INTERNSHIP REPORT

On,

“Study on Manufacturing Process High Pressure Nitric Acid’’

RASHTRIYA CHEMICALS & FERTILIZERS LIMITED,MUMBAI
TROMBAY UNIT

Submitted by

Miss. Khushi Dharmendra Singh

Roll No:32

TE Chemical Engineering

Under the Guidance of

Dr. Mahendra Guddad

Sir Visvesvaraiya Institute of Technology, Nashik

RASHTRIYA CHEMICALS & FERTILIZERS LIMITED,MUMBAI

(Training Period- 8th January to 18th January 2025)

Sir Visvesvaraiya Institute of Technology, Nashik

Department of TE Chemical Engineering

CERTIFICATE

This is certify that Miss Khushi Dharmendra Singh has successfully completed the Internship Training entitled **"Study on Manufacturing Process of High Pressure Nitric Acid "** under my supervision, in the partial full fillment of Third Year of Chemical Engineering of University of Pune.

Date:

Place: Sir Visvesvaraiya Institute of Technology, Nashik

Dr.M.V.Guddad (Guide)

Dr.Dipak K. Chandra (Head of Department)

ACKNOWLEDGEMENT

It gives us immense pleasure to represent the report on Manufacturing of High Pressure Nitric Acid studied during the internship at Rashtriya Chemicals and Fertilizers, Mumbai. I express deep sense of gratitude to all the faculties who guided me. For their guidance and suggestions, I am thankful to all of them and also for the encouragement they have given us for completing the study and report.

Secondly, I would like to express my gratitude to our colleagues and other members of the department for their timely support and the guidance. Special Thanks to Mr. Jagadish Kadve (senior Manager) Mr. Dilip .Kanetkar (DJM) . We would not forget to remember our respected teachers, H.O.D. Dr. Dipak K.Chandre and Dr.Mahendra Guddad for their kind support. We are truly grateful.

Yours Sincerely,

Miss. Khushi Dharmendra Singh

Rashtriya Chemicals and Fertilizers Limited
(Government of India Undertaking)

राष्ट्रीय केमिकल्स एण्ड फर्टिलाइजर्स लिमिटेड
(भारत सरकार का उपक्रम)

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HUMAN RESOURCE DEVELOPMENT DEPARTMENT

INTERNSHIP CERTIFICATE

Name : Ms. Khushi Dharmendra Singh
Institution : Sir Visvesvaraya Institute of Technology, Chincholi, Nashik
Discipline : Chemical Engineering
Period of Training : 08/01/2025 to 18/01/2025
Leave taken during training: Nil
Off Days & Holidays : 1 day
Actual Training Days : 10 days
Nature of Training : Study of High Pressure Nitric Acid Plant Process.

Report of Training

Aspects	Very Good	Good	Fair	Average	Below Average
1. Conduct	√	--	--	--	--
2. Punctuality	√	--	--	--	--
3. Knowledge	√	--	--	--	--
4. Interview Rating	√	--	--	--	--
5. Diary Rating	--	√	--	--	--

Internship has been imparted under the guidance of Shri Anil Gaikwad, Senior Manager (Chemical) in Nitric Acid Plant.

(Umesh Tembhare)
Dy. General Manager (HRD)
उमेश व्ही. टेंभरे
Umesh V. Tembhare
उप महा प्रबंधक (मा.सं.वि.)
Dy. General Manager (H.R.D.)

Date: 18-01-2025

18.01.2025

वर्क्स : प्रशासनिक भवन, चेंबूर, मुंबई - 400 074
WORKS : ADMINISTRATIVE BUILDING, CHEMBUR, MUMBAI - 400 074

ABSTRACT

OVERVIEW OF RCF-1

Rashtriya Chemicals and Fertilizers Limited (RCF), government of India undertaking is a leading fertilizers and chemicals manufacturing industry with about 75% of its equity held by the government of India. It has operating units, first at Trombay in Mumbai. The government of India has accorded "Nav-Ratna" status to RCF in 2023. RCF is one of the earliest unit that is set-up in the country with the vision of growth in fertilizers' production in food security. It manufactures urea, complex fertilizers, bio-fertilizers, micro-nutrients, soil conditioners and various types of other chemicals as well. The company is a household name in rural India with brands "Ujjwala" and "Suphala" which carry a high brand equity. RCF has countrywide marketing network in all major states. Apart from the own manufactured products, the company is also engaged in marketing of SSP and the imported fertilizers like DAP, MOP and NPK fertilizers. Besides of all these products, RCF also produces almost 20 industrial chemicals that are the important for the manufacturing of dyes, solvents, leather, pharmaceuticals and the host off the other industrial products. The company also made significant contribution in the great "Green Revolution" of the nation. RCF has also pioneered the manufacture of basic chemicals such as Ammonia, Ammonium Nitrate, Sodium Nitrate, Sodium Nitrite, Ammonium Bicarbonate, Methyl amines, Dimethyl Formamide, Dimethyl acetamide, Formic Acid, Argon in India.

LITERATURE SURVEY-2

1. Introduction to High-Pressure Nitric Acid

- **Definition**: High-pressure nitric acid refers to nitric acid produced or used under elevated pressure conditions (typically above 50 atm). These conditions can enhance the production efficiency, alter the chemical behavior of the acid, or enable specialized applications that require specific properties of the acid.
- **Historical Background**: Nitric acid has been produced primarily through the **Ostwald Process**, which uses ammonia oxidation at moderate pressure. However, high-pressure methods have been explored for improving yields, reducing energy consumption, and optimizing reaction kinetics.

2. Production Methods and Technologies

2.1. Ostwald Process Modifications

The traditional **Ostwald process** for producing nitric acid involves ammonia oxidation over a platinum-rhodium catalyst at moderate temperatures (800-1000°C) and pressures of around 1-2 atm. High-pressure modifications to this process have been explored to increase the efficiency and yield:

- **Increased Reactor Pressure**: Operating reactors at higher pressures can increase the solubility of oxygen, enhance ammonia oxidation, and produce higher yields of nitric acid.
- **Catalyst Advancements**: Researchers have developed catalysts specifically designed to operate efficiently under high-pressure conditions. Platinum and rhodium catalysts remain dominant, but other metals and alloys are being tested for increased catalytic activity under high pressure.

2.2. Ammonium Nitrate (AN) and High-Pressure Synthesis

- High-pressure conditions are crucial in the **production of ammonium nitrate**, a key ingredient in fertilizers and explosives, from nitric acid. The process involves neutralizing nitric acid with ammonia gas under high-pressure conditions, leading to ammonium nitrate formation. The **high-pressure fluidized bed reactor** is commonly employed in this process.

3. Chemical Behavior Under High Pressure

- **Thermodynamic and Kinetic Changes**: High pressure significantly alters the **thermodynamics** of nitric acid production. Nitric acid and its intermediate species such as nitrogen dioxide (NO_2) and nitrous oxide (N_2O) behave differently under pressure, impacting both the reaction rate and equilibrium.
- **Phase Transitions**: At pressures above **7 atm** and specific temperatures (above 150°C), nitric acid can enter a **supercritical phase**. In this phase, its density and reactivity increase, making it more effective in certain applications but also more difficult to handle.

4. Safety Concerns in High-Pressure Systems

- **Corrosion**: Nitric acid is highly corrosive, especially in concentrated forms. High-pressure systems increase the risk of corrosion, requiring the use of materials such as **titanium**, **stainless steel alloys**, and **nickel-based materials** for reactor and pipeline construction. Research continues into improving material durability under high pressure and nitric acid's corrosive conditions.
- **Explosion Risk**: The potential for explosion increases under high-pressure conditions. Several studies focus on the **explosive decomposition of nitric acid**, particularly when exposed to heat or in the presence of impurities like metal ions. To mitigate these risks, high-

pressure systems are equipped with **pressure relief valves**, **explosion-proof vessels**, and automated monitoring systems.

- **Emergency Protocols**: Research into the safe handling and emergency response procedures for high-pressure nitric acid systems is essential. There is a growing focus on advanced monitoring techniques, including the use of **sensors** to measure pressure, temperature, and chemical composition in real-time.

5. Applications of High-Pressure Nitric Acid

5.1. Fertilizer Production

- **Ammonium Nitrate (AN)**: The production of **ammonium nitrate** from high-pressure nitric acid is a key area of application. In the **high-pressure granulation process**, nitric acid reacts with ammonia to form ammonium nitrate, which is then granulated for use as a fertilizer. This process is more efficient under high pressure as it reduces energy consumption and enhances yields.

5.2. Explosives Manufacturing

- **Rocket Propellants**: High-pressure nitric acid is used in the manufacture of **liquid propellants** for rockets. The ability to produce highly concentrated nitric acid under high pressure enhances the efficiency and stability of the fuel.
- **TNT and Other Explosives**: High-pressure nitric acid is also essential in the **synthesis of TNT (trinitrotoluene)** and other explosives, where it acts as a nitrating agent. The high-pressure environment accelerates the nitration reactions, which are essential in the production of explosives.

5.3. Aerosol and Other Chemical Manufacturing

- **Aerosol Production**: The ability to atomize and control the dispersion of active ingredients in **aerosols** is another application of high-pressure nitric acid. This is particularly useful in the pharmaceutical and agricultural industries.

- **Organic Synthesis**: High-pressure nitric acid is used in organic chemical synthesis, where it can act as a nitrating agent to modify the molecular structure of various compounds.

6. Recent Developments and Innovations

6.1. Supercritical Nitric Acid

- Recent research into **supercritical fluids** has opened new possibilities for high-pressure nitric acid. Supercritical nitric acid exhibits unique properties that can enhance certain chemical reactions, such as **oxidation reactions** and **material processing**. Researchers are investigating its use in **clean energy technologies**, where supercritical nitric acid could play a role in **waste-to-energy processes** or **pollution control**.
- The use of supercritical nitric acid has shown promise in applications like the **conversion of biomass** into fuels and chemicals, as well as **advanced oxidation** processes for water treatment.

6.2. Green Chemistry Approaches

- There is increasing interest in making the production of high-pressure nitric acid more **sustainable**. New catalytic systems and reactors are being developed to minimize energy consumption, increase selectivity in reactions, and reduce harmful byproducts.
- **CO_2 Neutralization**: In addition to improving efficiency, studies have focused on incorporating **carbon capture technologies** to reduce CO_2 emissions associated with high-pressure nitric acid production.

7. Challenges and Future Directions

- **Energy Efficiency**: While high-pressure systems can improve yield, they also increase energy consumption due to the need to maintain high pressure and temperature. Research is directed toward **energy-efficient reactors** and processes, such as **catalytic reactors** that operate at lower temperatures.

- **Material Durability**: As nitric acid can corrode many materials, the development of new, more resistant alloys and coatings for high-pressure reactors will be essential.
- **Sustainability and Environmental Impact**: Future research is likely to focus on minimizing the environmental impact of high-pressure nitric acid production by developing processes that generate fewer greenhouse gases and other pollutants.

HPNA PLANT-3

High-Pressure Nitric Acid Plant

A **high-pressure nitric acid plant** is designed to produce nitric acid (HNO_3) under elevated pressure conditions. The production of nitric acid in such plants typically involves modifying traditional methods to enhance efficiency, yield, and safety. High-pressure conditions are often employed to increase reaction rates, improve ammonia oxidation, and ensure better yields for key industrial applications like fertilizers, explosives, and chemical intermediates.

Below is an overview of the key components, technologies, and considerations involved in the design and operation of a high-pressure nitric acid plant:

1. Overview of Nitric Acid Production

1.1. The Ostwald Process

The most common method for producing nitric acid is the **Ostwald process**, which involves the oxidation of ammonia (NH_3) with oxygen (O_2) in the presence of a catalyst, typically platinum or rhodium. The process generally occurs under moderate pressures (around 1-2 atm) and temperatures of 800–900°C. In a high-pressure nitric acid plant, this process is modified to operate at higher pressures, improving the efficiency and yield.

The main reactions involved in the Ostwald process are:

- **Ammonia Oxidation**:

  4NH3+3O2→2N2+6H2O4NH$_3$ + 3O$_2$ \rightarrow 2N$_2$ + 6H$_2$O4NH3 +3O2→2N2+6H2O

- **Formation of Nitric Oxide (NO)**:

  N2+O2→2NON$_2$ + O$_2$ \rightarrow 2NON2+O2→2NO

- **Formation of Nitrogen Dioxide (NO_2)**:

  2NO+O2→2NO22NO + O_2 \rightarrow $2NO_2$2NO+O2→2NO2

- **Absorption of NO_2 in Water**:

  2NO2+H2O→HNO3+HNO22NO_2 + H_2O \rightarrow HNO_3 + $HNO_2$2NO2+H2O→HNO3+HNO2

1.2. High-Pressure Modifications

In a **high-pressure nitric acid plant**, the pressure is typically elevated to improve reaction rates and achieve better yields, especially for the production of ammonium nitrate (AN) from nitric acid. The high-pressure environment facilitates the following:

- **Increased solubility of gases** like ammonia and oxygen, which improves reaction efficiency.
- **Enhanced oxidation reactions** leading to a higher conversion of ammonia to nitric acid.
- **Improved catalyst performance**, allowing for more efficient ammonia oxidation under elevated pressure.

2. Key Components of a High-Pressure Nitric Acid Plant

2.1. Ammonia Oxidation Reactor

The heart of a high-pressure nitric acid plant is the **ammonia oxidation reactor**, which operates at elevated pressures to facilitate the conversion of ammonia to nitrogen oxides (NO and NO_2).

- **Design Considerations**: The reactor is designed to withstand the extreme pressure and temperature conditions. **Rhodium or platinum catalysts** are typically used to promote the oxidation of ammonia to nitric oxide.

- **Operating Conditions**: The reactor is operated at pressures typically between **5 to 10 atm** and temperatures between **800–1000°C**.

2.2. Absorption Tower (Absorber)

After the production of nitrogen oxides (NO and NO_2), the gases are sent to the **absorption tower**, where they are dissolved in water to form nitric acid (HNO_3).

- **High-pressure Design**: The absorption tower is designed to handle the increased pressure of the incoming gases and ensure efficient absorption of the nitrogen oxides.
- **Concentration Control**: In a high-pressure system, the **nitric acid concentration** can be more easily controlled by adjusting the pressure and flow rates in the absorber.

2.3. High-Pressure Equipment

Due to the elevated pressure conditions, specialized equipment is required:

- **High-Pressure Pumps**: These pumps are used to transport ammonia, oxygen, and the product (nitric acid) at high pressures.
- **Pressure Vessels**: The entire system, including reactors, pipes, and tanks, is designed to withstand high pressures. **Corrosion-resistant materials**, such as **stainless steel, titanium, and nickel alloys**, are used to construct these vessels due to the corrosive nature of nitric acid.
- **Heat Exchangers**: Heat exchangers are used to control the temperature of gases and liquids throughout the process, ensuring efficient heat recovery and energy optimization.

3. Process Flow in a High-Pressure Nitric Acid Plant

1. **Ammonia and Oxygen Feed**: Ammonia (NH_3) is mixed with oxygen (O_2) in precise ratios and then fed into the **ammonia oxidation reactor** under high pressure.

2. **Ammonia Oxidation**: Inside the reactor, ammonia is oxidized with oxygen over a catalyst, typically platinum or rhodium, to form nitric oxide (NO) and water.
3. **Nitric Oxide to Nitrogen Dioxide**: Nitric oxide (NO) is further oxidized to nitrogen dioxide (NO_2) in the presence of excess oxygen.
4. **Absorption Tower**: The resulting gases (NO and NO_2) are absorbed into water in an **absorption tower**, where they form concentrated nitric acid.
5. **Product Nitric Acid**: The nitric acid is then separated and concentrated further if necessary.

4. Safety Considerations

4.1. High-Pressure Safety

High-pressure systems require stringent safety protocols, including:

- **Pressure Relief Systems**: The plant is equipped with **pressure relief valves** to prevent overpressure conditions.
- **Leak Detection**: Due to the corrosive nature of nitric acid, sensors and leak detectors are employed to identify any leaks in the system early.
- **Explosion Hazards**: The oxidation of ammonia in the presence of oxygen can potentially result in explosive reactions under certain conditions. **Explosive-proof equipment** and **automatic shutdown systems** are critical in ensuring safety.

4.2. Corrosion Control

Since nitric acid is highly corrosive, high-pressure plants must employ materials that are resistant to corrosion, such as:

- **Nickel and titanium alloys** for reactors and pipelines.
- **High-grade stainless steel** for structural components.

- **Corrosion inhibitors** may also be added to the process to extend the lifespan of the equipment.

5. Applications of High-Pressure Nitric Acid

5.1. Fertilizer Production

A major application of high-pressure nitric acid is in the production of **ammonium nitrate (AN)**, a key component in fertilizers. In a high-pressure plant, **ammonia is neutralized** with nitric acid at elevated pressures to produce ammonium nitrate. This is typically done in a **high-pressure fluidized bed reactor**.

5.2. Explosives Manufacturing

High-pressure nitric acid is used to produce explosives such as **TNT** (trinitrotoluene) and other nitrated compounds. The controlled nitration process under high-pressure conditions ensures that the products are produced with high purity and yield.

5.3. Industrial Applications

High-pressure nitric acid is also used in the manufacture of chemicals such as **aerosols**, **pharmaceuticals**, and **specialty chemicals**, where its unique properties at elevated pressures are useful for improving efficiency and yield in various reactions.

6. Environmental Considerations

6.1. Emissions Control

Nitric acid production, especially at high pressure, can release nitrogen oxides (NOx), which are harmful pollutants. **Scrubbing systems** and **catalytic converters** are used to reduce NOx emissions and comply with environmental regulations.

6.2. Waste Management

Proper disposal and treatment of waste streams, including any residual ammonia or nitrogen oxides, is critical for maintaining environmental sustainability. **Wastewater treatment** systems and **gas recovery units** can help mitigate environmental impact.

7. Challenges and Future Directions

- **Energy Consumption**: High-pressure systems require significant energy to maintain operating conditions. Future plants may focus on improving **energy efficiency** through better heat recovery systems or alternative energy sources.
- **Sustainability**: The production of high-pressure nitric acid can be energy-intensive and environmentally damaging. Research into **green chemistry** approaches, such as using renewable energy sources or reducing CO_2 emissions, is an ongoing trend.
- **Technological Advancements**: Advancements in **catalyst development**, **corrosion-resistant materials**, and **reaction optimization** are key to improving the overall efficiency and safety of high-pressure nitric acid plants.

OVERALL PROCESS DESCRIPTION DIAGRAM-4