TOPIC: **THE INDUSTRIAL PRODUCTION OF SULPHURIC ACID AND ITS USEFULNESS**

VENUE: **COLLEGE OF SCIENCE AND TECHNOLOGY (CST) CONFERENCE ROOM**

DATE: **FRIDAY, APRIL 7, 2017.**

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INDUSTRIAL PRODUCTION OF SULPHURIC ACID AND ITS USEFULNESS

Process description

Industrial production of Sulphuric Acid Plant is based on the most modern method called Double contact Double Absorption (DCDA) process and is designed to produce very high tonnage on 24 hours of normal operation using elemental sulphur as feed stock (See flow chart).

Raw materials required are:-

1. Sulphur
2. Oxygen
3. Demineralised water
4. Sulphuric acid H_2SO_4

Chemical Reaction

1. $S(s) + O_2 \xrightarrow{V_2O_5} SO_2(g)$
   sulphur + oxygen → sulphur dioxide
2. $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$
   sulphur dioxide + oxygen → sulphur trioxide
2. $SO_3(g) + H_2SO_4(aq) \rightarrow H_2S_2O_7(aq)$
   sulphur trioxide + sulphuric acid → oleum (100%)
4. $H_2S_2O_7(aq) + H_2O(1) \rightarrow 2H_2SO_4(aq)$
   oleum + demineralised water → sulphuric acid 98%

AIR AND GAS CIRCUIT

- **Air for sulphur burning is supplied through main Air Blower. The air is passed through drying Tower to remove practically all moisture content.**
- **High efficiency Deminster pads are on top of the drying tower to prevent acid carry over in air.**
- **Sulphur is burned in the sulphur furnace with dried air to produce gas containing 10.5% SO_2.**

- **This is a highly exothermic reaction, therefore heat is released which raises the gas temperature up to about 1000^{o}C.**
- **The hot gases from sulphur burner is cooled in waste Heat Boiler to about 430^{o}C.**
- **The conversion of SO_2 to SO_3 is optimised by carrying it out in four stages in the converter bed.**
- **The cooled gases from waste heat boiler I passes through the 1st catalyst bed of the converter where approximately 60% conversion is achieved. This increases the temperature of the outlet gases to about 600^{o}C due to exothermic reaction.**

- **The hot gases are cooled in waste heat boiler II and fed to the second catalyst bed of the converter.**
- **The waste heat is used to produce saturated steam at 17.5 kg km^2 pressure.**
- **A cumulative conversion of about 88% is achieved in the 2^{nd} bed and 94% in the 3^{rd} bed of the converter.**
- **The hot gases coming from 2^{nd} bed are taken through the tube side of Hot heat exchanger and fed to the 3^{rd} bed of the converter.**
- **Gases leaving the 3^{rd} bed are cooled in the tube side of the cold heat exchanger.**

AIR CIRCUIT

- **Acid circuit is designed to remove moisture in air and absorb SO_3 from gas to produce sulphuric acid. The hot acid from final Absorption Tower, Interpass Absorption tower and Drying Tower are returned to the Acid production tank.**
- **Hot acid from Acid production tank is pumped by acid circulation pump through plate heat exchanger where it is cooled by cooling Tower and fed to the respective towers.**

- **The concentration of the acid is continuously measured by concentration analyser and indicator and controlled by addition of demineralised water.**
- **The level of acid in the production tank is regulated by transferring the excess acid in the level control valve as product to the Acid storage tanks.**

Water & Steam Circuit

- **The circuit is designed to produce low pressure steam at 17.5 kg/cm^2 and 207^{o}C utilizing heat generated in the plant.**
- **The steam is used partly for in-plant consumption and the balance is transferred to Alum plant.**
- **A deaerator is mounted on Boiler feed water tank.**
- **Steam is introduced at 0.5 kg/cm^3 to remove dissolved oxygen.**

- **Make up demineralised water from DM water tank is fed at the top of the deaerator and collected in the Boiler fed water tank.**
- **Cold gases from Interpass Absorption Tower (IPAT) are passed through high efficiency candle filter for removal of acid mist.**
- **Outlet gases from candle fitter are heated to reaction temperature in the shell side of cold heat exchanger.**
- **Finally, in the shell side of Hot Heat Exchanger, located after the 2^{nd} bed of the converter and fed to 4^{th} bed of the converter.**

- **In the 4^{th} bed, a cumulative conversion of 99.75% is achieved.**
- **Gases leaving the 4^{th} bed are cooled in the economizer to preheat boiler feed water before being fed to the Final Absorption Tower (FAT) where SO_3 produced in the 4^{th} bed is absorbed in the circulating sulphuric acid.**
- **Reacting gases from FAT are passed through the Demister pad mounted on top of FAT for acid mist removal.**
- **The gases are passed through Alkali scrubber to reduce SO_2 emission level further and then vented through a stack mounted on the alkali scrubber.**

Note – the waste heat boiler system should be tested at test pressure in the presence of boiler inspector and necessary clearances should be obtained before plant commissioning.

- **All instruments which are installed should be tested and calibrated to ensure proper functioning.**
- **Electrical systems including Motor Control centre, interlocking system and overload tripping system should be checked to ensure normal functioning.**
- **Laboratory tests are carried out for raw materials:-**

  Sulphur - % moisture, % acidity, % ash + bituminous matter and percent purity.

ANALYSIS OF CONCENTRATED SULPHURIC ACID

- **The following parameters are usually analysed in the laboratory:**

  total acidity, residue on ignition, iron, chloride, lead, arsenic, oxidizable impurities, ammonia, nitrate, selenium, manganese, copper, zinc and specific gravity.

- **There are four types of sulphuric acid:**

  technical grade, battery grade, chemically pure grade and analytical grade.

- **Operation A: involves heating of sulphur burner, gas is fired into the furnace in the presence of oxygen from blower to heat the furnace and raise the temperature gradually.**
- **Operation B: involves the recovering of heat from the furnace by dry air and heating all the catalyst by dry hot air to a temperature above 125^{o}C.**
- **Operation A & B are carried out alternatively several times till the gas leaving the catalyst is above 125^{o}C.**

- **Operation C: this is to finally heat the plant for sulphur firing. Hot combustion gases are passed directly through the converter to raise the temperature of all beds.**

1st day – max. possible slow rate 35°C /hr.

2nd day – raise from 300°C to 400°C at the same rate.

3rd day – raise temperature to 500°C.

4th day – raise furnace temperature to 600°C for start up of new plants.

Subsequent start up, temperature can be raised to 50°C/hr.

DE-IONISED WATER

- **Demineralised water is produced by passing softener water into Cation and Anion Exchangers to remove positively charged and negatively charged ions respectively.**
- **Cation & Anion exchangers are loaded with resins.**

STORAGE

- **Sulphuric acid is stored in a large mild steel tank whose inside is lined with acid resistant Bricks.**
- **The acid is sold in acid resistant kegs of 20 litres, 30 litres, 200 litres or in tankers to big companies such as NNPC, Fertilizer plants, PHCN, etc.**

IMPORTANCE /USEFULNESS OF SULPHURIC ACID

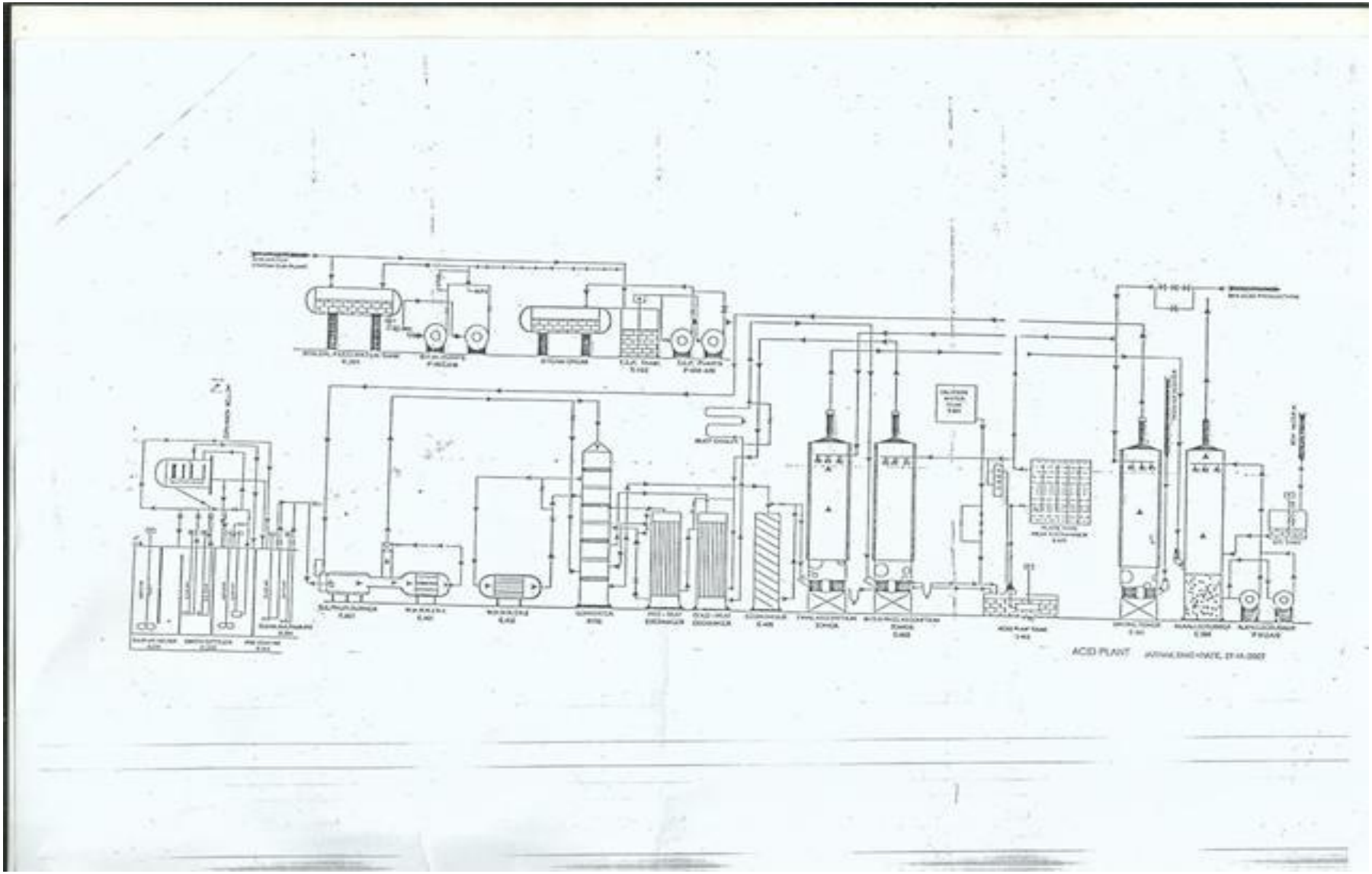
- More sulphuric acid by mass is produced worldwide than any other chemicals.
- It has been found that the production of sulphuric acid closely mirrors historical events such as major wars that affect a country's economy.
- For this reason, some economists use sulphuric acid production as a measure of a country's industrial strength.

- **Sulphuric acid is used directly or indirectly in nearly all industrial processes, including the production of fertilizers, detergents, paints, in ore processing, steel production and water treatment, approximately 250 million tonnes are produced annually across all continents.**

APPLICATION /USAGE

S/N	Application/Usage	Sector
1.	Used as an electrolyte in lead accumulator and batteries and in refining of metals by electrolysis.	The battery industry.
2.	Used to clean or pickle metals before electroplating or enameling.	Electroplating industry.
3.	Used for manufacturing of pigment e.g titanium (vi) oxide and barium tetraoxosulphate (vi) for use in plant and dyes.	Paints/pigment industry. Textile industry.
4.	Used as a dehydrating agent in the nitration of compounds used for making explosives.	Explosive industry
5.	Used in synthesis of phenol and alkylation of isobutane	Organic chemical industry
6.	Used for purification of crude oil and in the manufacture of artificial silk.	Petroleum/Textile Industry

7.	Recovery of fatty acids in soap manufacturing and sulphonation of dodecyl benzene	The soap and detergent industry
8.	Used in preparation of many important chemical compounds e.g HCl and HNO_3 acid, metallic tetraoxosulphate	Chemical industries
9.	Used for production of fertilizers like urea, single superphosphate and N.P.K assisting to increase the agricultural output of the country	Fertilizer Industry.
10.	Used for production of Aluminum sulphate.	Alum industry.
11.	Used for production of demineralised water	Water treatment plants.



A typical sulphuric acid plant

REFERENCES

- The Columbia Electronic Encyclopedia, 6th ed. Copyright © 2012, Columba University Press. All rights reserved.
- Sulphuric acid plant. African Hydro Agric chemicals Ltd. Opic Industrial Estate. Agbara, Ogun State.
- Nigerian Industrial Standard N1.5 788:1992.
- Lunge, Theoretical and Practical Treatise on the Manufacture of Sulphuric acid and Alkali, with the collateral Branches, 3rd ed., vol 1, part 2. page 975. (London, England, Gurney and Jackson 1903).

Thank You For Listening