TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
PULCHOWK CAMPUS

A REPORT ON

INDUSTRIAL ATTACHMENT AT VARUN BEVERAGES NEPAL PVT. LTD.

RAMGRAM-10, NAWALPARASI

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SUBMITTED TO

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF BACHELOR IN MECHANICAL ENGINEERING

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PREFACE

This report presents a comprehensive overview of my internship experience at Varun Beverages Nepal Pvt. Ltd. (VBNPL), conducted as part of the Bachelor of Mechanical Engineering program at Pulchowk Campus, Tribhuvan University. During this internship, I had the opportunity to integrate theoretical knowledge with practical applications, gaining valuable insights into advanced engineering systems and processes in the beverage industry. By working across departments such as utility, maintenance, quality control, and production, I was exposed to modern technologies and learned about key operational practices. This hands-on experience not only enhanced my technical expertise but also deepened my understanding of the industry's dynamics and the significance of engineering in optimizing production efficiency and quality standards.

The report highlights various aspects of my learning journey, including the design and operation of high-pressure compressors, refrigeration systems, and water treatment processes. It also discusses personnel management strategies and the importance of teamwork and safety in an industrial setting. This internship has been an invaluable milestone in my academic and professional development, fostering skills and knowledge that will serve as a solid foundation for my future career endeavors. I hope this report serves as a useful resource for students and professionals interested in exploring the practical applications of mechanical engineering in the beverage manufacturing sector.

ACKNOLEDGEMENT

I would like to express my heartfelt gratitude to the Department of Mechanical and Aerospace Engineering, Pulchowk Campus, IOE, TU, for incorporating the internship program into the Bachelor's in Mechanical Engineering (BME) curriculum and providing this invaluable opportunity.

I am sincerely thankful to Varun Beverages Nepal Pvt. Ltd. (VBNPL) for offering me the chance to intern at their esteemed organization. The experience has played a crucial role in my professional development. During my internship, I had the opportunity to learn about the state-of-the-art technology used by VBNPL, which enabled me to gain practical insights, develop new skills, and broaden my perspective. The exposure to VBNPL's culture and processes was an invaluable learning experience, deepening my understanding of the industry.

I am especially grateful to our supervisor, Er. Bibek Jha, and utility head,Er. Pannelal sir, for their consistent guidance throughout the internship. My deepest thanks also go to the utility and maintenance, quality control, and production departments for their continuous support during my journey. I would also like to extend my appreciation to Er. Ajay Kumar Gupta, Er. Manish Vishwokarma, Er. Sonu Das, Er. Jitendra Chaurasia, and all the operators and staff members at VBNPL who, in one way or another, contributed to making my experience valuable and enriching.

Thank you all for making this internship an unforgettable experience.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

VBNPL	Varun Beverages Nepal Pvt. Ltd.
cfm	cubic feet per minute
PHE	Plate Heat Exchanger
HP	High Pressure
LP	Low Pressure
PET	Polyethylene terephthalate
GRB	Glass Returnable Bottle
TDS	Total Dissolved Solid
PSF	Pressurized Sand Filter
ACF	Activated Carbon Filter
CSD	Carbonated Soft Drink
bph	bottle per hour
bpm	bottle per minute
CIP	Clean in Place
SIP	Sterilization in Place

CHAPTER 1: INTRODUCTION

Varun Beverages Nepal Pvt. Ltd. (VBNPL), a subsidiary of Varun Beverages Ltd. (VBL), is one of the largest franchisees of PepsiCo in the world, playing a significant role in Nepal's beverage industry. The company is part of the Ravi Jaipuria Group, which manages a vast network of beverage production facilities across multiple countries. VBL in Nepal produces, bottles, and distributes globally renowned brands like Pepsi, Mirinda, 7Up, Mountain Dew, and Aquafina, catering to a growing domestic demand for soft drinks. VBL established its first plant in 1985 AD in Madhyapur Thimi, Bhaktapur. In 2018, it established another plant in Ramgram-10, Nawalparasi.

The plant located in Nawalparasi is equipped with modern technology and follows stringent global manufacturing standards to ensure the production of high-quality beverages. The company's cutting-edge production facility includes bottling lines, refrigeration systems, mixing and blending units, and packaging lines designed for efficiency and sustainability. Varun Beverages Nepal plays a vital role in promoting PepsiCo's iconic product portfolio in Nepal. In addition to soft drinks, the company also produces non-carbonated beverages and bottled water like Aquafina. The Nepal facility also adheres to international standards, ensuring product consistency and safety across its beverage lines. Over the years, Varun Beverages Nepal has established itself as a leader in the non-alcoholic beverage sector, contributing to the nation's economy through employment and partnerships with local businesses. The company's ongoing innovation, high-quality standards, and commitment to customer satisfaction have solidified its reputation as a key player in Nepal's beverage industry.

Figure 1.1: Products of VBNPL

Figure 1.2: Plant layout Satellite view

CHAPTER 2:
PERSONNEL MANAGEMENT

2.1 Personnel Policy

VBNPL values its employees as its greatest asset. Recognizing the critical role that a motivated and skilled workforce plays in achieving organizational success, the corporation has implemented comprehensive personnel policies. These policies are designed to ensure that employees are not only well-trained but also operate in a safe and supportive environment.

2.2 Recruitment and Selection

VBNPL is dedicated to hiring qualified and capable individuals for each position. The recruitment process is transparent and competitive, guaranteeing equal opportunity for all candidates. The selection process includes written tests, interviews, and practical assessments to evaluate the skills and knowledge of applicants.

2.3 Training and Development

Employee improvement and development are central to VBNPL's personnel policy. The corporation offers regular training sessions and workshops on various aspects of brewery operations, safety procedures, and quality control. Employees are encouraged to pursue further training and professional development to enhance their skills and advance their careers within the organization.

2.4 Job and Performance Evaluation

VBNPL utilizes a structured performance evaluation system to monitor and assess employee performance. Regular appraisals provide feedback, identify areas for improvement, and recognize outstanding performance. Evaluation criteria are clear and objective, focusing on job performance, productivity, adherence to safety standards, and teamwork.

2.5 Employee Benefits

The corporation provides a comprehensive benefits package to its employees, including competitive salaries, health insurance, incentives, and paid leave. Additional benefits, such as bonuses, profit-sharing, and employee recognition programs, are also available to reward and motivate the workforce.

2.6 Workplace Environment

VBNPL is committed to maintaining a safe, healthy, and inclusive work environment. Strict adherence to health and safety regulations is enforced to protect employees from workplace hazards. The corporation promotes a culture of mutual respect, teamwork, and open communication. Regular meetings and feedback sessions address employee concerns and foster a collaborative atmosphere. Furthermore, VBNPL is an equal opportunity employer and does not discriminate based on race, gender, age, religion, disability, or any other characteristic protected by law. The corporation is dedicated to creating a diverse and inclusive workplace where all employees can thrive and contribute to the organization.

2.7 Organization Structure

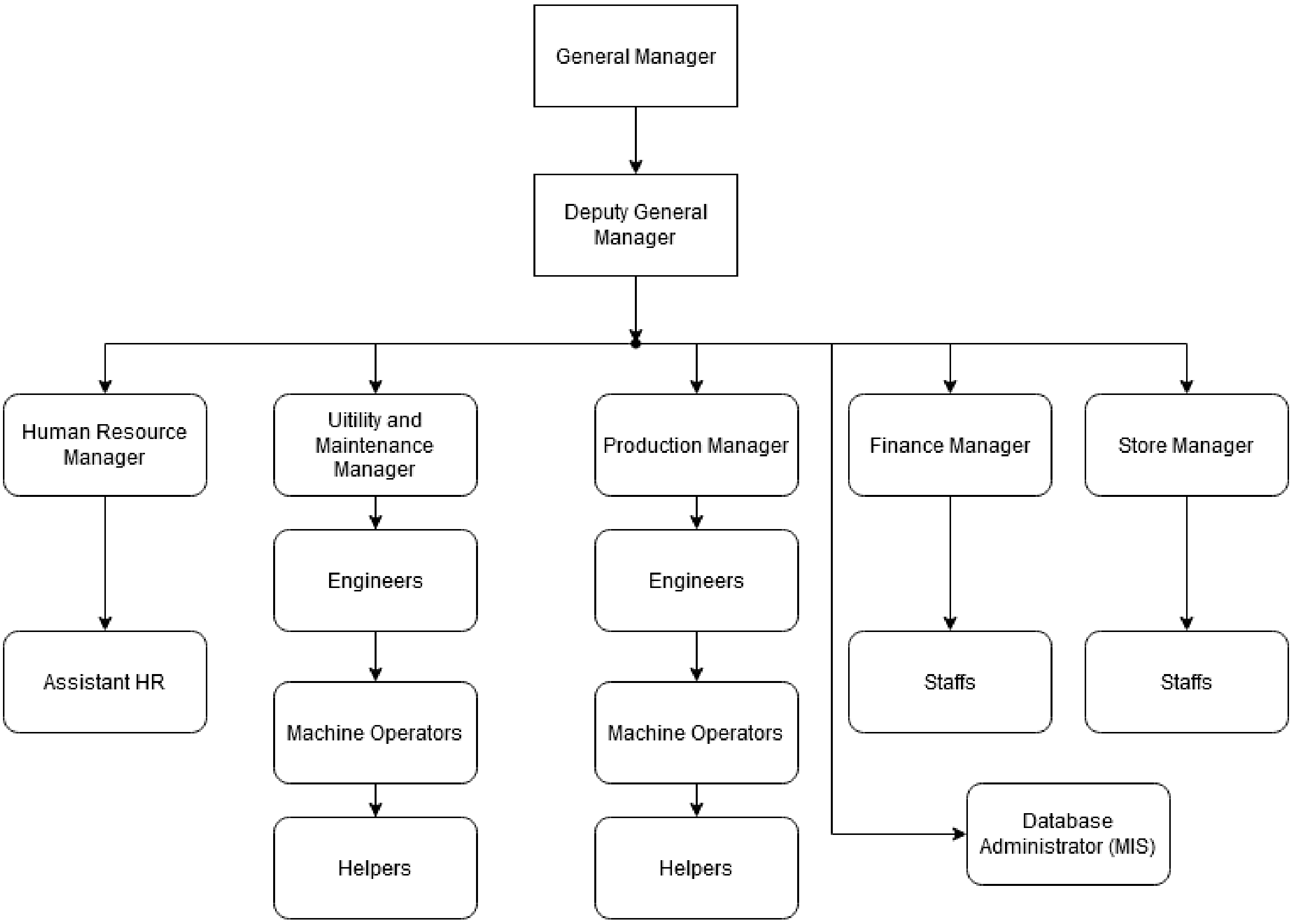

Figure 2.1: Organization Structure

The organizational structure depicted in the chart represents a hierarchical framework that enables efficient management and operations. At the top of the hierarchy is the General Manager, who oversees all functions and is directly supported by the Deputy General Manager. The structure is divided into several departments, each led by specialized managers, including the Human Resource Manager, Utility and Maintenance Manager, Production Manager, Finance Manager, and Store Manager. These managers supervise their respective teams, which consist of engineers, machine operators, helpers, staff, and specific roles like the Assistant HR and Database Administrator (MIS). This well-defined structure ensures a clear chain of command, streamlined communication, and coordinated efforts to achieve organizational goals.

CHAPTER 3:
MANAGEMENT INFORMATION SYSTEM (MIS)

In any factory such as VBNPL, the Management Information System (MIS) is a crucial component that supports efficient operations, decision-making, and strategic planning. The MIS integrates various technological tools and software applications to manage and analyze data, streamline processes, and enhance overall productivity. The key elements of the MIS in an advanced brewery factory include:

3.1 Data Collection and Processing

The MIS in an advanced brewery factory collects data from multiple sources across the production and administrative processes. These sources include sensors on production equipment, quality control systems, inventory management systems, and sales and distribution channels. The data collected covers various aspects such as raw material usage, production volumes, equipment performance, product quality, and sales figures.

3.2 Production Monitoring and Control

The MIS provides real-time monitoring and control of the production processes. It tracks the status of brewing operations, fermentation, bottling, and packaging. Automated systems and sensors relay data to the MIS, allowing managers to monitor key performance indicators (KPIs) such as production efficiency, downtime, and yield. This real-time visibility helps in promptly addressing any issues that arise during production and ensures optimal operation of the brewery.

3.3 Inventory Management

An efficient MIS manages the brewery's inventory of raw materials, packaging supplies, and finished products. It provides accurate and up-to-date information on stock levels, usage rates, and reorder points. This helps in maintaining optimal inventory levels, reducing waste, and ensuring that production is not halted due to shortages. The system also supports the management of supply chain logistics, including procurement and distribution.

3.4 Quality Control and Assurance

The MIS plays a critical role in quality control and assurance by tracking and analyzing data related to product quality. It monitors various parameters such as ingredient specifications, brewing conditions, and product testing results. This data is used to ensure that all products meet the required quality standards and regulatory compliance. The system also helps in identifying trends and patterns that may indicate potential quality issues, enabling proactive measures to be taken.

3.5 Sales and Distribution Management

The MIS supports sales and distribution activities by providing detailed insights into market demand, sales performance, and distribution logistics. It tracks orders, manages customer relationships, and analyzes sales data to identify trends and opportunities. This information is used to optimize sales strategies, improve customer service, and ensure timely delivery of products to the market.

3.6 Financial Management

The MIS integrates financial data to provide comprehensive financial management capabilities. It tracks expenses, revenues, profitability, and budget performance. The system generates financial reports and analytics that support strategic decision-making and financial planning. This ensures that the brewery's financial health is continuously monitored and managed effectively.

3.7 Reporting and Analytics

Advanced reporting and analytics capabilities are a significant feature of the MIS in a modern brewery. The system generates a wide range of reports, including production reports, quality control reports, inventory reports, sales reports, and financial statements. These reports are crucial for managers and executives to make informed decisions. The MIS also uses advanced analytics to identify trends, forecast future demand, and optimize operational efficiency.

CHAPTER 4:
PRODUCTION SYSTEM DESIGN

4.1 Locational Analysis

The location of a beverage plant is crucial to optimizing operational efficiency, managing costs, and expanding market reach. VBNPL located in Nawalparasi, offers several strategic advantages:

- Proximity to Key Markets: Being close to the India-Nepal border provides easy access to both Nepalese and Indian markets. This geographic positioning allows the plant to cater to a large consumer base in both countries, increasing its market reach and boosting sales potential.
- Cost-Effective Land: Land acquisition costs in Nawalparasi are relatively low compared to urban areas. This helps reduce the initial capital investment and allows more resources to be allocated to modern equipment and technology, improving operational efficiency.
- Reduced Transportation Costs: The plant's proximity to Sunauli, which is a major cross border transport route, minimizes transportation costs for raw materials. Since Nawalparasi is located in the middle part of Nepal along east-west, it provides optimized short distance to transport the finished products all over Nepal. Shorter travel distances, combined with efficient cross-border routes, contribute to lower logistics costs, enhancing overall profitability.

4.1.1 Infrastructure and Accessibility

1. Transportation Network: The plant benefits from a well-connected transportation network, including highways that link the border area with major cities in Nepal and India. The plant is located on Hulaki Highway and is only 10 km away from Mahendra Highway. This robust infrastructure facilitates smooth supply chain management, ensuring timely delivery of raw materials from India and the distribution of finished beverages all over Nepal.
2. Access to Raw Materials: The location is close to agricultural regions in Nepal and India, ensuring a steady supply of essential raw materials like sugar and water. Local sourcing reduces reliance on imports, further minimizing transportation expenses and supporting the local economy.
3. Labor Availability: The region has a reliable pool of skilled and unskilled, seasonal and regular labor available at competitive wages. This is beneficial for the plant's day-to-day operations, from production to distribution. Furthermore, the presence of local educational institutions can support staff training and skill development.

4.1.2 Economic and Regulatory Environment

1. Cross-Border Trade Advantages: Being near the India-Nepal border allows the plant to leverage favorable trade agreements and tariffs, which can reduce costs and streamline access to the Indian market. This offers a significant advantage for exporting finished products.
2. Government Incentives: Both the Nepalese and Indian governments provide incentives, such as tax breaks and subsidies, for industries in border regions. These policies promote economic growth and investment, helping the plant lower operational costs and increase profitability.

4.1.3 Challenges and Mitigation Strategies

1. Regulatory Compliance: Operating near the border requires compliance with both Nepalese and Indian regulations, including trade, environmental, and quality standards. The plant should establish a dedicated compliance team to navigate these regulations effectively.

2. Cross-Border Logistics: While proximity to the border reduces transportation costs, it also involves managing customs processes and potential delays. Investing in efficient supply chain and logistics systems can mitigate these challenges, ensuring smooth cross-border operations.

3. Market Competition: The strategic location may also attract competition from both local and international players. To address this, VBNPL can differentiate its products through high-quality offerings, strong branding, and exceptional customer service.

4.1.4 Plant Layout

The plant layout of a beverage facility plays a vital role in optimizing workflow, ensuring safety, and maximizing production efficiency. For VBNPL, the layout is designed to effectively utilize the available space while accommodating all necessary equipment and processes. VBNPL employs a horizontal plant layout, which offers several advantages:

1. Streamlined Workflow: A horizontal layout ensures smooth and efficient movement of materials throughout the plant, reducing bottlenecks and increasing overall productivity.

2. Ease of Access and Maintenance: The design allows easy access to machinery and equipment, simplifying maintenance and minimizing downtime.

3. Improved Safety: Clear pathways and organized sections help ensure safety by reducing accidents and equipment-related hazards.

4. Flexibility and Scalability: The layout is adaptable to future expansions, making it easier to scale up production when necessary.

5. Efficient Space Utilization: Maximizing the use of available space ensures optimal placement of equipment and storage areas.

6. Enhanced Communication and Supervision: The open layout allows supervisors to easily oversee operations and maintain communication with staff.

7. Simplified Logistics and Material Handling: The plant design supports efficient movement of materials and products, improving logistics and reducing handling time.

4.2 Flow Patterns and Material Handling Equipment

As a large-scale production facility, VBNPL employs mixed flow patterns to optimize the movement of materials. Machinery is strategically placed to reduce travel distances and support the plant's automated systems.

1. Fluid and Semi-Fluid Materials: Refrigerants, CIP (clean-in-place) chemicals, and production materials like syrups and contaminated water are handled through pressure-fed pipelines. These systems efficiently transport fluids between different sections of the plant.

2. Conveyor Systems: For solid materials, VBNPL uses conveyor belts. For example, husks are transported from silos to boilers, while bottles move through production and packaging

Figure 4.1: Plant layout

4.3 Plant Maintenance

Effective plant maintenance is essential to ensure uninterrupted operation, safety, and the longevity of equipment at VBNPL. The company employs a comprehensive maintenance strategy that includes the following:

1. Preventive Maintenance
   - Routine Inspections: Regular checks of equipment to detect wear and prevent breakdowns.
   - Lubrication: Ensuring moving parts are well-lubricated to reduce friction.
   - Calibration: Regular calibration of equipment to maintain accuracy.
   - Cleaning: Keeping equipment clean to avoid contamination and maintain performance.
   - Replacement of Parts: Timely replacement of worn parts before failure occurs.
2. Predictive Maintenance
   - Condition Monitoring: Real-time monitoring of equipment using sensors to detect potential issues.
   - Data Analysis: Analyzing sensor data to predict when maintenance is needed.
   - Scheduling Maintenance: Carrying out maintenance based on predictive data to minimize disruptions.
3. Corrective Maintenance
   - Immediate Repairs: Addressing any breakdowns or defects promptly.
   - Root Cause Analysis: Investigating failures to prevent recurrence.

- Documentation: Keeping detailed records of corrective actions to improve future maintenance practices.

4. Maintenance Management System

   - Scheduling: Using software to plan and track maintenance tasks.
   - Inventory Management: Maintaining an inventory of spare parts to avoid repair delays.
   - Maintenance Records: Recording all maintenance activities for better oversight.
   - Work Orders: Managing work orders to ensure all tasks are documented and completed.

4.4 Quality Management

Ensuring high product quality is a priority for VBNPL, and a robust Quality Management System (QMS) governs all aspects of production, from raw materials to final products.

1. Quality Assurance (QA)

   - Standard Operating Procedures (SOPs): Well-documented SOPs for all processes to maintain consistency.
   - Training and Certification: Regular employee training and certification in QA standards.
   - Compliance Audits: Frequent internal and external audits to ensure adherence to regulations and standards.

2. Quality Control (QC)

   - Raw Material Testing: Inspecting raw materials upon arrival to ensure quality. The weight of preform of different sizes are monitored.
   - In-Process Inspection: Monitoring various production stages to catch issues early. The bottle wt. ratio should be 35% ,45% in body and 20% in the base.
   - Final Product Testing: Comprehensive testing of finished products to ensure they meet specifications.
   - Sampling and Analysis: Using statistical sampling to ensure overall product quality

3. Quality Management System (QMS)

   - Document Control: Keeping accurate and updated quality documentation.
   - Process Mapping: Mapping production processes to identify key control points.
   - Non-Conformance Management: Addressing non-conformances with root cause analysis and corrective action.
   - Continuous Improvement: Regularly reviewing and improving quality procedures.

4. Laboratory and Testing Facilities

   - Chemical Analysis: Ensuring the correct composition of ingredients and products. For instance, the syrup to water ratio of Dew, Pepsi, Seven Up should be 1:5 whereas for Myrinda, it should be 1:4.
   - Microbiological Testing: Testing for contaminants to ensure product safety.

- Sensory Evaluation: Assessing the sensory qualities (taste, smell, appearance) of beverages.
- Data Recording: Keeping detailed records of all testing for traceability.

5. Supplier Quality Management

   - Supplier Selection and Evaluation: Selecting and regularly auditing suppliers to ensure consistent quality.
   - Incoming Quality Control: Testing materials upon receipt to verify they meet specifications.
   - Supplier Partnerships: Building collaborative relationships with suppliers to encourage continuous improvement.

4.5 Production Planning

The Production Planning and Control (PPC) department located in Kathmandu performs analysis of market demand, production capacity, market demand and profit in each product in order to maximize net income of the company. It performs optimization and generates monthly production plan provided to the plant. It takes the daily report of production and convert the monthly plan into daily or weekly basis. The production is monitored by production department. It consists of Production manager, Production engineer, Operators and Workers.

4.6 Production Line

The plant has four different production line namely New PET line, Old PET line, GRB line and Aquafina line. The raw materials required in production line are $C0_2$, treated water, preform, closure, syrup and steam. The syrup is different for different beverage.

4.6.1 GRB line

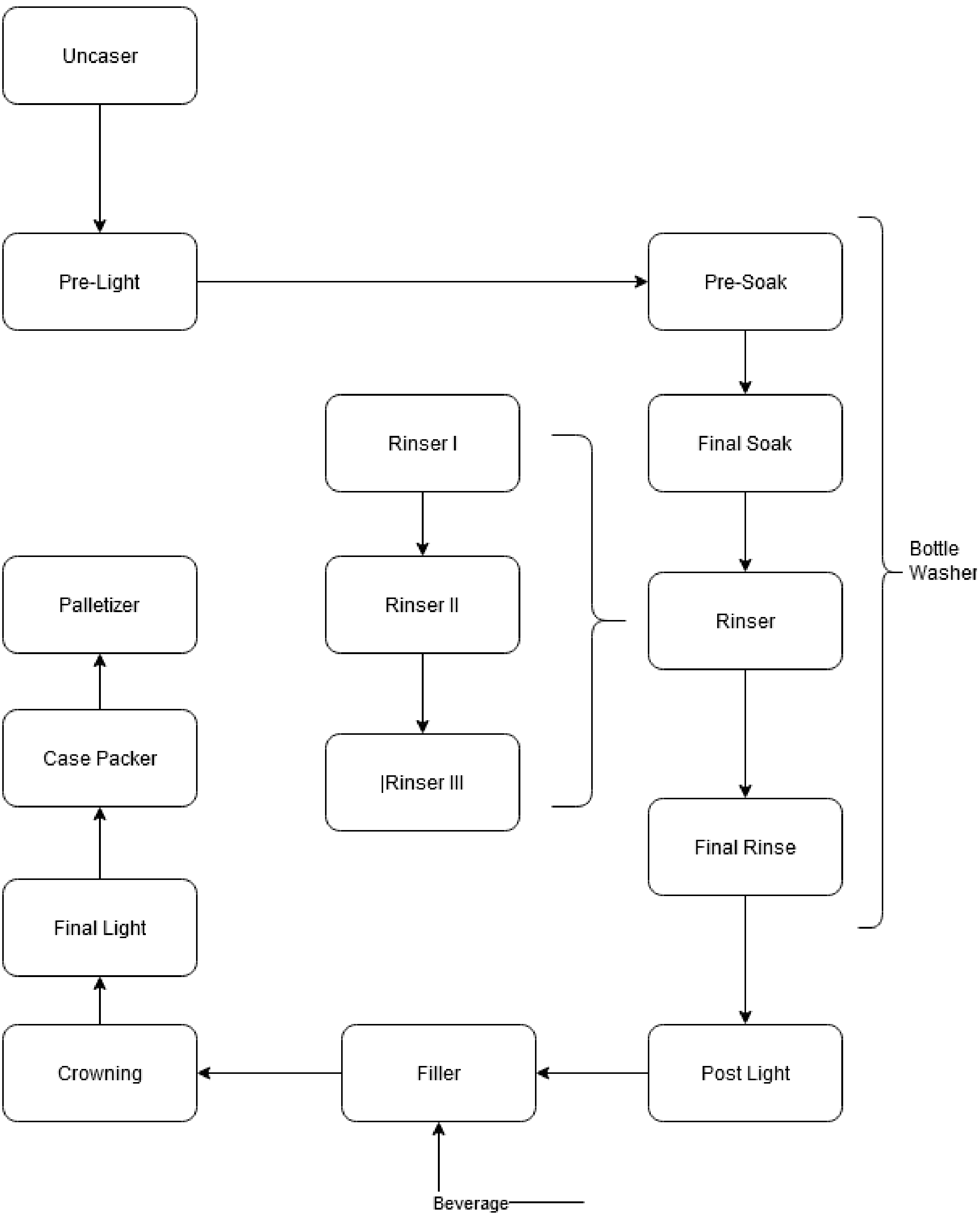

Figure 4.2: Schematic Diagram of GRB line

The GRB line at Varun Beverages is used to fill beverages into glass bottles that are returned for reuse. Since the bottles are not manufactured in-house, they are procured when required. The process follows a sequence of important steps, outlined below:

Uncaser

The process begins with the uncaser machine, where the forklift feeds pallets of returned glass bottles. The uncaser removes the bottles from their cases and places them onto the conveyor belt for subsequent steps.

Pre-light

Bottles are passed through a bright light for visual inspection. This step ensures that any cracked bottles or those containing foreign objects, such as wrappers, are removed and rejected from the line.

Bottle Washer

Since the glass bottles are reused, they often contain impurities. To ensure the bottles are clean and sanitized for reuse, they go through a series of washing steps in the bottle washer.

Pre-Soak: Bottles are soaked in hot water to loosen any debris.
Final Soak: Bottles are immersed in a caustic soda solution to remove any remaining impurities.
Rinsing: After soaking, the bottles pass through a series of rinsers, which have three compartments:
Rinser I: Hot water rinses the bottles.
Rinser II and III: Cold water completes the cleaning process.
Final Rinse: The bottles are rinsed with dry hot air, ensuring that they are completely clean and free of any residual particles.

Post Light

After washing, bottles are checked again under a light to ensure they are free from any objects or impurities. Bottles failing this inspection are rejected.

Filler

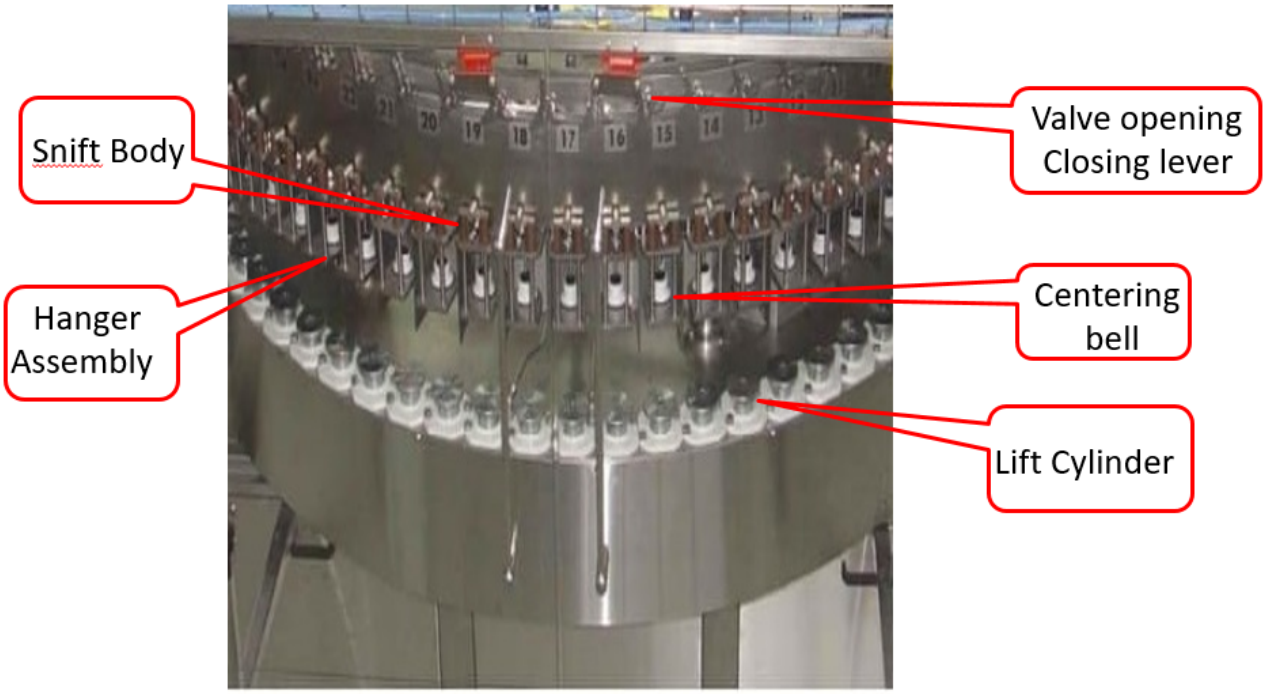

Figure 4.3: GRB Filler

The filling mechanism operates using the counter-pressure principle, similar to the old PET line. Bottles are tightly held in place, and CO is introduced to pressurize them. Once the pressure inside the bottle matches the pressure in the filling bowl, the filler valve opens, allowing the beverage to flow in. When the beverage level reaches the vent tube, the CO backflow is blocked, stopping the filling process.

Crowning

After filling, the bottles are sealed with crowns using a crowning machine. The crowns act as closures for the bottles, ensuring they are airtight.

Final Light

In this step, filled bottles are inspected again against a bright light to detect issues such as overfilling, underfilling, improper crowning, or the presence of foreign objects inside the bottle. This step is crucial for maintaining quality standards.

Case Packer

Once inspected, the bottles are packed into cases. Each case holds 24 bottles, arranged in a 6x4 grid.

Palletizer

Finally, the cases of glass bottles are arranged onto pallets by the palletizer. These pallets are then transported to the warehouse using forklifts for storage until they are ready for dispatch.

4.6.2 Old CSD PET line

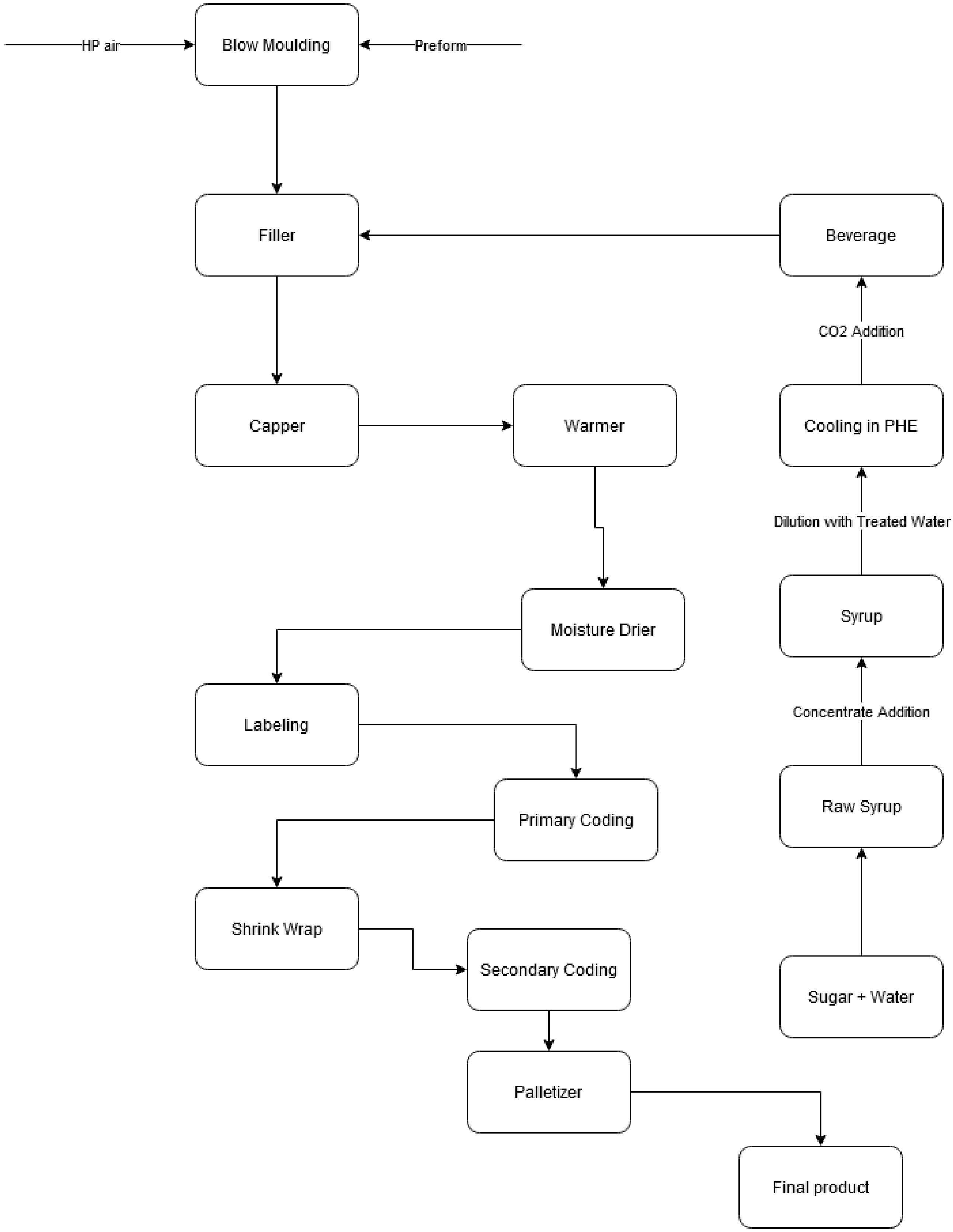

Figure 4.4: Schematic Diagram of PET line

Blow Moulding

Preform is manufactured in the husky room and transferred to the upper which infeeds the preform into the blow moulding machine. The preform is heated first in the penetration zone and second in the distribution zone. Penetration zone has 9 oven and distribution zone has 10 oven, each oven with 10 lamp. The temperature of preform in penetration zone reaches about 140 °C and about 160 °C. The heated preform is blown by high pressure air into the mould to give it the desired shape and size of bottle. There are two colors of preform available clear and green. For products like sting, pepsi, myrinda clear preform or bottle is used whereas for Mountain dew and Seven up green peform is used.

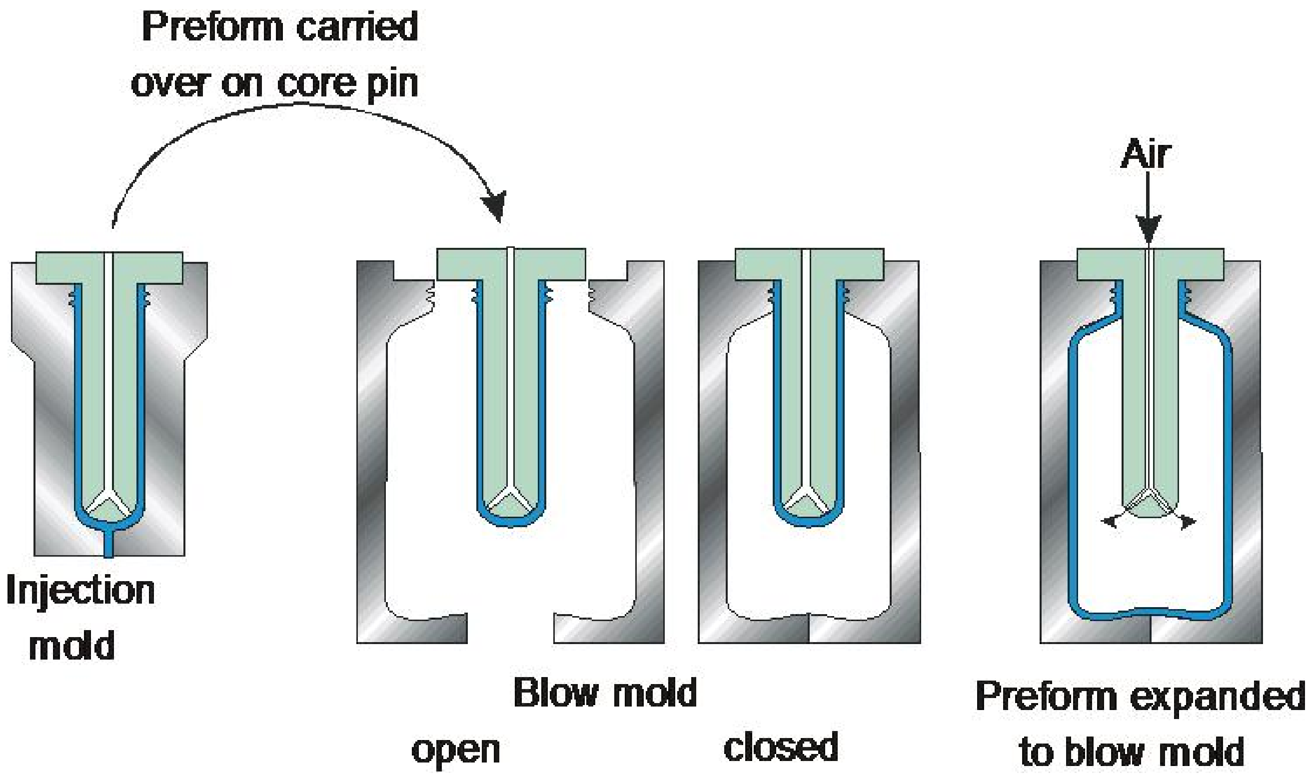

Figure 4.5: Blow Moulding Process [1]

For different size of bottle, preform of different weight are used as shown in the table:

S.N	Bottle Size	Preform Weight
1	250 ml	15.9 g
2	500 ml	22.2 g
3	1000 ml	32.5 g
4	1500 ml	50.7 g
5	2000 ml	50.7 g
6	2250 ml	50.7 g

Table 4.1: Preform and Bottle size

Syrup Making Process

Preparation of syrup starts in the raw syrup room where sugar and water are mixed to form a concentrated solution called raw syrup. Raw syrup is mixed with concentrate in syrup room to form syrup which is stored in syrup tank. Concentrate is the flavor of the product which gives the beverage its taste. The concentrate is not prepared in this plant rather it is prepared by Pepsi company and VBNPL is simply the bottler of the products.

Beverage Making Process

Beverage is made in the production line. Firstly, the syrup is diluted with treated water in the given ratio specific to product. The diluted solution is then cooled in PHE by help of cold glycol. Cooling the solution to 2-3 °C, it is then mixed with CO_2 whose amount is again specific to product. Finally, beverage is ready to fill.

Filler

The filler in Old CSD line works on the principle of cold filling . "Cold filling" It refers to the process through which Chilled Carbonated beverage is filled at Isobaric condition in a container. Counter Pressure Filling Method is used for filling Carbonated Beverage.
While filling, the filler bowl pressure and Container pressure equalizes. Filling of beverage in container happen in Isobaric condition.

Filling Cycle Steps:

- Empty Bottle Infeed
- Bottle rinsing
- Positioning: The bottle is pushed by the jack and is centered by the centering cup and conveyed to the filling position
- Pre – evacuation: Command rail presses push button valve which connects inside of the bottle, through collector. The vacuum pump in this condition sucks the air inside the bottle (not in Meyer filler).
- Pressurization: At the end of the pre-evacuation phase, the button in question re closes and simultaneously the pressurization valve opens; the CO2 enters the bottle through this valve, bringing it to the same pressure value as the filler bowl.
- Filling: When the pressure in the bottle reaches to the value in the bowl, the product valve automatically opens. Thus starting the gravity-fed isobaric filling cycle. The product is deflected against the bottles internal wall by means of the deflector, hereby minimizing turbulence and foam formation. As the liquid flows out, the gas flows back into the filler bowl through the gas passage hole.
- Snifting: The filling cycle ends when product level in the bottle reaches the bottom end of the vent tube, there by stopping the gas from returning to the filler bowl.
- Capping/ Crowning: Pressure and product valves closes and remains close during decompression. The residual gas in the bottle neck flows out through the push button valve
- Filled Bottle Out feed

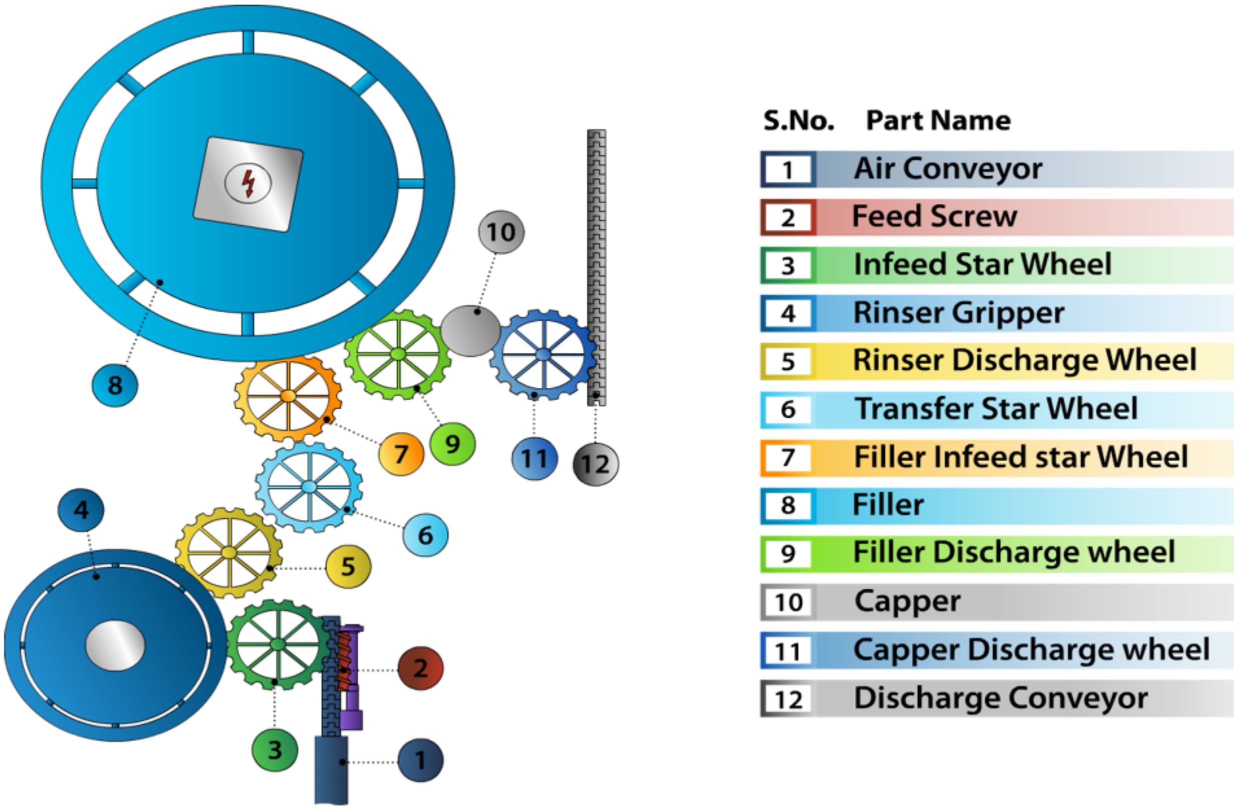

Figure 4.6: Parts of PET filler

Capper

The plastic closure application unit applies a pre-thread plastic closure on the bottle It consists of two sections: **Closure sorter**, which holds and selects the closures **Capper**, which seals the closure to a pre-set torque on the bottle

Process of Closure Application: The closures are properly oriented in the sorter and then fed to the closure pick-up The closure pick-up releases the closures to the bottle finish The bottles with pre-tightened closures are finally applied to pre-set static application Torque bye a magnetic capping head.

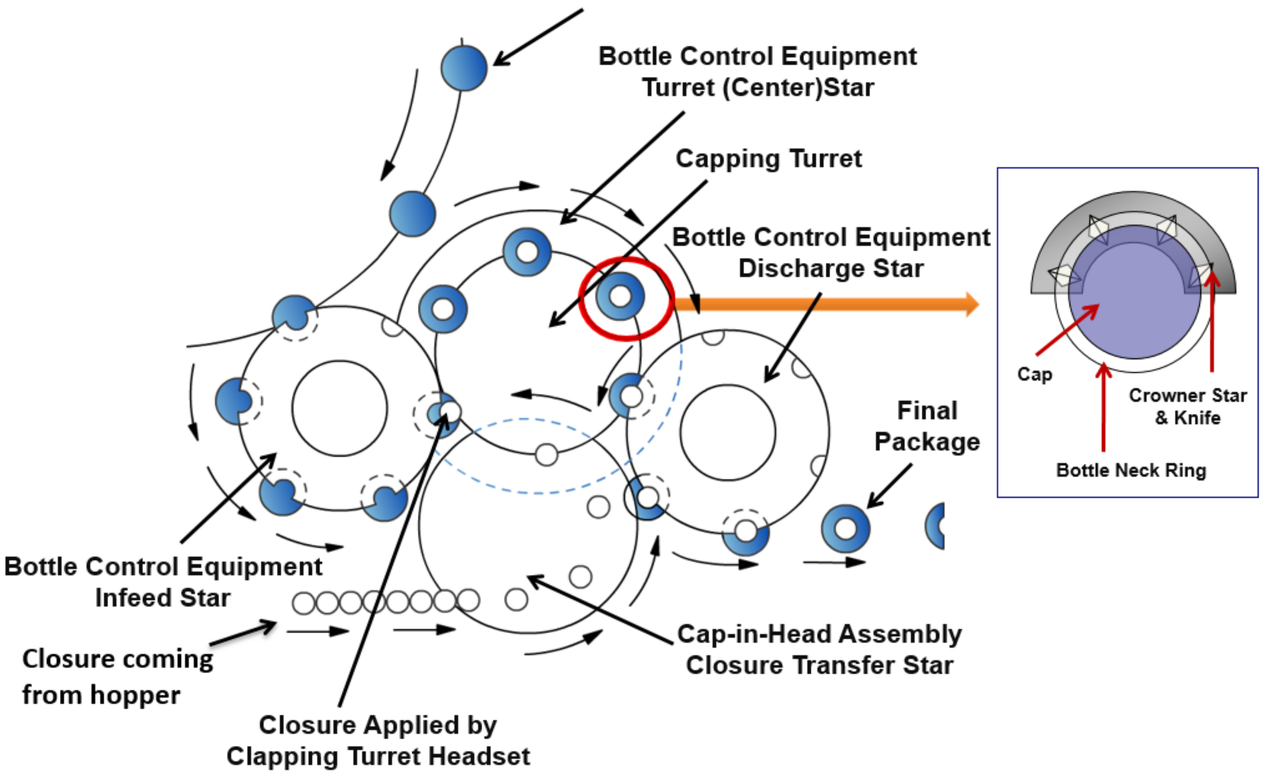

Figure 4.7: Capper arrangement

Warmer

The filled bottle of beverage is transfered on conveyor belt outside filler room. At this point the temperature of the beverage is around 4 °C which is sufficient to form water drops on the bottle. Since coding and labeling cannot be done on wet bottle, the tempr should be dropped. So the chilled bottle is passed through warmer where it is washed by hot water to reduce the temperature.

Moisture Drier

Here the outside of bottle is dried by blowing hot dry air on it.

Labeling

Labeling is the process attaching a label on the beverage bottle to denote the product whether it is slice, Mountain Dew, Pepsi on any other. It is done by labeling machine. The label include the name of product, ingredients, nutritional value and product life.

Primary Coding

It is the process of coding the serial no. and manufacturing date on the bottle by the coding machine. The coding machine sprays the ink to code without touching the bottle.

Shrink Wrap

Here the given number of bottles are wrapped by shrink film to form a case.

Secondary Coding

Here coding is done on the case. The code include date of manufacture, serial no., no. of bottles contained and bottle size.

Palletizer

Here the cases are arranged on pallete. In old line, it is done manually by the workers. Each palletes of beverage are transfered by forklift to keep it in stock in godown.

4.6.3 New CSD PET line

Most of the parts and workings are almost similar to Old CSD PET line. The key differences are noted in following points.

High Speed

The overall system is designed to operate in high speed upto 35000 bph for 1000 ml bottle as compared to old line which is very slow.

Volumetric Filling

It uses electronic programmed controller and actuator to control the volume of beverage to be filled in the bottle which is very precise as compared to the old line which uses counter pressure mechanism.

Palletizer Machine

It uses highly automated palletizer machine which automatically arranges the cases into palletes. It employs photoelectric proximity sensor to count the no. of cases to be arranged in each row of the pallete. Once the arrangement is complete, the pusher pushes the rows of cases on the pallete and repeat the process thrice to make the pallete a cube shape.

CHAPTER 5:
UTILITIES

5.1 Refrigeration System

5.1.1 Working Principle

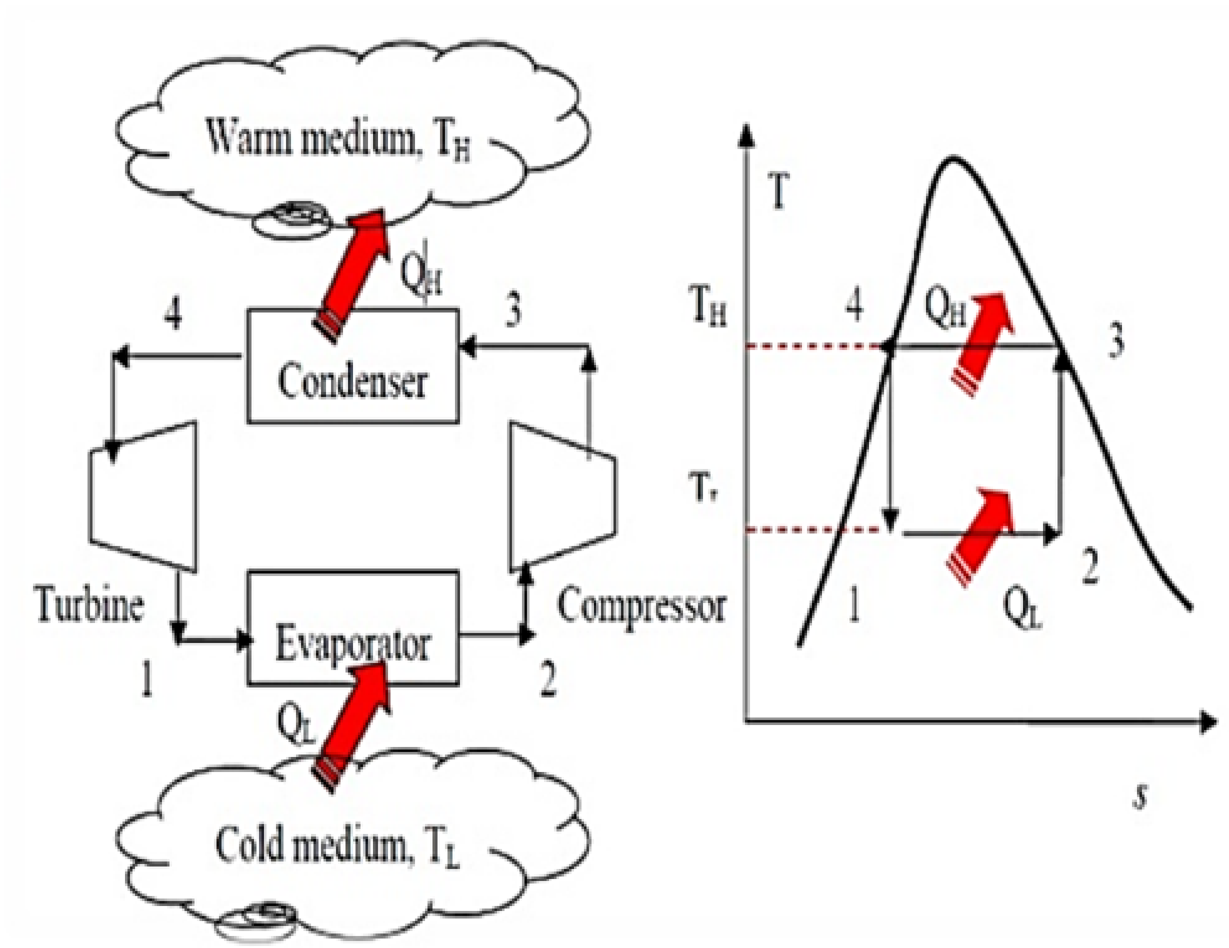

Figure 5.1: Reversed Carnot Cycle [2]

The Reversed Carnot Cycle is the idealized thermodynamic cycle that represents the working principle of refrigeration systems. In this cycle, heat is transferred from a cold body to a hot body, which is the opposite of what occurs in a natural heat flow. The cycle consists of four stages: isentropic compression, isothermal heat rejection, isentropic expansion, and isothermal heat absorption.

In the isentropic compression phase, the refrigerant is compressed adiabatically, meaning there is no heat exchange with the surroundings, causing the temperature and pressure of the refrigerant to rise. This high-temperature refrigerant then undergoes isothermal heat rejection at constant temperature to the surrounding environment, typically through a condenser, where it loses heat and condenses into a liquid. Next, in the isentropic expansion phase, the refrigerant expands through an expansion valve, causing its temperature and pressure to drop without exchanging heat. Finally, the refrigerant absorbs heat from the cold space during the isothermal heat absorption process, where the refrigerant evaporates at a constant low temperature in the evaporator, thereby cooling the space.

This cycle is reversible, and while it represents an ideal process, it provides a theoretical foundation for the operation of real-world refrigeration and heat pump systems, although practical systems have inefficiencies and cannot achieve the ideal Carnot efficiency.

5.1.2 Components

Compressor

The compressor increases the pressure of the refrigerant gas, turning it into a high-pressure, high-temperature vapor. It drives the refrigerant through the system. There are two types of compressor used in refrigeration system KC-6 and KCX9. Both are reciprocating type compressor having 6 cylinders in KC-6 and 9 cylinder in KCX9. KC-6 is water cooled type whereas KCX9 is air-cooled type. There are 3 KC-6 and one KCX9 compressors running in parallel whereas one KC-6 compressor work separately which directly supplies ammonia in carbonation tank. The working ratio of suction pressure and discharge pressure is 1:5. The discharge pressure remains about 15 bar whereas 16 bar is the maximum pressure limit. Under preventive maintenance, the filter of the compressor should be changed after every 500 working hour (5-6 months).

Oil Separator Tank

The high pressure ammonia vapor from the compressor discharge contains some leaked oil (lubricant) and hence passed through oil separator tank where the liquid oil settles down and pure vapour of ammonia is sent to the condenser. The oil collected here is removed in around every 15 days.

Condenser

Condenser condenses the vapor ammonia into liquid. Ideally, ammonia should convert into liquid completely however this is not seen in practice. There are three condenser connected in parallel in the refrigeration plant. The condenser used in this plant is flat plate heat exchanger type. The hot compressed ammonia vapor is cooled down by the cold water moving through the heat exchanger. The heated water is sent to cooling tower. Descaling is the process of removing the scales that is formed in the pipes by passing acid-water through it. It is done in every 1-2 months.

Cooling Tower

A cooling tower is an essential component in many industrial processes, including refrigeration, where it serves to remove excess heat from the system. In the cooling tower, hot water from the condenser is circulated and sprayed from a height, creating fine droplets of water. This process increases the surface area of the water droplets, which significantly enhances heat transfer through convection. As a result, the heat from the water is dissipated into the surrounding air, cooling the water effectively before it is recirculated back into the system. This process ensures that the refrigeration system remains efficient by maintaining a lower operating temperature. The total dissolved solid (TDS) of the raw water used for cooling the compressor andcondenser should not exceed 2000 ppm.

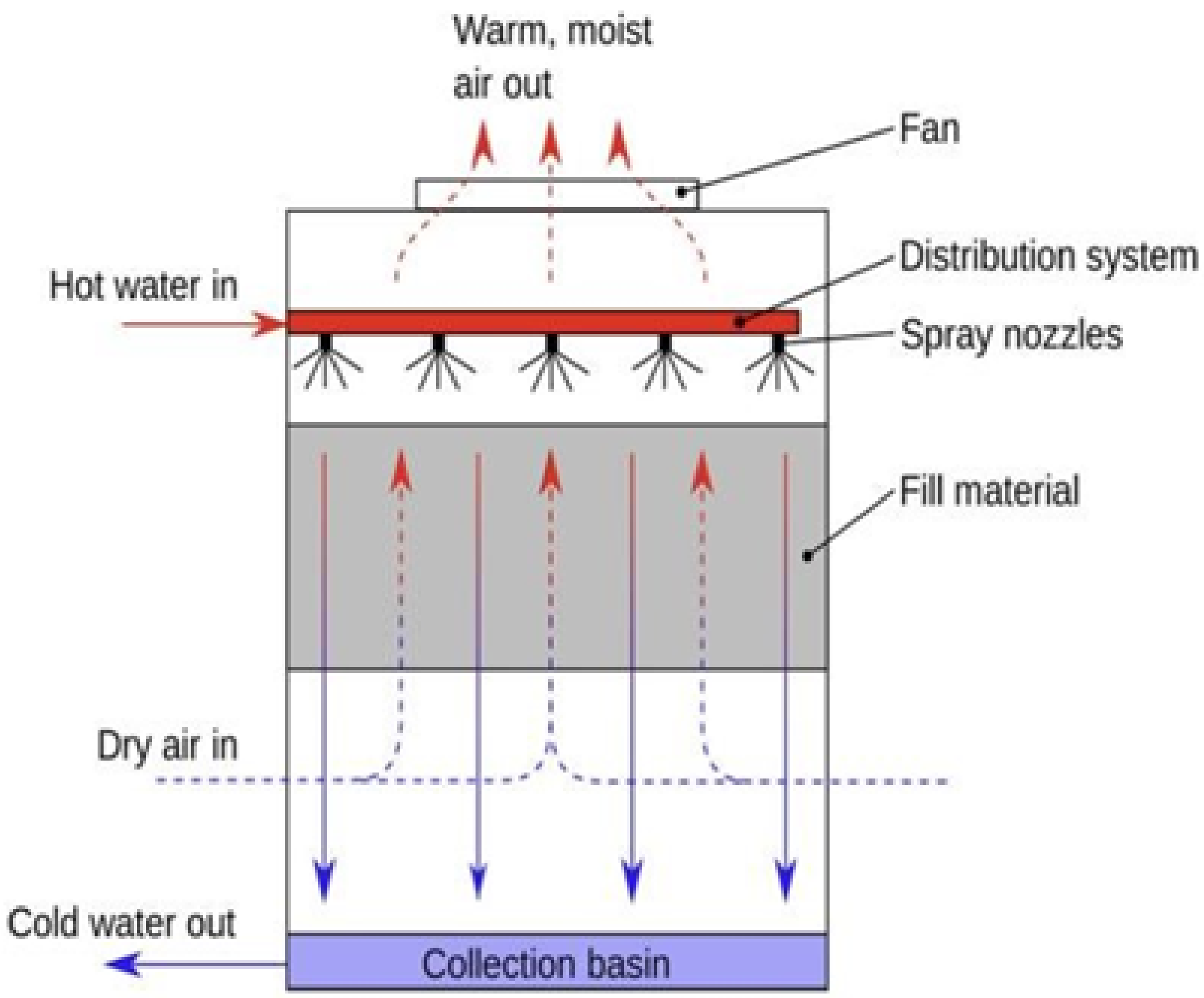

Figure 5.2: Cooling Tower [3]

Receiver

In condenser, the ammonia may not get converted into liquid completely and some amount of vapor ammonia may be present there. To ensure the supply of liquid ammonia in the expansion valve, receiver is present. It collects the discharge of condenser and sends only liquid ammonia to the expansion valve.

Expansion Valve

In expansion valve, there is significant drop in pressure as the liquid ammonia is allowed to expand isentropically. The high pressure liquid ammonia comes out to low pressure region through an orifice.

Accumulator

An accumulator is a crucial component in refrigeration systems, designed to enhance efficiency, ensure stability, and protect essential parts from damage. It primarily serves as a buffer for refrigerant, preventing sudden pressure changes and maintaining a consistent flow within the system. Positioned between the evaporator and compressor, the accumulator prevents liquid refrigerant from entering the compressor, a situation known as ”liquid slugging,” which can cause severe damage since compressors are built to handle vapor, not liquid. The accumulator captures excess liquid refrigerant, ensuring only vapor reaches the compressor, thus extending its operational lifespan. Additionally, it helps regulate the refrigerant charge by storing surplus refrigerant during low load periods and releasing it when demand increases, especially during varying conditions like start-up or defrost cycles. The accumulator also plays a significant role in stabilizing system pressure by absorbing excess refrigerant, preventing erratic refrigerant flow, which can lead to inefficient cooling and increased energy consumption. Overall, the accumulator is vital in ensuring efficient and reliable operation, protecting the compressor, maintaining the correct refrigerant charge, and regulating pressure, making it indispensable in modern refrigeration systems.

Cold Well and Hot Well

In the refrigeration system, the cold well and hot well serve as essential components for managing glycol circulation. The cold well is a tank that collects and stores cold glycol after it has been cooled in the evaporator or heat exchanger. From here, the cold glycol is distributed to various parts of the system, such as production lines, to maintain the required low temperatures for the processes.

On the other hand, the hot well is the tank where the hot glycol, after absorbing heat from the system during its operation, is collected. The hot glycol is then sent to the heat exchanger for cooling, completing the circulation loop in the system. These wells play a crucial role in maintaining the temperature control and stability of the glycol used in the refrigeration process.

Primary Pump

The primary pump in VBNPL's refrigeration system plays a critical role by supplying hot glycol from hot well to the heat exchanger, specifically a plate heat exchanger (PHE). In this process, heat is transferred from the glycol to the liquid ammonia. As the liquid ammonia absorbs heat, it vaporizes, which is essential for the refrigeration cycle. In addition to the primary pump, the system utilizes two secondary pumps, arranged in parallel. These secondary pumps help manage the flow of glycol and maintain consistent pressure and efficiency in the heat transfer process. This configuration ensures a steady and efficient operation of the refrigeration system, supporting the overall cooling requirements of the plant.

Secondary Pump

The secondary pump in the refrigeration system at Varun Beverages Nepal Pvt. Ltd. (VBNPL) plays a crucial role in distributing cold glycol to the cold spaces. This pump supplies cold glycol from the refrigeration system to various production lines. Specifically, VBNPL has separate pumps dedicated to supplying cold glycol to multiple production areas, including the old PET line, Aquafina line, New PET line, and GRB line. This setup ensures that the cold glycol is delivered efficiently to maintain the required temperatures in these distinct production sections, facilitating smooth operations across the facility.

Cold Space

In a beverage production plant, "cold space" refers to the designated areas that require precise cooling to maintain product quality and ensure smooth operations. These spaces include the old PET line, GRB line, Aquafina line, new PET line, syrup room, and carbonation tank. Cooling is a critical part of production, particularly in processes where temperature-sensitive steps are involved, such as carbonating beverages, storing ingredients, or filling bottles.

To meet the cooling demands of these various cold spaces, cold glycol is used as the cooling medium. Glycol, a commonly used coolant in industrial refrigeration, is circulated through these areas by separate pumps for each line or section. This ensures that each specific part of the plant receives the required cooling independent of others, allowing for precise temperature control.

For instance, the old PET line and new PET line might have different cooling needs due to variations in production rate or bottle size. The syrup room, where beverage concentrates are prepared, must be kept cool to maintain the quality and stability of the syrups. Similarly, the carbonation tank, where carbon dioxide is dissolved into the beverage, also requires controlled cooling to achieve the proper level of carbonation.

By providing cold glycol through separate pumps for each of these cold spaces, the plant ensures that cooling is tailored to the specific needs of each section. This contributes to overall efficiency, product consistency, and energy optimization in the production process.

S.N	**Name**	**Model no.**
1	Compressor	KC-6
2	Compressor motor -3 phase squirrel cage	M2B4315SMB4
3	Compressor	KCX9
4	Compressor motor -3 phase	M2BAX355SMB4
5	Heat Exchanger (Condenser-Cooling tower)	PK15-BWFDSPC
6	Heat Exchanger (Evaporator-Glycol)	PK15-BWFGSPF
7	Primary pump motor-3 phase	MG180LB2-42FF300-H3
8	Secondary Pump motor	MMG132SB-2-38FF265-E1

Table 5.1: Major Equipments of refrigeration system

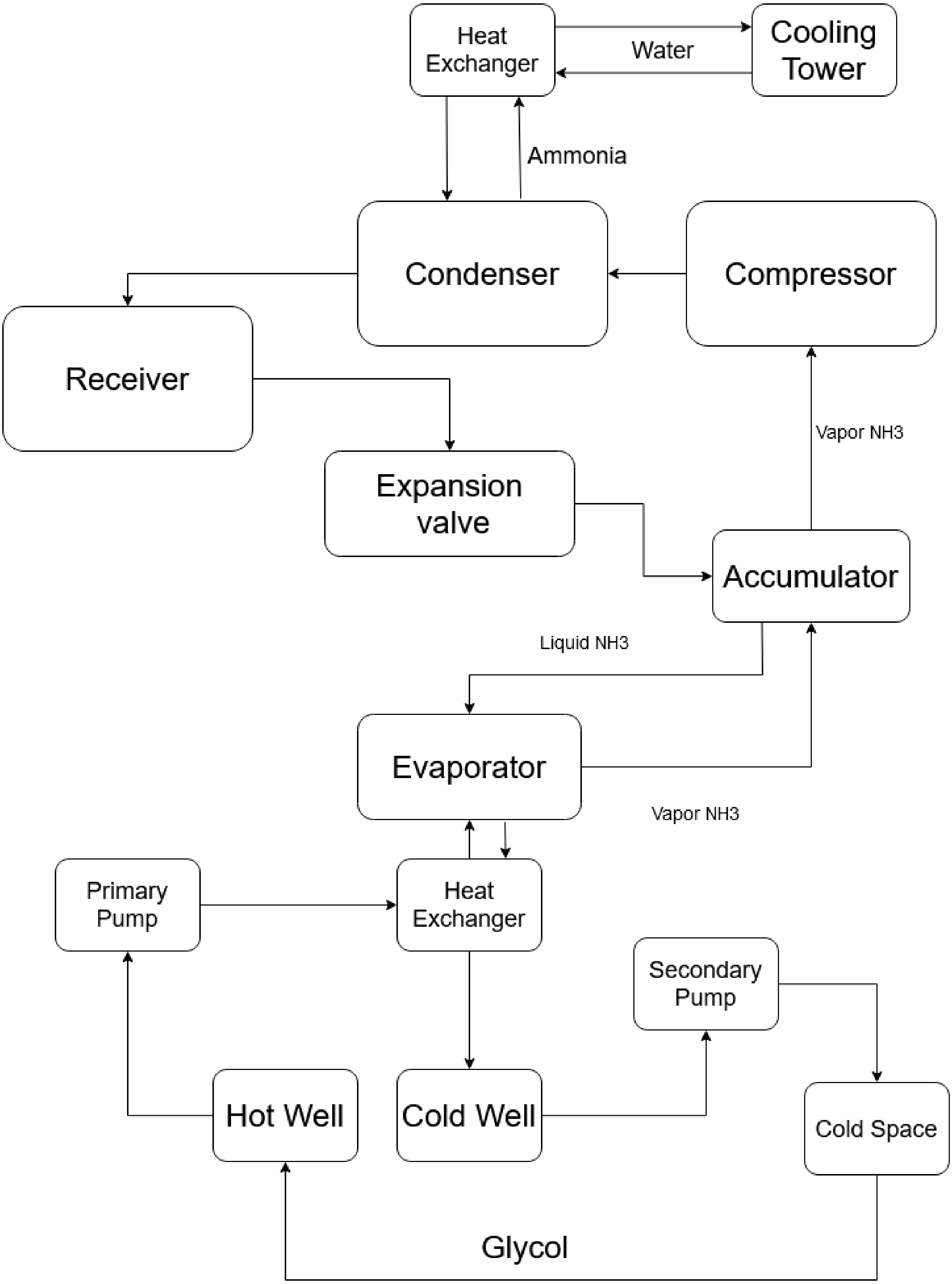

Figure 5.3: Block Diagram of Refrigeration System

5.2 HP Compressor

S.N	Name	Model no.
1	HP compressor	40P37-335PD-IVR-A
2	Motor 3 phase	NADZD4962

Table 5.2: HP compressor model

In the production line at Varun Beverages Nepal Pvt. Ltd. (VBNPL), the HP (High Pressure) compressors play a critical role in the blow molding process, where preforms are blown into bottles. These compressors are designed to handle very high pressures, reaching up to 35 bar, with a design pressure of 40 bar. There are four HP compressors, each with different capacities: 960, 960, 500, and 400 cfm (cubic feet per minute), and they operate automatically based on the demand for high-pressure air in the system.

The HP compressors are three-stage compressors, consisting of three primary compressors, one secondary compressor, and one tertiary compressor. The compression process is done in steps: starting with 5 bar in the first stage, 15 bar in the second stage, and reaching 35 bar in the final stage. To manage the heat generated during compression, the system incorporates intercooling water flow in the secondary and tertiary stages, ensuring the compressors remain efficient and do not overheat. This staged compression and cooling are crucial for maintaining high operational reliability and optimizing the air compression process.

Additionally, the compressors are driven by powerful motors. For example, one of the HP compressors is a model 40P37-335PD-IVR-A, and it is powered by a three-phase motor (model NADZD4962). This setup ensures a consistent supply of high-pressure air, crucial for the bottle-blowing process in the beverage production line.

Figure 5.4: HP compressor [4]

5.3 LP Compressor

S.N	Name	Model no.
1	Low pressure compressor	HX2T-100NP
2	LP compressor motor -3 phase	NADV10443

Table 5.3: LP compressor model

The LP (Low Pressure) compressor in an industrial setting, like at Varun Beverages Nepal Pvt. Ltd. (VBNPL), is designed to compress air to a relatively low pressure, typically around 5 bar. This compressed air is crucial for operating various pneumatic systems and valves across the plant, which depend on pressurized air for automation and control.

The LP compressor operates in two stages. In the first stage, air is drawn in and compressed to an intermediate pressure, which significantly raises its temperature. In the second stage, the air is compressed further to the desired pressure, around 5 bar. As a result of this compression, the air reaches a high temperature, which leads to moisture condensation upon cooling.

The cooling process is vital to maintain the quality of the compressed air. When the pressurized air cools, the vapor present condenses into liquid form, and this moisture is removed using separators or air dryers. Removing the moisture is critical to prevent water buildup, which could otherwise damage pneumatic valves and components through corrosion or clogging.

The LP compressor is essential in ensuring the smooth functioning of pneumatic systems and helps in maintaining an efficient and reliable operation across the plant's automation processes.

5.4 Boiler

A boiler is an essential component in the production process at Varun Beverages Nepal Pvt. Ltd. (VBNPL), supplying steam to various points of production such as the blending room, rinser, and hot wash stations. The model in use, CB-40/10.54/1026, is a composite type boiler, combining both water tube and fire tube designs—water tubes positioned at the bottom and fire tubes at the top.

This boiler has a steam-generating capacity of 4000 kg/h, providing the necessary steam for different production applications. The boiler is fueled by husk briquettes and wood, making it more sustainable compared to purely fossil-fuel-powered systems. It has a connected load of 30.07 kW to power auxiliary equipment.

5.4.1 Boiler Mountings

Mountings are the safety devices and control mechanisms installed on the boiler to ensure safe and efficient operation. They typically include:

Safety Valves

The safety valve is one of the most crucial mountings on the boiler. Its primary function is to prevent the boiler from operating at unsafe pressure levels. When the pressure inside the boiler exceeds a predefined limit, the safety valve automatically opens to release the excess steam and bring the pressure back within safe limits.

Water Level Indicator

The water level indicator shows the water level inside the boiler to prevent dangerous conditions such as low water levels, which could lead to overheating and damaging the boiler.

Function: It usually consists of a glass tube or sight glass that visually shows the water level inside the boiler drum. The operator must ensure that the water remains within a safe range.

Pressure Gauge

The pressure gauge measures the pressure of steam inside the boiler. It gives an accurate reading to ensure the boiler operates within the designed pressure range.

Working: It is typically a Bourdon tube pressure gauge, where a coiled metal tube straightens as pressure increases, and this movement is translated into a dial reading. The operator can monitor the pressure reading and make adjustments as needed.

Blowdown Valve

This valve is used to discharge water from the boiler for cleaning purposes. It removes sediment, sludge, and impurities that accumulate at the bottom of the boiler drum over time.

Purpose: Regular blowdown is necessary to maintain boiler water quality, prevent scaling, and ensure efficient heat transfer. Excessive impurities can lead to poor performance, higher fuel consumption, and potential damage.

Fusible Plug

The fusible plug is a safety device that prevents the boiler from overheating in case of low water levels. It is located on the boiler's furnace or combustion chamber.

Operation: The fusible plug contains a metal with a low melting point. If the water level falls too low and exposes the plug to steam or flue gases, the metal melts, creating an opening. This releases steam or water into the furnace, extinguishing the fire and preventing further overheating.

Steam Stop Valve

The steam stop valve is used to regulate the steam flow from the boiler to the steam pipe. It allows the operator to start or stop the steam flow when required.

Purpose: The stop valve ensures controlled steam flow from the boiler to the production system or other machinery. It also isolates the boiler for maintenance or emergencies.

Feed Check Valve

This valve controls the flow of water from the feed pump to the boiler and prevents backflow of water into the pump when the boiler pressure exceeds the feed water pressure.

Purpose: It ensures a continuous supply of water into the boiler and prevents damage to the feed pump due to reverse flow.

Air Vent Valve

Located at the top of the boiler, the air vent valve is used to remove air from the boiler drum when it is being filled with water or during startup.

Importance: Removing air from the system is essential as trapped air can reduce heat transfer efficiency and cause inaccurate pressure readings.

These mountings play a critical role in ensuring that the boiler operates safely and reliably under various production conditions.

5.4.2 Testings

To ensure the smooth and safe operation of the boiler at Varun Beverages Nepal Pvt. Ltd. (VBNPL), three major tests are conducted regularly every 15 days. These tests help maintain the boiler's efficiency, reliability, and safety. Below are the descriptions of the tests:

Steam Test

Objective: The primary objective of the steam test is to verify the proper functioning of the safety valves, which play a critical role in releasing excess steam from the boiler. This ensures that the boiler doesn't over-pressurize, which could lead to a dangerous situation or potential equipment failure.
Process:

First, the boiler is operated under normal conditions to allow steam to build up to operational levels. The safety valves are then monitored to ensure that they open automatically at the set pressure limit (typically above normal operating pressure). The release of steam from the valve should be smooth and effective in lowering the pressure inside the boiler. Once the pressure falls below the set limit, the valve should close automatically, restoring the system to normal operation. Any failure of the valve to open or close properly would indicate a need for immediate maintenance or replacement to ensure safety.

Hydraulic Test

Objective: The hydraulic test aims to detect any leaks or structural weaknesses in the boiler's components. This test is critical for assessing the integrity of the pressure vessel, piping, and joints, ensuring that the boiler can withstand operational pressure without any risk of rupture or leakage.
Process: The boiler is completely filled with water, eliminating any air pockets inside the vessel. Pressure is applied using a hydraulic pump, raising the internal pressure to a value significantly higher than the boiler's normal operating pressure (usually 1.5 times the maximum working pressure). The system is then inspected for leaks at joints, welds, valves, and any other potential weak points. The boiler is held under this elevated pressure for a specified duration (as per regulations), while visual inspections are conducted to spot any visible leaks or deformations. If any leakage is observed, necessary repairs are carried out, and the test is repeated until the boiler passes the inspection.

Open Test

Objective: The purpose of the open test is to clean the firetubes and other components of the boiler by removing accumulated soot, dust, and scale. This ensures efficient heat transfer, optimal combustion, and prolonged boiler life by reducing the risk of overheating or corrosion due to deposits.

Process: The boiler is first shut down and allowed to cool. The firetube access doors or covers are opened, and the internal components are visually inspected for soot, ash, and scale buildup. Manual cleaning tools, such as brushes and scrapers, are used to remove any deposits from the firetubes, water tubes, and heat-exchange surfaces. In some cases, chemical cleaning solutions may be used to dissolve more stubborn scale and mineral deposits. Once cleaned, the tubes and components are inspected for any damage or corrosion, and necessary repairs are made if required. After cleaning, the boiler is reassembled, and the system is tested to ensure proper functionality.

5.4.3 Dust Removal Mechanism

Cyclonic separation is a technology used to remove particulates from air, gas, or liquid streams through vortex separation. It is a mechanical process that does not rely on filters but uses rotational effects and gravity to separate the components of a mixture. This makes cyclonic separators both cost-effective and efficient in removing large particulate matter from the exhaust gases produced during combustion.

Working Mechanism:

Inlet of the Boiler Effluent Gas:

The flue gas produced by the combustion of fuels (like husk briquettes and wood) in the boiler contains fine solid particulates (such as ash) and liquid droplets. Before this gas is released into the environment, it enters the cyclonic separator.

Vortex Formation:

Inside the separator, the gas stream is introduced tangentially at a high speed, creating a rotating motion or vortex. The shape of the separator causes the gas to spin rapidly in a downward spiral along the walls of the cylinder.

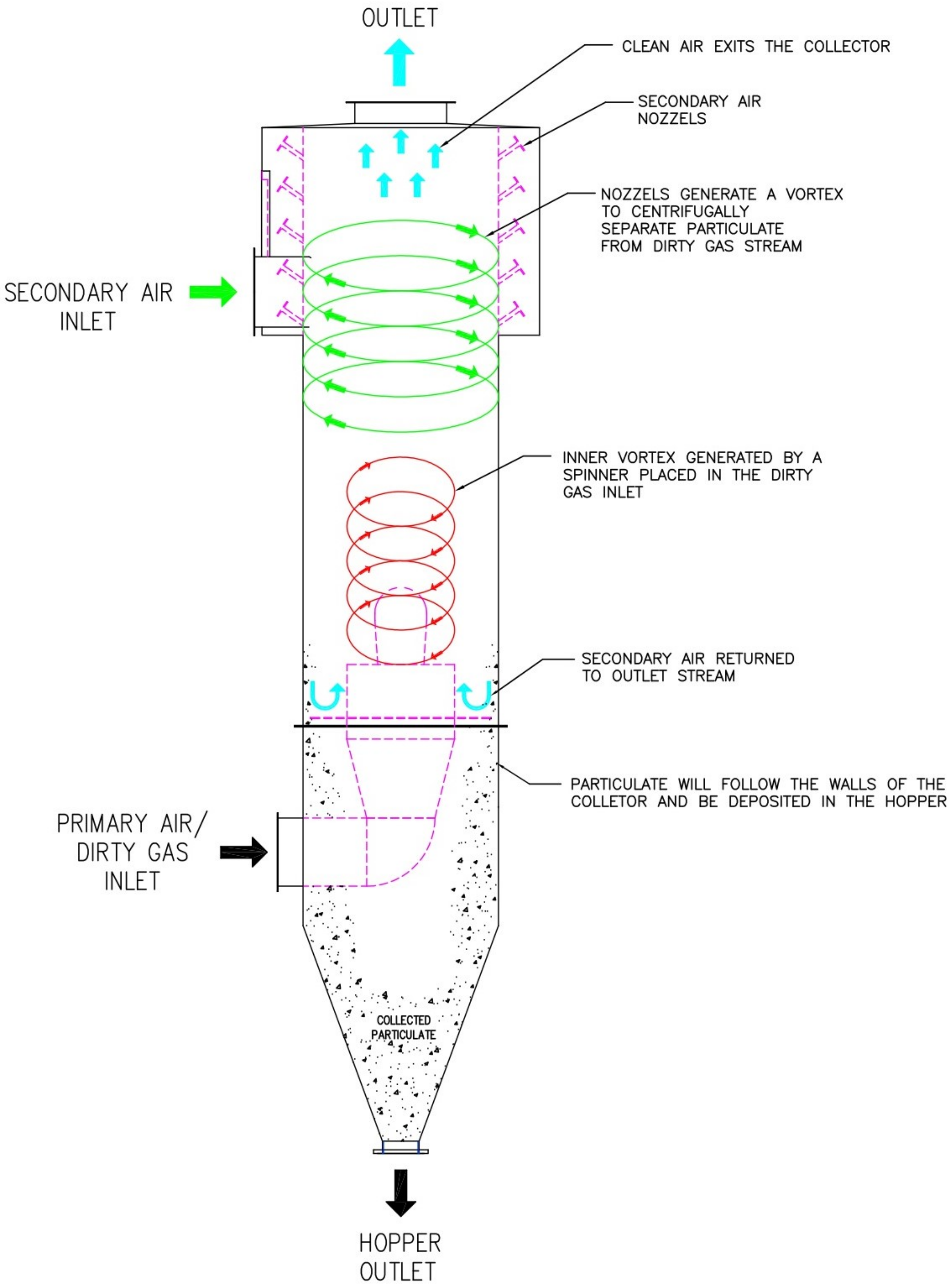

Figure 5.5: Cyclone separator[5]

Separation by Centrifugal Force:

As the gas spins, the heavier particles (solids and liquids) experience centrifugal force, causing them to move outward and toward the walls of the separator. These particulates lose their velocity due to friction and fall into a collection chamber at the bottom of the cyclone.

Clean Gas Exit:

The cleaned gas, now free of particulates, flows upward through the center of the vortex. **Application** Gas Cyclones are specifically used in the boiler exhaust system to remove ash, soot, and other solid pollutants generated during fuel combustion. The boiler at VBNPL, which operates using husk briquettes and wood, produces exhaust gases containing a significant amount of ash and fine particles. The cyclonic separator ensures that these pollutants are captured before the exhaust gases are vented into the atmosphere. This reduces the environmental impact of the boiler's emissions, ensuring compliance with emission standards and reducing air pollution.

CHAPTER 6:
WATER TREATMENT PLANT

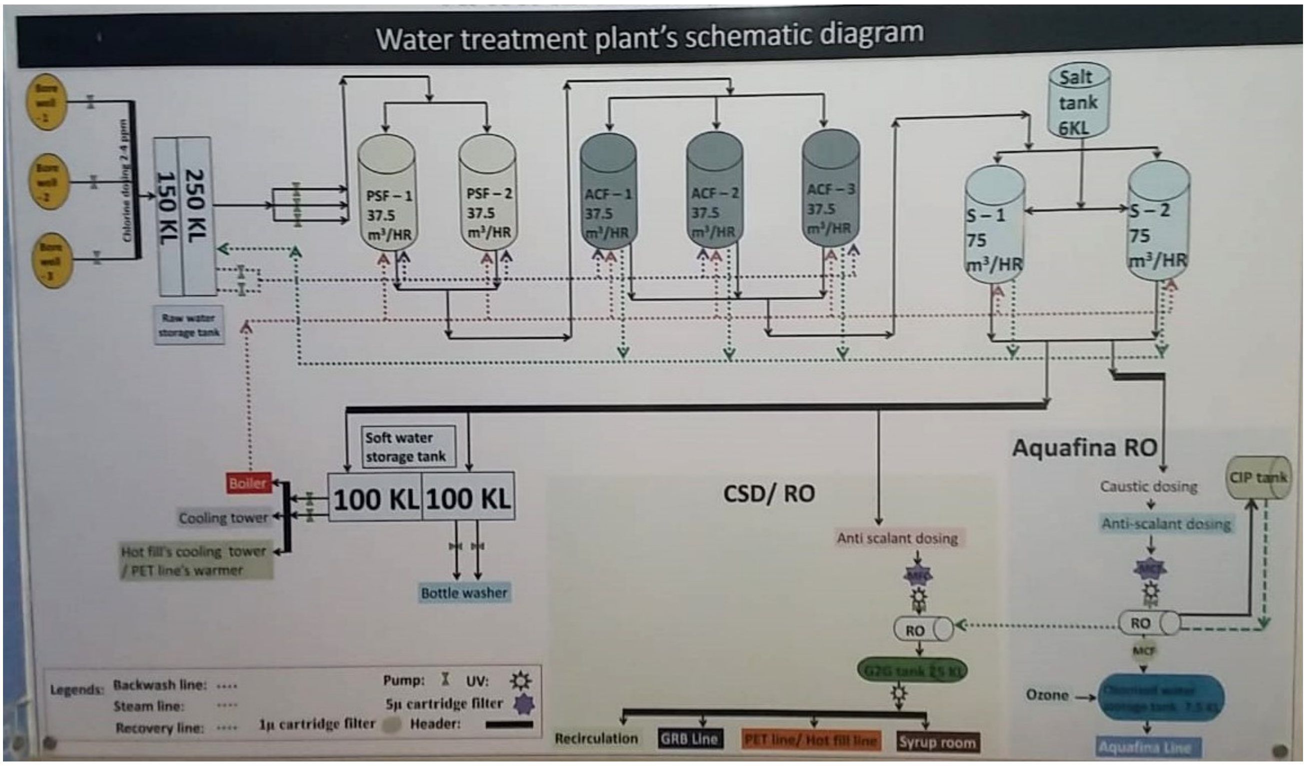

Figure 6.1: WTP schematic diagram

6.1 Overview

The water treatment process shown in this diagram is used to treat raw water and produce high-quality water for various uses such as bottle washing, syrup making, RO (Reverse Osmosis) systems, and other production processes at Varun Beverages Nepal Pvt. Ltd. The plant consists of different stages, tanks, filters, and dosing systems to treat and condition the water.

6.2 Key Components and Processes

6.2.1 Raw Water Storage Tank (250 KL and 150 KL)

In this plant there are altogether five deep boring as a source of raw water among which only three have got permission for use. This is where untreated water is stored before entering the treatment process. The tank ensures that there is a continuous supply of raw water available for the system. Raw water is chlorinated at the inlet to control microbial contamination, with a dosage rate of 2–4 grams per liter (g/m³).

6.2.2 Pressure Sand Filters (PSF-1 and PSF-2)

Capacity: 37.5 m³/hr each.
These filters remove suspended solids, dirt, and larger particles from the raw water. Sand is the primary

filtering media, and it ensures the first stage of water purification.

6.2.3 Activated Carbon Filters (ACF-1, ACF-2, ACF-3)

Capacity: 37.5 m^3/hr each.
The filtered water then passes through activated carbon filters, which help remove chlorine, organic compounds, and any residual odors or taste. This is important for both aesthetic reasons and for protecting downstream equipment from chlorine damage.

6.2.4 Soft Water System (S-1 and S-2)

Capacity: 75 m^3/hr each.
Softening involves removing hardness-causing ions (such as calcium and magnesium) from the water. This is accomplished through an ion-exchange process where hard ions are replaced with sodium ions. The salt tank (6 KL) provides the brine solution for the regeneration of the ion-exchange resins in the softeners.

6.2.5 Soft Water Storage Tanks (100 KL each)

After the water has been softened, it is stored in soft water tanks, ensuring an adequate supply for various production processes like bottle washing and blending.

6.2.6 Boiler and Cooling Tower System

The boiler, connected to the soft water storage, uses the softened water for steam generation. The cooling tower cools the hot water coming from the condenser by sprinkling it from a height, allowing heat to dissipate via convection using atmospheric air. This steam is used for various applications, such as hot fill operations and PET line's warmer.

6.2.7 Bottle Washer

This system uses treated soft water for cleaning and rinsing bottles before they are filled. The water is free of hardness, which prevents scaling and ensures proper hygiene of the bottles.

6.2.8 Reverse Osmosis (RO) System for CSD and Aquafina Line

CSD/RO (Carbonated Soft Drink/Reverse Osmosis):

Anti-scalant dosing is used to prevent scaling in the RO membrane. RO filters water at a molecular level, removing dissolved salts, impurities, and contaminants to produce high-quality water for making carbonated soft drinks (CSD).

Aquafina RO System:

There is a separate RO process specifically for the production of Aquafina bottled water. The water undergoes caustic dosing and anti-scalant dosing to protect the RO membrane. After treatment, the water is ozonated (disinfection with ozone) to ensure its purity and to prevent microbial growth.

6.2.9 CIP Tank (Cleaning In Place)

This tank is used for cleaning and maintaining the RO system by circulating cleaning chemicals through the system without the need for disassembly. It ensures the RO membranes remain clean and efficient over time.

6.2.10 G2G Tank (2.9 KL)

This is part of the RO system, used to store high-quality treated water before it is sent to the production line.

6.3 Recirculation and Dosing Systems

Anti-scalant Dosing:

This process involves adding chemicals to prevent scaling, which can damage equipment like RO membranes. Scaling occurs when dissolved minerals precipitate out of the water and form deposits.

Caustic Dosing:

Used to adjust the pH of the water, particularly before the RO process, to prevent damage to the membranes and ensure effective filtration.

6.4 Color-coded Sections

Red Line:

Indicates the steam line from the boiler to various parts of the plant.

Blue Line:

Represents water recirculation, ensuring continuous water supply to processes such as the PET line, hot fill line, syrup room, and Aquafina line.

Green Line:

Indicates backwash lines used for cleaning the filters.

CHAPTER 7:
EFFLUENT TREATMENT PLANT

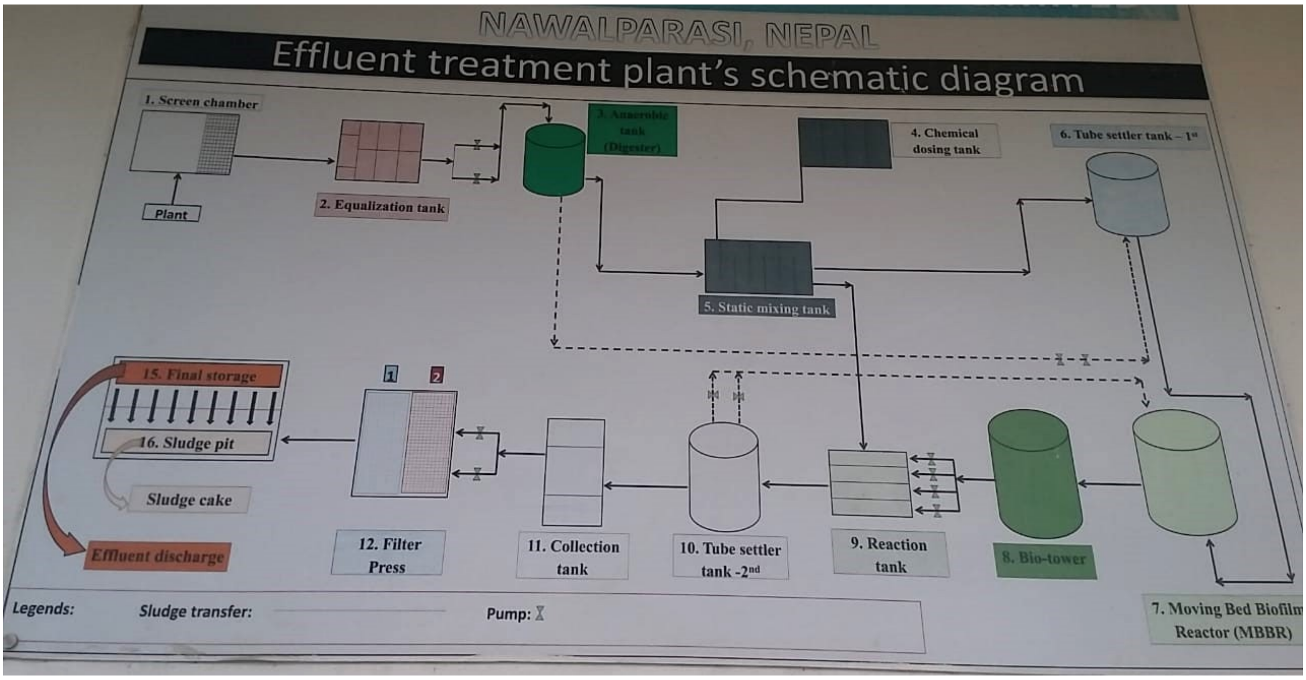

Figure 7.1: ETP schematic diagram

This schematic diagram presents the effluent treatment process at VBNPL , located in Nawalparasi, Nepal.The effluent treatment plant at VBNPL incorporates multiple stages of mechanical, chemical, and biological processes to treat wastewater efficiently. It ensures that the effluent meets regulatory discharge limits and minimizes the environmental impact of industrial operations.

7.1 Screen Chamber

The first step in the effluent treatment process is screening. The screen chamber helps in removing large solid particles and debris from the wastewater. These materials could clog downstream equipment, so this initial step is crucial for preventing operational issues.

7.2 Equalization Tank

After the screening, the wastewater is collected in an equalization tank. This tank helps in balancing the flow rate of the incoming effluent and ensures a consistent concentration of pollutants. Equalization is critical to provide a steady flow to the downstream processes, which otherwise could be disturbed by fluctuations in effluent composition.

7.3 Anaerobic Tank (Digester)

The anaerobic tank, also known as a digester, is used for the breakdown of organic materials in the absence of oxygen. In this tank, microorganisms break down biodegradable material in the wastewater, resulting in biogas production. Anaerobic digestion is an efficient way to reduce the organic load before further treatment.

7.4 Chemical Dosing Tank

In this stage, chemicals such as coagulants and flocculants are added to the wastewater. This step aids in the aggregation of smaller particles into larger flocs, making it easier for them to settle out in subsequent stages.

7.5 Static Mixing Tank

The static mixing tank allows for thorough mixing of the wastewater with the chemicals introduced in the dosing tank. This ensures optimal contact between the chemicals and the contaminants, enhancing the coagulation and flocculation processes.

7.6 Tube Settler Tank (1st Stage)

The first tube settler tank separates the coagulated floc material from the wastewater. The tube settler design maximizes the settling surface area, allowing for more efficient sedimentation of solids. This tank produces clearer effluent, which is then passed on to the next stages for further purification.

7.7 Moving Bed Biofilm Reactor (MBBR)

The MBBR is a biological treatment process where microorganisms grow on small plastic carriers that are suspended in the reactor. The biofilm developed on these carriers degrades organic pollutants. This system is highly efficient for removing biological oxygen demand (BOD) and other organic contaminants.

7.8 Bio-Tower

The bio-tower is another biological treatment unit. Here, wastewater trickles down over a medium where microorganisms are growing. These microorganisms further degrade organic pollutants, ensuring the effluent is even cleaner before it enters the final treatment stages.

7.9 Reaction Tank

In this tank, additional reactions might take place, such as chemical precipitation, pH adjustment, or further oxidation of pollutants. This step is crucial for adjusting the chemical properties of the effluent to meet discharge standards.

7.10 Tube Settler Tank (2nd Stage)

A second tube settler tank further clarifies the wastewater by allowing additional solids to settle out. The remaining suspended particles are removed here before the effluent moves into the final stages of filtration.

7.11 Collection Tank

The collection tank temporarily holds the effluent after it has passed through the second tube settler. This tank acts as a buffer for the final filtration process.

7.12 Filter Press

The filter press removes any remaining suspended solids from the effluent. It is a mechanical dewatering process where water is pressed out of the sludge, leaving behind a solid ”cake” of concentrated waste material. This reduces the volume of waste and prepares it for disposal.

7.13 Final Storage

The treated effluent is stored in this final storage unit before discharge or reuse. This step allows for any remaining suspended solids to settle out further and ensures that the effluent meets environmental discharge standards.

7.14 Sludge Pit

The sludge pit is where the sludge, a byproduct of the treatment process, is stored temporarily. The sludge is further dewatered to form a sludge cake. This sludge cake can be disposed of or repurposed depending on the type of waste it contains.

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