled acid is then circulated through IAT & FAT for absorption of so3 from the convertor gases and through DT for the removal of moisture from atmosphere air. Simultaneously some of the cooled acid is passed through the product acid cooler for further cooling of the acid. This cooler is a plate heat exchanger cooler which utilizes salt water as a cooling media for cooling the acid. This product acid of 98% conc. of temp 400c is pumped to the product storage tank by the product transfer pumps.

**2.9 Equipment description in brief**:

The operational steps involved in the production of sulphuric acid are:

* Melting section
* Combustion section
* Conversion section
* Absorption section

**2.9.1 MELTING SECTION:**

This section is adopted mainly for the purpose of cleaning the raw Sulphur (i.e., making the raw Sulphur free of impurities). This cleaning operation is carried out in the following compartments namely melting, dirty, precoating and clean Sulphur pit.

**Melting compartment:**

**Construction:** It is a rectangular trough like compartment provided with a set of Steam coils or tubes. It is provided with 22coils, and the compartment is lined with acid bricks. In the middle of this compartment a central agitator is placed used for proper melting of materials in the corners of the trough and to maintain temperature uniformly. At the top this compartment cage made of iron is arranged for better pushing of a Sulphur material into the compartment.

**Process:**

The raw Sulphur stored in the godown is transferred to the melting compartment through a pay loader by maintaining regular interval of time. Steam at a temperature of 1350C 4kg/cm2 or 1750C and 7kg/cm2  pressure is passed through the steam coils of the compartment. steam supplied to the steam coil inlet for melting of raw Sulphur and the condensate is drawn out through the outlet. As the Sulphur melts at 1190C, the temperature raise to 1350C is used to make the molten Sulphur free flow pumping through the pipelines. In this compartment lime is added to maintain pH of Sulphur and to neutralize acidity and ash content and also to prevent the equipment free from corrosion. The melting compartment has only solids and liquids. After proper melting of Sulphur by an agitator moving at constant speed is overflows to another compartment for further processing

**Specifications:**

Volume of melting compartment - 5.3m3

Number of steam coils - 22

**Dirty compartment:**

This is also a rectangular compartment located inside the ground. It is also provided with agitator. It acts as a buffer vessel to maintain constant pH of the Sulphur before sending it for filtration. This also provided with steam coils to avoid solidification. The overflow from this compartment flows to the precoating compartment.

**Specifications:**

Volume of dirty compartment - 8.8m3

Number of steam coils - 2

**Pre coating compartment:**

It is a tank made of carbon steel. The overflow from the dirty compartment flow through this compartment. The main purpose of this compartment is to add a precoated material called Decolite, which is used in the formation of initial cake layer on the filter leaves, for better filtration. This Decolite is homogeneously mixed with the given molten Sulphur and pumped to the filter continuously for ½ hour for deposition of of decolite on leaves through vertical submerged pumps to the clean Sulphur pit for storage.

**Specifications:**

* Volume of precoating compartment - 5.3m3
* Number of steam coils - 2
* Decolite powder added per day - 50bags.

**Pressure leaf filters:**

The filtration of molten Sulphur is carried out in specially designed filter aid type equipment called shell & leaf filter

**Construction:**

It is a horizontal tank provided with a set of vertical leaves held on a retractable rack. The leaves are generally closed inside the tank during the operations. Feed enters through the side of the tank and the filtrate passes through the leaves into the discharge manifold.

**PRESSURE LEAF FILTER:**

**Process:**

The filtration of molten Sulphur is carried out in this filter. In this molten Sulphur from the precoating compartment is sent to the feed tank of the filter. The Decolite which is mixed with molten Sulphur forms a layer on the filter leaves. Initially as the molten material passed through the filter leaves doesn’t form an effective layer. Hence the filtered material is again recycled for several times until a thick layer of Decolite is formed on the leaves, which are known by increase of pressure, drop in the filter. Finally, the filtered molten Sulphur is flows into the delivery pipe to the clean compartment.

**Specifications:**

* No of leaves - 18
* Temperature of molten Sulphur inlet - 135oC

**Molten Sulphur:**

* Purity - 99.99%
* Ash content - 100ppm
* Acidity - 0.02%

**Advantages:**

* It is more effective if washing of cake is necessary.
* It is widely used for filtration involving filter aids.
* It is used for handling materials of high toxicity.

**Clean Sulphur pit**:

**Process**:

The filtered molten Sulphur before going to the Sulphur burner is stored in a ground pit having 8 steam coils of 40NB pipe schedule 40 called clean Sulphur pit or clean compartment. This compartment also provided with a submerged centrifugal pump. Steam coils are installed at bottom with side inlet and outlet. Here LP steam having 1350 C and 4kg/cm2 passed through the coils for maintaining Sulphur in molten form. From here it is fed to the furnace for further processing.

But now, the COROMANDEL is importing molten Sulphur directly to the plant by using steam jacketed trucks and stored in the clean compartment. All the molten Sulphur lines are steam jacketed to prevent plugging of lines.

**Specifications:**

* Volume of Clean Sulphur pit compartment - 327m3
* Number of steam coils - 8
* Capacity - 588MT

**Air blower:**

The main air blower system is a turbine driven blower which utilizes high pressure super saturated steam from the acid plant itself. It has been designed to move gas to the acid plant system. The air is sucked from atmosphere and pushed through the downstream equipment up to the stack.

**Description:**

It is a horizontal centrifugal turbine driven air blower. It is designed to handle 90,000Nm3/hr of air. The rotation speed of the impeller is 4000rpm under steam conditions ranging from 38-40kg/cm2 gauge pressure and with temperature of 300 – 390oc of super heated steam and the exhaust pressure of 3-3.1kgf/cm2(g). It is connected to a steam turbine with multiple coupling. This connection helps to breakdown the connection with turbine when the motor gets over loaded. An air filter is installed at the suction of the blower to prevent dust particles in atmosphere from entering the blower. The filter consists of filter cloth housed in the shell. Air blower discharge pressure should be gradually made such to avoid fluctuation in the volume of gas.

**Process:**

The filtered atmospheric air enters the suction of the blower through the inlet nozzles via filter with a flow rate of 90,000nm3/hr. The blower provided enough head its push the air & the later gas (after the Sulphur combustion) through & remainder of the plant. Then the air enters in to drying tower and contacts counter currently with 93% concentration H2SO4 at a temperature of 45-60oC.The acid absorbs the moisture present in air because of its dehydrating nature. The dry air is fed to the furnace and to the convertor.

**Specifications:**

* Flow rate of air to blower - 90,000 Nm3/hr.
* Rotation speed of blower - 5000 rpm.

**There are two types of trip mechanisms:**

* Lube oil trip mechanisms
* High speed trip mechanism

**Turbine:**

It is pressure and velocitycompounded, reaction type, throttling governing and non condensate turbine. The turbine is run by steam which rotates the rotor in the shaft and finally the impeller by which the air is supplied. The rotor and the shaft are connected using flanged coupling. The shaft unsupported by the bearings. The bearings used are journal bearings. Continuous lubrication system is adopted so that the bearings do not wear. The governor of the steam turbine controls the volume of gas flow through the plant. The governor alters the speed of the turbine as per the steam inlet so as to maintain the desired blower output. HP steam of 75T/hr is used to run the blower and exhaust of the turbine is LP steam of temperature 135oC & 3-4kgf/cm2 pressure.

**Specifications:**

* Inlet steam pressure - 32-38 kg/cm2 (HP)
* Outlet steam pressure - 3- 4 kg/cm2 (LP).

**2.9.2 COMBUSTION SECTION:**

The combustion section consists of furnace and a waste heated boiler.

**FURNACE:**

the Sulphur combustion system conducts combustion of Sulphur to produce Sulphur dioxide as per the following reaction.

S + O2 SO2  ΔH=- 70.9 Kcal/Kg mol

(Sulphur) (Oxygen) (Sulphur Dioxide)

**Description:**

Furnace is a large horizontal cylindrical vessel made up of mild steel. Internally it is provided with three baffles for more retention time and better oxidation. The furnace is lined inside with three layers of refractory linings.

* Inside - two layers of fire bricks
* Middle - asbestos sheet
* Outside - two layers of insulation bricks.

At the entrance of the furnace three swirl jet nozzle type spray Sulphur guns are provided for atomization of Sulphur particles. The diameter of the nozzles is approximately 7.5 mm temperature of the furnace should not exceed 1200oC & should not fall below 600°C (min). the Sulphur gun is actually a concentric pipe. The inner pipe carrying the molten Sulphur and the outer pipe contacting low pressure steam for maintaining the Sulphur in molten state during its run through the gun.

**Initial Starting of furnace:**

The temperature of the furnace is slowly increased to 900oC by heating the furnace by combustion of kerosene. The kerosene is initially fed through the middle gun and LPG is used for ignition of kerosene.

**Process**:

The Sulphur is pumped from the clean compartment to furnace at a pressure of 8 kg/cm2. The guns atomize the Sulphur ensuring the complete combustion. The blower feeds the moisture free air from the drying tower at the top of the furnace. The following reaction takes place in the furnace.

The above reaction is exothermic reaction, so a lot of heat is released. Hence the temperature inside the furnace is around 1080oC.therefore the volume of SO2 produced at 1100oc is about 11.5%.the theoretical flame temperature corresponding to various percentage of SO2 in the burner gas are as follows (inlet air to burner is at 80oc).

|  |  |
| --- | --- |
| SO2 by volume | Approximate sulphur burner exit temperature |
| 6.0%  7.0%  8.0%  9.0%  9.5%  10.0%  10.5%  11.0%  11.5%  12.0% | 6480c  7290c  8140c  8960c  9370c  9760c  10140c  10560c  10910c  10990c |

Therefore the outlet temperature of furnace is 10500c-11000c with 12% SO2, 8.9%O2 and 79.1%N2 conversion. Then the gases are fed to waste hest boiler for steam production and to decrease the temperature up to 3500c-4000c.

**Furnace specification:**

Diameter (OD shell) - 5000 mm

Length (straight) - 16450 mm

Baffles - 03

Gas outlet temperature - 1140oC

Air inlet - 1480 mm

Gas outlet pressure - 1868mm

Sulphur nozzle - 4 no’s (spraying system)

Nozzle diameter - 7.5mm

Capacity of gun - 400MT

**Parameters:**

Inlet temperature of molten Sulphur - 1350c

Air inlet temperature - 800c

**Waste heat boiler:**

**Purpose:**

The sulphuric acid plant operates with a high pressure steam system. It is so designed to recover process heat by superheating the saturated steam. The high pressure steam is generated is delivered to the turbine of main air blower and the remaining steam is supplied outside the plant. The waste heat boiler with steam drum, super heater, economizers are taken as a part of thermal systems waste heat recovery package.

**Description of waste heat recovery boiler:**

It is a single pass fire tube horizontal shell & tube boiler made of mild steel. Boiler consists of two horizontal drums namely mud drum and steam drum placed one above the other. It consists of 15 no. of raisers and 12no.of downcomers. Down comers provided from the side of the. steam drum to the bottom of the mud drum to circulate water. Mud drum consists of 1196 tubes. Risers are provided at the top of mud drum to the bottom of the steam drum. These risers open above the water level in steam drum. A blow down tank is installed for the continuous and intermediate blow downs required for waste heat boiler. Blow down valves are provided below the mud drum to remove the settled solids periodically. Manways are provided to access the shell & tubes.

**Specifications:**

Purpose: - To cool the furnace outlet gases

Type: - Horizontal fire tube boiler.

Gas composition: - SO2 -12%, O2 -8.9%, N2 -79.1%

Gas inlet temperature - 1140oC

Gas outlet temperature - 420oC

Operating steam pressure - 39kgf/cm2

Design Pressure: - 42kgf/cm2

Hydraulic test pressure: - 66.52kgf/cm2

Heat transfer area: - 1269sq.cm

Steam generation: - 64MT/hr-76MT/hr

Number of tubes: - 1196

**Steam drum:**

Steam drum is a cast steel, horizontal, cylindrical tank with dished ends. It is connected with waste heat boiler with down comers & risers’ tubes. In the steam drum, water level is maintained of 50% to produce steam feed water inlet to steam drum. Demister pads are provided in the steam drum to eliminate the carry over mist present in steam. A duct is also provided at the top of the steam drum to collect steam of 32kgf/cm2 pressure. Two relief valves and vent valves are placed above the steam drum.

**Steams drum specifications:**

Shell size: - 1800mm

Length: - 6500mm

Thick ness - 50mm

Risers: - 15 no’s

Down comer: - 12 no’s

Demister pads: - 8 no’s

**Boiler has boiler mounting & accessories:**

**Boiler mountings:**

Mountings are used to eliminate the accidents and for effective functioning of a boiler. They are :

* 1. water level indicator
  2. pressure gauge
  3. feed check valve
  4. blow off valve
  5. safety valve
  6. steam stop valve
  7. fusible plug

**Boiler accessories:**

Accessories mean additional auxiliary components to remove efficiency of steam and to produce high quality steam. They are:

1. economizer
2. super heater
3. desuperheater
4. steam traps
5. steam separator

**Process involved in waste heat boiler:**

The SO2 bearing gases after combustion in the furnace are passed through the waste heat boiler. The temperature of SO2 coming out of the furnace at 1100oC should be reduced to 420oC for efficient conversion of SO2 to SO3 gas. Hence, the Waste heat boiler is to recover the enthalpy of the gases. These gases (12% SO2, 8.9%O2 and 79.1%N2) from the furnace enters the tube side of the waste heat boiler. Boiler feed water enters into the steam drum of the boiler with a temperature of 250oC and pressure of 50kg/cm2.the boiler feed water before entering the steam drum has to be preheated up to the saturation point before it enters the steam drum. This is done by the economizer; the heat transfer takes place between furnace off gases water by radiation & convection heat transfer modes. Here 50% of water level is maintained in steam drum for steam generation. The water from the steam drum enters the shell side of mud drum through down comers. Therefore, the outlet temperature of the gases is about 325oC and flows through the duct to the convertor. The water gets vaporized by taking the heat from the gases and produces saturated steam of 3500c & pressure of 39kgf/cm2.the steam generated in the steam drum is volute to superheater. Here the steam collects and superheated & this is routed to the turbine of the main blower. The exhaust of the turbine is low pressure steam is sent to utilities, The inlet and outlets of the boiler are joined by a 3-way bypass valve. This valve bypass certain amount of the gases from the furnace and mixes them with the boiler outlet gas to attain optimum temperature of 420oC.a chemical feed system comprises of trisodium phosphate tank and TSP pump tank agitator and TSP pumps. This system provides the chemical dosing required for the steam drum. Safety valves for the TSP pumps (reciprocating type) are provided at the pump outlet and their discharge is routed to TSP tank. Trisodium phosphate acts as a corrosion inhibitor.

**Hot gas filter:**

It is vertical packed bed type equipment. The entire tower of the filter is filled with packed material called silica quartz supported on a perforated plate. Hot gases from the furnace are fed to the bottom of the filter. The gases while passing through the bed impurities contained in the gas is removed and the clean dust free gas passed to the converter. Hot gas filter is equipped only in SAP-2.

**Specifications:**

Filter media -- silica quartz pebbles.

Gas flow rate -- 33,000nm3/hr

Height -- 5000mm

**2.9.3 CONVERSION SECTION:**

**Purpose:**

The convertor system performs conversion of Sulphur dioxide gas to Sulphur trioxide gas in the vanadium containing catalyst as per the following reaction.

**Chemical equation at converter**

V2O5 + 2SO2 + O2 2SO3 + V2O5

The conversion of SO2 to SO3 takes place in the five separate convertor passes the converter is designed to convert 99.9% of the SO2 to SO3 at the designed rate. The heat exchanger allows the gas temperature to be regulated to each converter pass, maximizing conversion. The stack releases the emission generated from the plant at higher altitudes.

**Description:**

The Converter is a double contact double absorption five pass with intermediate absorption after third pass. It is a vertical cylindrical vessel made of mild steel lined inside with machinate layer to prevent corrosion of the shell. It is insulated with asbestos or glass wool to maintain required temperature. This insulation is covered with aluminum sheet. The first & second passes since bearing high temperature gases are internally insulated with thick insulation bricks. Solid cast steel division plates are welded between each convertor pass. Each pass contains vanadium promoter catalyst .quartz silica stones are provided on the top and bottom of the beds for preventing degradation of catalyst. Some empty space is provided on the top and bottom f the bed for distribution of gases. All the beds are equipped with inlet and outlet thermocouples each pass has an access man way above & below the catalyst bed. The convertor is designed for a maximum gas flow containing up to 11.0%SO2 and 10.4%O2 for an acid production rate of 1400 &300 MTPD (100%H2SO4 basis) as 98.5% H2SO4.

As the number of passes increases, the percentage conversion of SO2 to SO3 increases there by decrease in SO2 content. Hence the bed thickness is increased in order to increase the contact area and retention time.The temperature of the gasses must be cooled to optimum condition because, according to the Lech atelier’s principle the forward reaction is exothermic is favored at low temperatures, so for yield of SO3 can be obtained at low temperature. A temperature of 420oC is optimum.

**Process:**

The SO2 bearing gasses after combustion in the Sulphur burner and before entering the convertor are passed through the hot gas filter. The convertor and gas heat exchanger system is operated to maximize conversion of SO2 to SO3 in the five convertor passes and in order to maximize conversion the inlet temperature to each pass must be properly controlled. The SO2 gases coming from the furnace are converted in SO3 in the presence of catalyst V2O5 and promoter K2O.this conversion takes place in five passes within the convertor passes the conversion of SO2 to SO3 increases the gas temperature. The heat generated by the exothermic reaction is removed by passing it through various boiler accessories like super heater, hot heat exchanger, cold heat exchanger and economizers.

The designed catalyst performance is

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Pass | Design temperature(0c)  Inlet (0c) outlet(0c) | | Expected conversion (%) | Pressure drop mmwc |
| Pass-1 | 418 | 608 | 63.3 | 176 |
| Pass-2 | 440 | 519 | 89.6 | 137 |
| Pass-3 | 440 | 459 | 95.9 | 109 |
| Pass-4 | 430 | 445 | 99.8 | 55 |
| Pass-5 | 420 | 420.4 | 99.5 | 79 |

**Cooling between each passes consists of:**

Pass 1 : super heater

Pass 2 : hot heat exchanger

Pass 3 : cold heat exchanger economizer 1B.

Pass 4 : quench air.

Pass 5 : economizer 2A/C.

**The design catalysts are**:

PASS CATALYST TYPE

Pass – 1 LP120

Pass – 2 LP120

Pass – 3 LP110

Pass – 4 LP110

Pass – 5 LP110

LP 110 : Type of V2O5 catalyst used for low percent conversion.

LP 120 : Type of V2O5 catalyst used for high percentage catalyst.

Catalyst V2O5 : 400oc (activated state & <4000c (inactive state).

**Specifications:**

Type : vertical, cylindrical.

No. Of passes : 5

Shell (ID) : 9500MM.

Shell height : 16875mm.

**First pass:**

The gasses from waste heat boiler at a temperature of 4200C are passed through the first bed. At this temperature the SO2 gases are converted to SO3 in the presence of promoted vanadium pent oxide catalyst. Within the converter pass the conversion of so2 to so3 increases the gas temperature. Therefore, the temperature of outlet gas of first bed rises to 250c. The heat generated by the exothermic reaction removed by the super heater, the heat of reaction is decreased to 4350c. in the first pass,65percent of conversion takes place

**SUPER HEATER:**

**Construction:**

Super heater is a cross flow, vertical shell and tube heat exchanger. It consists of “S” shaped coils. The tubes are made up of steel alloy and shell is made up of carbon steel alloy. The bottom of the super heater is lined with acid proof bricks. The super heater is designed to cool 92,24NM3/hr of so3 process gas from maximum (degree) deg0c to 4350c. It is provided with four openings for the inlet and the outlet of the gases and steam. The entire system is insulated with glass wool. The super heater is provided with two safety valves, one at the top coil and other at the bottom coil. The super heater has an intermediate desuper heater which is controlled by the temperature controller. Man, ways are provided to access the shell & tube sides.

**Specifications:**

Shell side fluid - gas

Flow - 92,241 NM3/hr

Inlet/outlet temp - 620/4410c

Working pressure - 0.3 kgf/cm2

Design temperature - 6500c.

Tube - fluid - saturated steam from BFW

Flow - 2 coils of each 31.967kg/hr

Inlet/ outlet temperature - 244/3850c

Design temperature - 4250c

Working temperature - 38.7kgf/cm2

Design pressure - 42.6kgf/cm2

Heat transfer area - 1125m2

Top coil outlet safety valve - set at 42.5 kgf/cm2

Bottom coil outlet safety - set at 42.5 kgf/cm2c

**Process:**

The gases from the converter’s first bed at a temperature of 625oC enter the shell side of the super heater. & Steam enters through the tubes from the steam drum. Heat transfer takes between them and brings down the temperature of the gases from the converter to 4200c. The steam gets super-heated, and the temperature increases to 3850c. After exiting the super heater the process gas flows to 2ndconverter pass.

**Second pass:**

The gases from the super heater enter the converter second bed at a temperature of app. 420oC.in the presence of promoter v2o5 the further conversion of so2 to so3 takes place where 85 percent of conversion is obtained. the temperature rises to5250c the gases from 2nd pass are sent to the hot heat exchanger.

**Hot heat exchanger:**

**Construction:**

It is a vertical shell and tube heat exchanger. It consists of a tube bundle containing 1416 tubes. Tubes are constructed out of steel alloy and the shell made of carbon steel. The bottom of the heat exchanger is lined with acid proof bricks.

Type – shell & tube

Heat transfer area – 1192.5 m2

No of tube – 1416

Tube length – 5277 mm

Tube diameter – 50.8 mm

Shell (ID) - 3275 mm

**Process:**

The gasses from second bed enter into the hot heat exchanger at 525oC temperature. This temperature is not adequacy for next conversion. Hence the hot gasses from second pass are enters through tube side of heat exchanger. The cooling medium is unconverted gases, passing through tube side from cold heat exchanger. So heat transfer is takes place between those two gases in counter current flow the temperature is reduced from 525 oC to 436oC. therefore, In the same way the unconverted gases from cold heat exchanger is increase to 420oC from 322oC.

**Parameters:**

Shell side - hot gases from 2nd pass

Tube side - cold gases from cold heat exchanger

Hot gas inlet/outlet temp - 5250c/4360C

Gas from CHE i/d temp - 4200c /3220C

**Third pass:**

The gases from hot heat exchanger enter into the third pass for further conversion at 436oC. Due to heat of reaction the temperature of gases is increase to 464oC and 92%of conversion takes place. This gas then enters into the intermediate absorption tower at temperature of 200oC via cold heat exchanger, economizer 1.

**Cold heat exchanger:**

**Construction:**

It is a single pass vertical shell and tube heat exchanger single segmental baffles. It consists of tube bundle containing 1700 tubes which are constructed out of steel alloy and shell is of carbon steel. Cold heat exchange occurs between the third pass outlet gases and the return gases from the I.A.T. The converter outlet gases enter the tube side and return gases through the shell side. A temperature drops of about 450 to 307oC occurs in the tube side and 79 to 322oC in shell side. The cold heat exchanger is provided with many ways access at the top & bottom tube sheets as well as the shell side vestibules. Drain valves area provided for the shell and tube side of the cold heat exchanger.

**Process**:

From the hot heat exchanger ,the process gas flows to the 3rd converter pass, where further conversion of SO2 TO SO3 occurs .the gases exiting converter pass 3 area cooled in the cold heat exchanger .unabsorbed gases comes into the cold heat exchanger and passes through the shell side and the converter gases areas passed into the tubes .heat transfer takes between them resulting in the temperature drop of cold heat exchanger gas (tube side)i.e. from 450 to 307 0c and increase in the return gases from the IAT i.e. 79 to 3220c in shell side .thus process heat recovered in the cold& hot heat exchangers from the 2nd and 3rd converter passes respectively, is used to raise the gas temperature to the 4th pass inlet temperature prior to entering the 4th pass.

**Specifications:**

* Type : shell & tube ,counter current.
* Heat transfer : 2574m2
* No. of tubes :1700
* Outer dia.of tubes : 50.8mm
* Length of tubes : 9575mm
* Tube side in/out temperature : 450/2670C
* Shell side in/out temperature:79/3220C
* Shell side flow: 98183 Nm3/hr
* Tube side flow:110433Nm3/hr

**Economizer – 1:**

It is simple cross flow, vertical, shell and tube heat exchanger. It has water and tube side and gases at casing side. Gilled tubes with hair pin bends are mounted in rectangular casing. Economizer one B is designed to cool 90125N m3/hr of so3 process gas from 3070c to 190oc at 44kg/cm2 BFW operating pressure. Manways are provided to access the shell&tube sides.

**Process :**

The economizer boiler feed water during its flow through the three sections up to the saturation temperature of steam drum operating pressure generally the boiler feed water from economizer to bottom bundle of coils is fed and heated. BFW again enters into the economizer 1b top coil. The temperature of water rises from 1350c to2210c the temperature of the gases is dropped from 307 to 200oc. The tubes present in the Economizer in the form of bundles. BFW is flown through the tubes. The BFW from the Economizer-II bottom bundle of coils is fed and the heated BFW is again enters into the Economizer-II top coil. The temperature of the water is raised from 135 to 221oC. The temperature of the gases is dropped from 307 to 200oC.The gases from the Economizer-I are sent for intermediate absorption of SO3 gases. This absorption of SO3 reduces the product concentration favoring the forward reaction. In this IAT absorption of so3 gases in H2SO4 takes place and the unconverted gases from IAT via cold heat exchanger and hot heat exchanger to converter fourth pass.

**Specifications:**

**Purpose:** To cool gas from C.H.E &heat boiler feed water.

* Type : gilled tubes
* Duty-gas vol : 90215 Nm3/hr.
* Duty gas composition : SO2-1.2% ; SO3-27.8% ; O2 -3.2% ; N2 - 67.8%
* Gas inlet temp : 307 oC
* Gas outlet temp : 190 oC
* Heat transfer area : 1375 m2
* Bfw inlet temp : 135 oC
* Bfw outlet temp : 221 oC
* BFW rate : 51,770 kg/hr.

**Fourth Pass:**

The unconverted gases from the absorption towers enter the fourth bed of the converter. As the temperature of the gases doesn’t follow a regular trend, an amount of first bed gases are passed through the fourth bed or through cold and hot heat exchangers to raise the temperature to 420 oC. Intermediate bypass valves also provided for the control of inlet gasses temperature. A quench airline to the fourth pass is provided so as to provide air for the combustion in the 5th pass and also to reduce the gas temperature It is very important that oxygen is added to these beds which inturn improves the SO3. Finally as the gases from fourth bed not have so much of temperature raise, they are directly fed to the fifth bed for further conversion.

**Fifth pass:**

As the gases from the 4th bed will not have the required raise temp there directly fed to the fifth bed for the conversion The gases fed to the fifth bed undergo the same reaction with outlet gas temperature 4500C and passed to the fed to the final absorption tower via economizer-ll. Here conversion of 98.5% is takes place.

**Economizer - 2:**

As usual the BFW is preheated and fed to the boiler. The specialty of this Economizer-II is that it contains three bundles of coils with three individual inlet and outlet headers. They are top middle and bottom coils: BFW from the utility plant is divided into two streams. One stream is fed to the middle coil and the other is fed to the bottom coil. The out let from the bottom coil is fed to the Eco-I. The water from the Eco-I is fed to the top coil. The overall temperature raise in the Eco-II in the both the coil is from 115oC to 249oC.

**Process:**

The BFW from utility plant is divided into two streams. One stream is fed to the middle coil and other is fed to the bottom coil the outlet from the bottom coil is fed to the top coil the over all temperature is raise in economiser two in the 60th coil is from 115 oC to 249 oC

**Specification:**

Purpose : To cool gas to the final tower &heat boiler feed water.

Type : gilled tubes. Three separate water side section.

Duty-gas vol : 78,500 Nm3/hr.

Duty gas composition : So2-0.05% ; So3-21% ; O2 -3.98% ; N2 - 93.9%

Gas inlet temp : 424 oC

Gas outlet temp : 200 oC

Heat transfer area : 1875 m2

BFW inlet/outlet temp(bottom tanks) : 115/135oc

BFW inlet/outlet temp (Middle tanks) : 115/249oc

BFW inlet/outlet temp To top tanks : 221/249oc

BFW rate to bottom module : 51770 kg/hr.

BFW rate to middle module : 14140 kg/hr.

Middle coil outlert relief valve : set at 44kg/cm2

Top coil outlet relief valve : set at 44 kg/cm2

**Inter pass cooling of the gases:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Pass** | **Cooling Equipment** | **Shell side Temperature change oC** | **Tube side temperature change oC** | **Gases**  **Shell Tube** | |
| **I** | Super Heater | 620 to 430 | 250 to 385 | 1st pass gases | Steam |
| **II** | H.H.E | 322 to 420 | 525 to 436 | Return Gases from C.H.E | II pass  Gases to third bed |
| **III** | C.H.E | 79 to 322 | 450 to 307 | Return  Gases | III pass  Gases |
| **IV** | Economizer-I | 307 to 200 (max) | 135 to 221 | III pass  Gases | BFW |
| **V** | Economizer-II | 424 to 200 (max) | 115 to 249 | IV pass  Gases | BFW |

**2.9.4 ABSORPTION SECTION:**

The absorption system from is designed to absorb the so3 from the process gas to form H2SO4dilution water is added to the system at the IAT & FAT absorbing pump tank to form sulphuric acid .The SO3 produced in the converter is absorbed in the absorption towers.

S03 + H2SO4  → H2S2O7

H2S2O7 + H2O → 2H2SO4

The absorption is done twice; first after third bed conversion and second after fifth bed

**The main equipments in this section:**

1. Intermediate Absorption Tower.
2. Final Absorption Tower.
3. Circulation Tanks and coolers

**Construction of Absorption Towers:**

Both the towers are of same construction. It is a cast iron steel cylindrical, vertical packed absorption tower with flat bottom & internally lined with thiophenol are bricks. the tower is packed with cross partition rings of different sizes accumulating to the total packed height. the tower consists of partition rings at the bottom and Intralox saddles at the top . The packing is supported on grid bars which span brick arches in the bottom of the tower. The gas inlet nozzle is a 450c brick lined nozzles. the acid outlet nozzle is a ceramic sleeved nozzle. Provision for the stick test is provided for the mist analysis on the IAT&FAT gas outlet nozzles. the tower has mist eliminators installed at the top of the tower. Eight mist eliminators are installed. These mist eliminators are hanging type so the housing is brick lined. For these mist eliminators removal housing is provided above the mist eliminators tube sheet without the brick lining. the glass fiber material with alloy 20 mesh separates the acid mist particles from the gas stream and returns to the tower. They are provided with V-notch type distribution system place between mist eliminators and the bed. The gas entrance is placed at the bottom of the tower. The tube supplying the gas is divided into two at the entrance of the tower for better distribution of the gases. Both the towers are provided with two individual circulation tanks. I.A.T is provided with two acid coolers where as F.A.T is provided with only one cooler, as the absorption capacity is less for F.A.T.

**Process of absorption:**

Sulphuric acid is used for the absorption of so3 from the gases. The process of absorption (counter current) is same for the both the towers. They vary only in the quantity of SO3 absorbed. Absorption is more in I.A.T than in F.A.T. by 98.5% Sulphuric acid of temperature 65oc through the packed column in both IAT &FAT. The Sulphuric acids is distributed through trough type CI distributors installed over the packing & cover the entire cross sectional available area to avoid channeling of air. The distributor has distribution points and down comers are covered with ceramic Intralox saddle packing. This reduces the acid spray from the distributor. the process gas enters the IAT and fat absorbing towers with a temperature of 425oc through the gas inlet nozzles at the bottom of the tower. The gas is contacted with a counter current flow of acid in the packed section of each tower.

The gases from the converter are fed from the bottom of the tower. at a temperature of 200oC temperature absorption takes place efficiently (this is why gases from the converter are cooled to 200oC).

Acid at a concentration of 98.5% and a temperature of 78oC is sprayed over the fixed bed. The SO3 from the gases is absorbed by acid spraying in counter current direction and the so3 reacts with the free water in the acid to form additional Sulphuric acid. The absorption process is an exothermic hence the temperature of the acid is raised. And as well the temperature is conveyed from the gases to the acid. Hence the gases from the absorption leave at a temperature of 78 to 80 oC. The gases’ leaving the bed flow through the mist eliminators to recover the entrapped acid in the gases and then leaves the tower. The concentrated acid by absorption from the towers flows into the respective circulation tanks. In circulation tanks the concentration of the acid is brought back to 98.5% by dilution with fresh water. This dilution of the acid is done in the small well into which the water is added. During the dilution the temperature is raised around to 105oC. Hence this temperature is to be reduced this is done in coolers. The cooled acid from the coolers is fed to the absorption towers.

**Intermediate absorption tower specifications:**

* Shell dia : 6000mm
* Shell height : 17645mm
* Rhephenol lining : 3mm
* Acid distribution system trough system V-notch
* Acid flow : 937m3/hr
* Inlet acid strength : 98.5%
* Inlet acid temperature : 77oC
* Outlet acid temperature : 105 oC
* Gas inlet temperature : 200 oC
* Gas outlet temperature : 65 oC

**Mist eliminators**:

* Material of construction:glass fiber + alloy 20
* Efficiency:100% for > microns
  + 99% for < microns

**Final absorption tower specifications:**

* Shell dia : 6000mm
* Shell height : 11400mm
* Rhephenol lining : 3mm
* Acid distribution system trough system
* Acid flow : 372.5m3/hr
* Inlet acid strength : 98.5%
* Inlet acid temperature : 77oC
* Outlet acid temperature : 105 oC
* Gas inlet temperature : 200 oC
* Gas outlet temperature : 65 oC

**Mist eliminators**:

* Material of construction:glass fiber + alloy 20
* Efficiency:100% for > 3 microns
  + 99% for < 3 microns

**Circulation tanks:**

1. **They are three circulation tanks:**

IAT circulation tank

FAT circulation tank

DT circulation tank

These are large vertical cylindrical tanks brick Lined, carbon steel tank with acid proof brick lining and top sealed They are also provided with submerged centrifugal pumps the tank receives the acid from the two towers respectively the tank along with the tower bottoms provides for ad run back volume when the acid system is not in operation dilution water is added to the pump tank through a Teflon tube The pump tanks is also provided with vent line to the vent scrubber to discharge entrain gods from the pump tank acid.

**Specifications :**

**IAT circulation tank**:

* Dimensions – I.D-5790mm
* Height – 2695mm
* Lining – 3mm lead & 105 mm and proof brick
* Dilution chamber – 1500 mm (l) X 1000mm (w) X 1545 mm (B)
* Pump height from bose – 2210mm

**FAT circulation tank:-**

* Dimension – I.D = 4758mm, height = 2870mm
* Lining – 3mm lead & 105mm acid proof brick
* Dilution chamber dimension – 1500mm(l) x 1000mm(w) x 1545mm(H)
* Pump height from base – 2145mm
* Distance between pump – 807mm (or) 28%

**DT circulation tank:**

* Dimension – I.D.5500mm: height – 2140mm
* Lining - 3mm lead & 105mm acid proof/bricks.
* DT circulation pumps:
* Type – vertical, centrifugal, submerged.
* Capacity- 385m3/hr.
* Head- 25mlc.
* Kw/rpm - 75/1480.
* Material of Construction: shaft : Alloy 20
* Impeller: Ni-Cr.
* Impeller diameter - 323.85 mm

**Circulation pumps:**

**IAT & FAT circulation pumps:**

* Circulation pumps generally installed in the pump tanks which supplies the acid to the absorbing towers.
* These pumps are vertical submerged centrifugal pumps.
* These pumps can supply 98.5% H2so4 at 88oc with 25 mlc discharge pressure.

**I.A.T. circulation pump:**

* Type – vertical,centrifugal,submerged
* Capacity – 1112m3/hr
* Head – 24.5mbc
* kw/rpm – 200/1480
* MOC – shaft-alloy 20
* Impeller – Ni-Cr
* Impeller diameter – 342.9mm

**FAT circulation pump:-**

* Type – vertical, centrifugal, submerged
* Capacity – 385m3/hr
* Head – 25m/c
* Kw/rpm – 75/1450
* M.D.C – shaft-alloy 20
* Impeller – Ni-Cr

**COOLERS**

**Construction of Circulation tanks:**

These are large cylindrical tanks made of cast iron with acid proof brick lining and top sealed. They are also provided with submerged centrifugal tanks.

**Protection and Construction of Coolers:**

**There are three coolers**:

1. Intermediate Absorption cooler
2. Add On IAC
3. Final Absorption Cooler

All the three are shell and tube heat exchangers. The acid flows in tube side and cooling tower water flows in shell side. They are provided with anodic protection system to avoid corrosion. In this system the tube sheet are connected to a supply of 400mV supply. At the starting of the cooler a current of 15 A is supplied as an electron layer is to be formed on the surface of the tubes. Once layer is formed on the tubes the corrosion is avoided, as corrosion does not occur on cathode. Once a layer of electron is formed the resistance is increased and current to be supplied is around 1A.Therefore, the cooled acid (circulating acid cooler discharge is then circulated through IAT and FAT for absorption of so3 from the converter gas and through DT for the removal of moisture from atmospheric air.

**Specifications:**

**I.A.T acid coolers:**

Type – horizontal shell & tube co-current shell side-fluid-98.1% sulphuric acid

In/out temp – 104/77oc

Tube side – fluid-cooling tower water.

In/out temp – 32/47oc

Heat transfer area – 356m2

**Add on IAT acid cooler:**

Type – horizontal shell & tube co-current

Shell side – fluid-98.1% H2SO4 acid

In/out temp – 32/47oc

Flow – 207m3/hr

Heat transfer area – 70.6m2

**FAT acid coolers:-**

Type – shell & tube counter current

Shell side – fluid – 98.5% H2so4

IN/out temp – 92/77oc

Tube side – fluid – cooling tower water

In/out temp – 32/42oc

Heat transfer area – 136.8m2

**Drying of Air:**

The atmospheric humid air from main air blower discharge enters the DT through the inlet nozzle the air enters the bottom of the DT. the air flows upward through the packing were it is contacted with a counter current flow of 98.5& sulphuric acid. The sulphuric acid dries the air and flows by gravity as sulphuric acid being hygroscopic in nature Is used for the absorption of moisture from air. The dried air exists the packing and flows up through the DT mist eliminators. The DT mist eliminators removes the majority of the acid mist from the air and returns it to the tower after existing the mist eliminators the dried air leaves the DT.along with the acid return from the drying tower strong acid from the absorbing acid system is also added to the pump tank to maintain the sulphuric acid concentration of the acid pump tank. The DT return acid and the strong acid from the absorbing acid system mixes in the respective pump tank and the majority of the acid is pumped through the circulating acid cooler. Where the acid is cooled and sent over the drying tower and the 2 absorbing towers.

**Specifications:**

* Shell diameter (I.D) – 6000 mm
* Shell height – 13645 mm
* Rephenol lining – 3mm.
* Acid flow – 302.5m3/hr.
* Inlet acid strength – 93%
* Inlet acid temp – 43oc
* Mist eliminators
* Material of construction : alloy 20
* Efficiency : 100% > 3mm microns ; 99% < 3mm microns

**Collection of the product acid:**

The product is taken from the drying tower circulation tank (D.T.C). Acid from the circulation tanks of absorption towers (I.A.T.C and F.A.T.C) are transferred to the D.T.C when ever the height of the acid level in the tanks crosses 45%. The acid from the drying tower is withdrawn when acid height cross 50%. The acid is drawn after the cooler from all the circulation tanks. To decrease the product acid temperature plat type heat exchangers are using and see water as cooling media for higher temperature difference.

**SCRUBBING SYSTEM:**

For reducing emission of SO2 gases, there is a new project for this using caustic soda solution SO2 is converted as sodium carbonate. Here for scrubbing, packed towers are used (counter current flow is employed).

Now the SAP-I is also revamped to 5 pass conversion system so as to increase the production rate according to the requirement.