

Overview Of CCD

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Overview Of CCD

Acknowledgement

This report outlines key observations from a 30-day observational training program conducted at the Coal Chemicals Department (CCD) of SAIL, Rourkela Steel Plant (RSP). The primary aim was to familiarize participants with departmental operations and the application of Engineering principles to industrial challenges. All critical information sources are rigorously cited in the **References** section.

Introduction

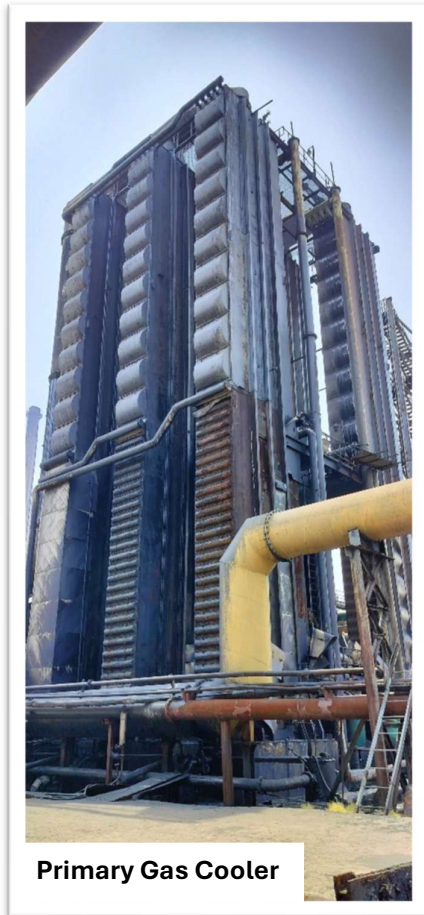
The Coal Chemicals Department (CCD) is an indispensable operational pillar at SAIL-RSP, ensuring integrated steel production through two critical functions. Firstly, it enables economic valorisation by converting coke oven emissions into profitable by-products (e.g., ammonium sulphate fertilizer), offsetting costs and enhancing revenue. Secondly, Coal Chemicals Department enforces **environmental compliance** by treating toxic gases and waste. Without Coal Chemicals Department, Rourkela Steel Plant would face production halts, regulatory penalties, lost revenue, and stalled sustainability goals, underscoring its strategic non-negotiability.

Observation Sites

1. Site A, B, C
2. New CCD
3. BOD Plant Unit
4. Sulfuric Acid Plant

1. Site A:

Primary Gas Cooler (PGC)



Firstly, the raw Coke oven gas is directed into the Primary Gas Cooler, which is basically an Industrial arrangement of Shell and Tube Heat Exchangers in series. Shell side pass consists of water at a normal temperature and Tube side pass consists of Hot Coke Oven Gas at an inlet temperature of about 700-800 degree Celsius. The Primary Gas Cooler (PGC) is a critical part in gas treatment systems across various industrial processes, especially in coke oven by-product recovery plants and sulfuric acid production units. Its primary function is to reduce the temperature of raw process gas to a level suitable for later gas cleaning and processing stages. This cooling step also starts the condensation of tars, oils, and water vapor, thereby aiding in the first phase of gas purification.

Objectives of a Primary Gas Cooler

The implementation of a PGC in a gas cleaning system serves several operational and environmental goals:

- To **lower the temperature** of hot raw gas at once after its generation (typically between 400°C–900°C) to safer and more manageable levels (around 80–100°C).
- To **facilitate the condensation** of tar vapours and moisture, allowing for easier removal downstream.

- To **protect downstream equipment** such as electrostatic tar precipitators, ammonia scrubbers, and gas boosters from thermal damage.
- To **improve overall gas cleaning efficiency** by starting the removal of condensable impurities early in the process.
- To **contribute to energy recovery**, especially when waste heat is used via heat exchangers or in hot water generation.

Working Principle

The basic working of a Primary Gas Cooler is governed by principles of heat exchange and condensation:

- **Hot raw gas** enters the gas cooler, typically at an inlet temperature between 700°C and 800°C.
- It flows through a horizontal **shell-and-tube heat exchanger** where **cooling water** is passed in a counter-current direction.
- **Heat is transferred** from the gas to the cooling medium, reducing the gas temperature significantly.
- **Tar vapours, oils, and water vapor** present in the raw gas **partially condense**, collecting at the bottom of the cooler.
- The **cooled gas**, now at approximately 80–100°C, exits the PGC and moves to the next stage of treatment.

Advantages of Primary Gas Coolers

- **Initial removal of condensable** substances(tar and water vapor).
- **Protects downstream equipment** from thermal stress and corrosion.
- **Improves operational efficiency** of electrostatic tar precipitators and ammonia scrubbers.

- **Reduces environmental impact** by condensing pollutants early.
- **Facilitates waste heat recovery** in energy-conscious plants.

Challenges and Maintenance Concerns

- **Fouling due to tar deposition**, especially in COG systems.
- **Scaling and corrosion** due to poor water quality.
- **Erosion of heat exchanger surfaces** due to solid particles in gas.
- **Condensate handling issues**, including blockages and overflow.
- **Need for regular cleaning and inspection** to maintain thermal efficiency.

Decanters

After the PGC, the cooled gas moves into the Decanters, where Ammonia water or simply **flushing liquor** is separated. Decanters (or **tar decanters**) are settling tanks designed to separate the condensed mixture into distinct layers:

- **Light ammonia liquor** (top layer, density $\sim 1.03 \text{ g/cm}^3$).
- **Emulsion layer** (middle layer)
- **Heavy coal tar** (bottom layer, density $\sim 1.18\text{--}1.23 \text{ g/cm}^3$).

Operational Importance at RSP

In RSP's CCD plant, decanters are vital for:

- Maximizing **by-product revenue** (tar, ammonium sulphate).

- Protecting **environmental compliance** (e.g., reducing pollutants in effluent water).
- Maintaining **process stability** in gas purification (e.g., preventing tar fouling in final coolers or scrubbers).

Three Decanters are present in the old ccd and 2 are operational by conventional practice and one is at standby. **Flushing liquor** is composed of **water, ammonia, phenols, cyanides, tar, volatile matter** etc. is used in the Blast Furnace quenching.



Raw coke oven gas when treated leaves behind tar mist and dust which is washed out using water and heavy liquid settles in the drain seal pot (Yellow coloured container). Coal Tar is sent to site- B for distillation and the Emulsion layer is sent for further reprocessing. Then the cooled gas is sent into **Electrostatic Tar Precipitator** which is discussed in detail.

Electrostatic Tar Precipitator



The primary objective of the tar precipitator is to **remove fine tar mist and entrained particles** from the cooled coke oven gas stream after it passes through the **Primary Gas Cooler (PGC)**. This process improves the quality of gas for subsequent treatment steps such as exhauster compression, ammonia removal, and benzol recovery.

Working Principle

The **electrostatic tar precipitator** operates on the principle of electrostatic precipitation. The working mechanism is described below:

- **Gas Inlet:** Coke oven gas exiting the PGC at approximately 80°C enters the ETP unit.

- **Ionization:** High-voltage electrodes (typically 40–60 kV) generate a strong electrostatic field. This field ionizes the tar particles suspended in the gas.
- **Particle Migration:** The ionized tar droplets move towards the grounded collecting electrodes due to electrostatic attraction.
- **Collection:** Upon contact, these particles coalesce on the electrode surfaces and form a film, which eventually flows down by gravity into tar collecting troughs or sumps.
- **Gas Outlet:** The cleaned gas, now with significantly reduced tar content, exits the precipitator and proceeds to the exhauster and further gas cleaning units.

Technical Specifications

Parameter	Value/Range
Inlet gas temperature	~80°C
Applied voltage	40–60 kV
Removal efficiency	>95% for fine tar mist
Electrode material	Corrosion-resistant steel
Operation type	Dry-type, vertical flow

Note: Actual values may vary based on design vendor and operating conditions.

Role in Overall Plant Operations

The Electrostatic Tar Precipitator is strategically placed **after the primary cooling** stage to ensure:

- Prevention of **tar deposition** in exhausters and pipelines.
- Improved **gas calorific value stability** for downstream usage.

- Enhanced **by-product recovery**, contributing to the economic viability of coal carbonization.

Cooling Towers



Now the COG is taken into the cooling towers to reduce temperature further down to **30-35 degrees Celsius**.

Why Cooling Before the Booster is Essential?

Reason	Explanation
Protects Booster Blades	High-temperature gas can damage impellers and lubricants .
Improves Condensation	Allows residual condensable vapours (like light oil) to be partially removed.
Ensures Safe Operation	Maintains mechanical integrity and operational efficiency of the booster.

Booster Mixers

In the **SAIL RSP Coal Chemicals Department (CCD)**, the **booster mixer** plays a critical role in managing the **fuel gas supply** to the coke oven heating system (under fire and overfire). There are 5 operational Booster Mixers named 1,2,3,4,5 out of which by general practice only two out of 1,2,3 boosters and only one out of 4,5 boosters are in use. Booster Mixer has a motor with a shaft at the end rotating it. The clean gas is mixed only after treatment. CO gas fixed monitor is installed at various places near the booster, and we were advised to use the portable CO monitor with permissible limits around 50 ppm. The **booster mixer** is a **gas mixing and pressure-boosting station** where **diverse types of by-product gases**—such as:

- **Coke Oven Gas (COG)** – high calorific value
- **Blast Furnace Gas (BFG)** – low calorific value.
- **Basic Oxygen Furnace (LD) Gas** – medium calorific value

are **mixed in desired ratios** to:

1. Achieve Required Calorific Value:

- Mixing helps to **balance the heat content** of the fuel gas going to the ovens.
- For example, **pure COG is too rich**, while **BFG is too lean**. So, a **controlled mix** gives a **moderate, stable flame**.

2. Ensure Combustion Control:

- Proper gas mixing allows the **flame temperature and heating rate** in the coke oven to be controlled.
- This affects the **quality of coke** and the **life of the oven bricks**.

3. Maintain Constant Pressure:

- The **booster fans or compressors** in the mixer **increase the pressure** of the mixed gas.

- This ensures a **steady and uniform supply** of gas to the **under-fire line burners** across the entire battery.

Potential sludge found anywhere at site-A was directed into small storage pits with pumps installed directing it into the condensate pit for storage. This is the point where site-A concludes.

Site B:

The Site-B of the CCD is the coal tar distillation plant. We saw distillation columns where coal tar is processed. When coal tar is fractionally distilled several products like-

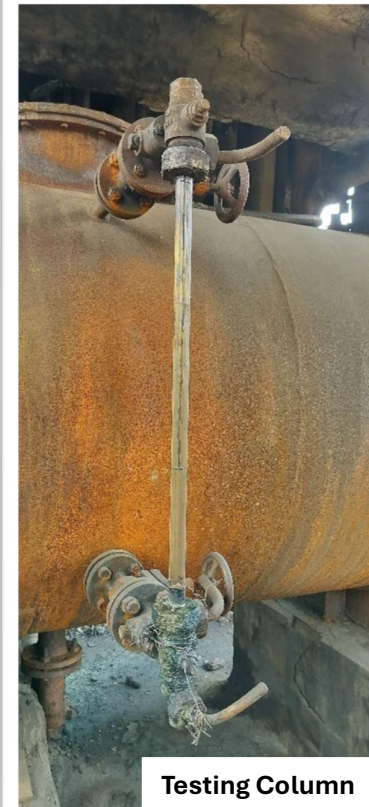
Fraction	Boiling Range	Products Obtained
Light oil	up to 170°C	Benzene, toluene, xylene
Middle oil	170–230°C	Naphthalene
Heavy oil	230–270°C	Wash oil, creosote oil
Anthracene oil	270–360°C	For dyes
Pitch	Residue	Used in electrodes, roads, etc.



Firstly, we observed the raw coal tar at a temperature of 35-40 degrees Celsius is directed into furnace for preheating to achieve the desired temperature before distillation. This lowers the viscosity and removes residual moisture for a better flow. We observed an incredibly old pump at CCD which is still operational shown below.



Furnace/Preheater



Testing Column



Shell and Tube Heat Exchanger

The pump has both Venturi meter and Orifice meter attached with a flow controller to control the flow rates. However, by modern means of industrial practice Venturi meter is not used because it is not compact and requires a lot of supporting equipment and is therefore not used in

flow mechanisms these days. Then the coal tar is again regulated to

optimum temperatures using the Shell and Tube Heat exchangers and is kept moisture free before it enters the distillation column.

Tar Distillation Column



This is the heart of the plant. Heated tar enters a **vertical distillation column** where it is **fractionally distilled** under **controlled temperature and pressure**. Vapours rise through the column and are **condensed** at various levels. Light oil is used as the reflux medium. The 11th tray serves as the **feed tray**. The feed is part liquid and part gas with q value ranging from **0 to 1**. Each fraction is **cooled**,

condensed, and collected in separate receivers. The heavy black **residue left at the bottom** of the column is **pitch**. Pitch is **pumped hot into storage** or **cast into Molds**. Hard pitch is used in the Hall-Hérault process. The soft pitch is used as a binder. Light oil goes to further refining units for **benzene recovery** in the benzol plant.

Reflux and Temperature Control

- The **reflux ratio** is important to **improve separation efficiency** in the column. In short, it controls the purity of the products.
- **Temperature control** is critical—each fraction needs a specific boiling point range. Also required for safety concerns for smoother operations. In short it ensures the safety, thermal integrity and quality of the pitch.

Uses of various products obtained.

- **Pitch** – Anode binder in aluminium plants (e.g., NALCO) in aluminium extraction Hall-Héroult process, road construction.
- **Creosote oil** – Wood preservative.
- **Naphthalene** – Dyes, mothballs
- **Light oil** – Benzene, toluene recovery
- **Anthracene oil** – Dye intermediates

Next, we move to the Site-C of the CCD.

Site C:

The Fertilizer Unit located at **Site-C of the Coal Chemicals Department (CCD)** in **SAIL Rourkela Steel Plant** is responsible for the recovery and conversion of **ammonia**, a by-product of **coke oven gas**, into **ammonium**



Ammonia Saturator

sulphate ($\text{NH}_4)_2\text{SO}_4$ – a valuable nitrogen-based fertilizer. This process not only supports **by-product utilization** but also contributes to the **zero-waste and sustainability efforts** of the plant.

The main objective of the Fertilizer Unit is:

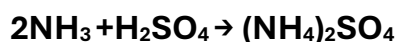
- To **recover free ammonia** from ammonia liquor generated in coke ovens gas.
- To convert the recovered ammonia into **ammonium sulphate** using **sulfuric acid neutralization**.

- To produce a **commercial-grade fertilizer** from industrial waste streams.

Coke oven gas (COG) contains **free and combined ammonia**. This gas is cooled and scrubbed using **ammonia liquor**. The resulting **ammonia-rich liquor** is collected and sent to **ammonia stills**. In the stills, **steam is used to strip ammonia gas** from the liquor. The **ammonia gas** is

absorbed in **dilute sulfuric acid (H_2SO_4)** supplied from storage tanks of 400 m³ capacity inside an **absorption tower**.

This exothermic reaction forms **ammonium sulphate** solution:



Ammonium Sulphate crystals/Raja Khad

Bubble Cap Tray



The ammonium sulphate solution is **cooled** to form **crystals**. The **solid crystals** are separated from the liquid using **centrifuges or filters**. The moist ammonium sulphate crystals are passed through a **rotary dryer**. Dried crystals are then **cooled, screened, and bagged** for dispatch and use as fertilizer.

Final Product – Ammonium Sulphate (sold commercially as a product named “Raja” Khad.

- **Chemical formula:** $(\text{NH}_4)_2\text{SO}_4$
- **Appearance:** White to off-white crystalline solid

- **Uses:** Widely used as a **nitrogen fertilizer** in agriculture
- **Packed in:** Moisture-proof HDPE/PP bags.
- **Typical nitrogen content:** ~20.5% (Process is called **Nitrogen Purging** which is a process used to remove unwanted gas like oxygen and moisture from the system environment by using inert nitrogen gas. It helps in creating a stable environment, moisture removal and even food packaging to extend shelf life of food products)

The Fertilizer Unit at Site-C plays a vital role in transforming a **pollutant (ammonia)** into a **valuable agricultural product**, thus contributing to both **environmental sustainability** and **economic value addition**. It exemplifies effective **waste-to-wealth conversion** in an integrated steel plant setup.

2. New CCD

The New Coal Chemicals Department (New CCD) at SAIL Rourkela Steel Plant (RSP) is a modern, high-capacity by-product recovery facility started in 2012, designed to process coke oven



ETP Unit at NEW CCD

gas generated from the newly commissioned Coke Oven Battery No. 6. This facility represents a technological leap over the older CCD, integrating automation, energy-efficient operations, and comprehensive environmental safeguards. It plays a vital role in recovering valuable chemicals and ensuring the clean and efficient utilization of coke oven gas.

Superiority of New CCD over Old CCD

The New CCD was commissioned to overcome the limitations of the older unit in terms of capacity, efficiency, and environmental compliance. A detailed comparison is provided below.

Comparison: Old CCD vs New CCD

Parameter	Old CCD	New CCD
Designed Capacity	Approximately 1.6 MTPA	Designed for 2.5 MTPA coal throughput
Automation	Manual operations and basic relay logic	Fully automated with SCADA and DCS integration
By-product Recovery Efficiency	Moderate	Significantly higher yield and purity
Environmental Compliance	Basic scrubbers and low emission control	Advanced multi-stage scrubbers, emission monitors
Gas Mixing and Heating Control	Limited control	Real-time adjustment of calorific value and pressure
Safety Systems	Manual safety mechanisms	Automated interlocks, sensors, and alarms
Maintenance Frequency	High, frequent downtime	Low, with durable equipment and better reliability

The New CCD ensures precise control of process parameters, improved recovery of chemicals, and adherence to national environmental and safety standards.

Process Flow Overview-

The New CCD follows an optimized process sequence to ensure efficient cooling, cleaning, recovery, and gas management.

1. Primary Gas Cooling

Raw coke oven gas at approximately 800°C is cooled to around 80–90°C using flushing liquor in primary gas coolers (shell-and-tube heat exchangers).

2. Electrostatic Tar Precipitation

High-voltage electrostatic precipitators remove condensed tar particles from the cooled gas stream.

3. Ammonia Scrubbing

The gas passes through a scrubbing column where it is treated with sulfuric acid or water to absorb ammonia and produce ammonium sulphate.

4. Naphthalene and Benzol Recovery

Additional cooling and scrubbing stages remove light oils such as naphthalene, benzol, toluene, and xylene, which are later separated through distillation.

5. Final Gas Cooling and Booster Mixer Station

The cleaned gas is passed through a booster mixer, where it is blended with blast furnace gas (BFG) and basic oxygen furnace gas (LD gas) to adjust the calorific value and pressure. This mixed gas is then sent to the under-fire system for coke oven heating.

Advanced Features of the New CCD

- Integrated SCADA and DCS control systems for real-time monitoring
- Multi-stage gas scrubbers for improved environmental compliance

- Pressure-balanced booster stations to ensure consistent gas supply.
- Automated safety interlocks and flame detection systems
- Energy-efficient regenerative heating and waste heat utilization
- Reduced emissions and fugitive losses through modern sealing and ventilation systems

The New Coal Chemicals Department at SAIL Rourkela Steel Plant is a critical component of the plant's modernization initiative. It significantly enhances the capacity, efficiency, and safety of coke oven gas processing compared to the Old CCD. With increased throughput, improved chemical recovery, and advanced environmental control, the New CCD is an example of sustainable and efficient design in the steel industry. Its integration with modern automation platforms also ensures long-term reliability and performance optimization.

Solar Oil Recovery at Benzol Plant



3. BOD Plant Unit

The Coal Chemicals Department (CCD) at SAIL Rourkela Steel Plant is a critical division involved in the processing and recovery of valuable by-products from coke oven gas. However, this recovery generates enormous quantities of wastewater laden with organic matter, phenols, ammonia, cyanides, tar residues, oils, suspended solids, and toxic compounds. To treat this complex effluent and ensure safe discharge and

reuse, a sophisticated Biological Oxygen Demand (BOD) Treatment Plant has been commissioned. This plant combines chemical and biological processes, advanced membrane technologies, and disinfection systems to ensure effective pollutant removal and water reuse, particularly in the steel plant's cooling towers.

Characteristics of Effluent

The wastewater generated in CCD mainly originates from gas cooling, tar separation, ammonia scrubbing, naphthalene and light oil recovery, and various tank farm operations. The effluent has high chemical oxygen demand (COD), biological oxygen demand (BOD), oil and grease content, total suspended solids (TSS), total dissolved solids (TDS), phenols, cyanides, and ammoniacal nitrogen. It is highly variable in composition and therefore requires a flexible, multi-stage treatment approach.

Treatment Process Description

The treatment begins with mechanical screening to remove large debris followed by oil and grease separation in skimming tanks. The flow is then

directed to an equalization tank, which ensures a steady hydraulic and pollutant load to downstream units. Equalization stabilizes shock loads, improves process control, and enhances the performance of chemical and biological processes.

From the equalization tank, the effluent is routed to a **pre-anoxic tank**, where **denitrification** begins under oxygen-deprived conditions. This tank harbours **heterotrophic denitrifying bacteria**, primarily *Pseudomonas*, *Paracoccus*, and *Bacillus* species. These microbes



utilize **nitrate (NO_3^-)** as an electron acceptor and convert it into nitrogen gas (N_2), thus reducing total nitrogen in the effluent. To support denitrification, **methanol** is dosed into this tank as an external carbon source. Methanol acts as a readily biodegradable substrate, enabling bacteria to perform effective nitrate reduction in the absence of sufficient organic matter. The stoichiometric addition of methanol ensures efficient nitrate removal without excessive residuals, optimizing nitrogen balance for downstream nitrification.

After the anoxic stage, the effluent enters the **High-Rate Solid Contact Clarifier (HRSCC)**. Here, coagulation, flocculation, and sedimentation take place. Key chemicals dosed include **lime** for pH correction, **ferrous sulphate** for co-precipitation of phosphates and heavy metals, **poly aluminium chloride (PAC)** as a primary coagulant, and **polyacrylamide (PAM)** as a flocculant to enhance solid settling. The HRSCC rapidly mixes the influent with chemicals, promotes contact between floc particles, and settles the flocs in a clarifier section, thereby removing significant suspended solids and improving clarity.

To support microbial metabolism in subsequent biological treatment, **phosphoric acid** is added as a nutrient source. Biological systems require a balanced carbon:nitrogen:phosphorus (C:N:P) ratio for optimal bacterial growth. Since industrial wastewater often lacks sufficient phosphorus, phosphoric acid dosing ensures microbial vitality and stable process kinetics.

The clarified water from the HRSCC proceeds to the **aeration tank**, the core zone for **aerobic biological treatment**. This tank is equipped with surface aerators or fine bubble diffusers to maintain dissolved oxygen levels around 2–4 mg/L. Within this environment, **autotrophic nitrifying bacteria**, particularly *Nitrosomonas* and *Nitrobacter*, play a vital role in **nitrification**. *Nitrosomonas* oxidizes **ammonia (NH_4^+)** to **nitrite (NO_2^-)**, which is then converted to **nitrate (NO_3^-)** by *Nitrobacter*. Simultaneously, heterotrophic bacteria degrade organic compounds responsible for BOD and COD. These microbes form a mixed liquor suspended solids (MLSS) system, facilitating complete oxidation of biodegradable pollutants.

The mixed liquor is then directed to a secondary clarifier, where activated sludge settles under gravity. A portion of this sludge is recycled back to the aeration tank to maintain a high concentration of active biomass, while excess sludge is sent for dewatering and disposal.

Inside the Aeration Tank



For tertiary treatment, the plant employs a **Membrane Bioreactor (MBR)**. The MBR integrates biological treatment and membrane filtration in a compact system. Hollow fibre or flat-sheet membranes physically retain suspended solids, colloidal matter, bacteria,

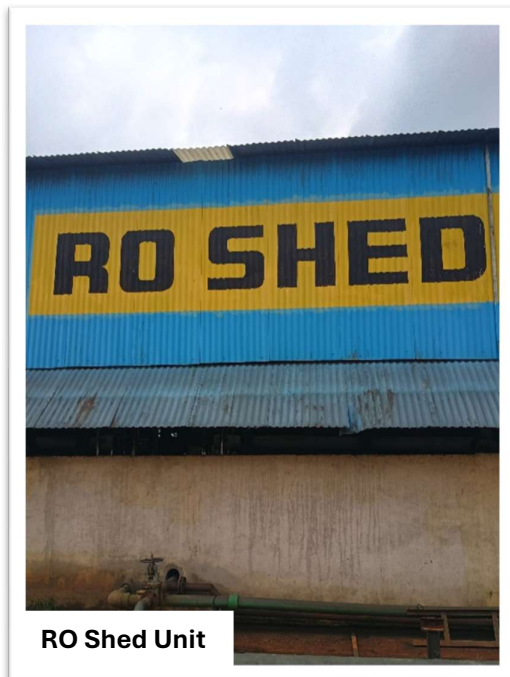
and even some TDS. MBR treatment ensures effluent quality with turbidity <1 NTU and BOD/COD levels well within regulatory limits. It also allows operation at higher concentrations, enhancing treatment efficiency and reducing footprint.

The MBR-treated water undergoes final polishing which is achieved by RO. The RO membranes remove residual TDS (including dissolved salts, low-molecular organics, and trace metals) and any remaining pathogens, yielding high-purity water suitable for reuse in cooling towers and other plant utilities.

A massive portion of the UV-treated water is pumped to **cooling towers** and other utility areas within the steel plant. The reuse of high-quality recycled water helps reduce the demand for freshwater, lowers operational costs, and supports sustainable water resource management.

The BOD Treatment Plant at SAIL Rourkela CCD employs a robust, integrated approach to effluent management. Through advanced processes like methanol-aided denitrification, chemical clarification, aerobic nitrification with *Nitrosomonas*, and membrane-based polishing,

it achieves exceptional removal of BOD, nitrogen, phosphates, oil, and pathogens. The recovery and reuse of treated water exemplify



sustainable, zero-liquid-discharge-ready industrial wastewater treatment. RO reject to be disposed of through drain leading to existing lagoon.

The objective of the design shall be to minimize requirement of recurring operating cost on account of Power, Chemicals & Utilities of Zero Liquid Discharge Plant. Therefore, wherever possible gravity flow shall be preferred over pumping and chemical dosing

optimization shall be done. In addition, for maintenance to each dynamic component easy access shall be provided.

4. Sulphuric Acid Plant

The Sulphuric Acid Plant located in the Coal Chemicals Department(CCD) of SAIL Rourkela Steel Plant is a critical facility designed to convert elemental sulphur and sulphur-rich gases into concentrated sulphuric acid using the Contact Process. The acid produced is primarily utilized in the Ammonium Sulphate Plant for ammonia neutralization, besides being used across other processes for pH adjustment and chemical synthesis.

Process Description

The process begins with the melting of elemental sulphur in a sulphur melter at a temperature range of **120 to 140°C**. The molten sulphur is then directed into the sulphur burner, where it reacts with dry air to form

sulphur dioxide (SO_2). This combustion reaction is **highly exothermic**, resulting in gas temperatures reaching approximately **1000 to 1100°C**.

The hot SO_2 -laden gas is passed through **a waste heat boiler** where the heat is recovered in the form of high-pressure steam, and the gas



Acid Plant at CCD

temperature is reduced to around 450°C. Further cooling is carried out to bring the gas to optimal filtration conditions.

Before proceeding to the catalytic converter, the gas undergoes a

cleaning sequence. First, ambient air is dried in a **drying tower using 98% sulphuric acid to remove moisture**, preventing acid mist formation and catalyst deactivation.

Following this, the SO_2 gas passes through a hot gas filter unit containing candle filters coated with **kieselguhr (diatomaceous earth)** prepared in the **precoat pit**. This filter removes any fine suspended particles that might harm the downstream catalyst beds. Spent kieselguhr and contaminated acid are collected in a dirty pit for settling and controlled discharge.

After filtration, the cleaned and dried SO_2 gas is sent to the **five-bed catalytic converter**, where it undergoes oxidation to form **sulphur trioxide (SO_3)** in the presence of **vanadium pentoxide (V_2O_5)**. The catalyst remains in original lumped state and is not processed or pulverized. This reaction is also **exothermic** and sensitive to temperature. The gas passes sequentially through the five beds, with inter-stage heat exchangers used between them to control the

temperature. The first bed operates at around 420 to 430°C, suitable for initial high-rate conversion. Then it is directed into a Waste Heat Boiler again. The second bed continues the conversion process at similar temperatures (500°C), and after the second bed, the gas passes through the third bed followed by an economiser that reduces its temperature to 80°C and then into **Interpass Absorption Tower (IAT)** where a significant portion of SO_3 is absorbed by circulating sulphuric acid, effectively reducing the SO_3 load in the gas before further processing.

The gas leaving the interpass tower still contains unconverted SO_2 . This gas then enters the fourth and fifth catalyst beds, where the remaining SO_2 is gradually converted to SO_3 . The operating temperature in these later beds is controlled around **400 to 405°C** to ensure equilibrium favours further conversion without catalyst deactivation. The fourth and fifth beds serve as polishing stages to push the overall SO_2 conversion around 99.5%. Oxygen is essential in these beds even at trace concentrations of SO_2 , and hence dry air is carefully **supplied to maintain the required O_2 : SO_2 ratio**.

After the final catalytic stage, the SO_3 -rich gas enters the final absorption tower, where it is absorbed in circulating 98% H_2SO_4 to form more sulphuric acid. Direct absorption of SO_3 in water is avoided because it leads to formation of dense, corrosive mist. Therefore, the SO_3 is absorbed in concentrated acid to form oleum ($\text{H}_2\text{S}_2\text{O}_7$), which is subsequently hydrolysed with water to generate usable sulphuric acid. **Oleum is not stored at the plant due to its hazardous nature and is instead immediately converted into product acid for circulation.** This not only ensures safety but also simplifies inventory handling.

The acid formed is collected in an **acid circulation tank** to be distributed and continuously pumped back to the absorption towers via acid-proof centrifugal pumps. A **buffer tank is also maintained for storage**. The acid is cooled before being recycled to maintain desired absorption efficiency and prevent equipment damage.

The materials of construction throughout the plant are selected for their corrosion resistance and thermal stability. The catalytic converters and

ducts are constructed from heat-resistant steel, while the absorption and drying towers are lead-lined or brick-lined to resist the corrosive action of sulphuric acid. The sulphuric acid plant at SAIL Rourkela's Coal Chemicals Department is a state-of-the-art installation designed **for high conversion efficiency, environmental sustainability, and operational safety**. The integration of five catalytic beds, intermediate and final absorption towers, hot gas filtration, and precise temperature and oxygen control enables the plant to achieve over 99.5% conversion of sulphur dioxide to sulphuric acid. It also supports energy integration through steam generation and **avoids oleum-related hazards by direct conversion**. Overall, the plant reflects an optimized approach to chemical processing within a large-scale integrated steel manufacturing ecosystem.

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