TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
PULCHOWK CAMPUS

INDUSTRIAL ATTACHMENT AT GORKHA BREWERY PVT. LTD.

SUBMITTED BY:
SAROJ BASNET (077BME037)

An Industrial Attachment Report Submitted to the Department of Mechanical and Aerospace Engineering in Partial Fulfillment of the Requirements for the Bachelor's Degree in Mechanical Engineering

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING
PULCHOWK CAMPUS
PULCHOWK, LALITPUR

November 2024

ABSTRACT

This internship report provides a comprehensive overview of my one-month experience as a mechanical engineering intern at Gorkha Brewery Pvt. Ltd., integrating theoretical knowledge from a mechanical engineering education at IOE Pulchowk Campus with practical experience in the brewing industry, focusing on utility systems, production processes, and organizational management. The internship provided a valuable opportunity to bridge theoretical knowledge with practical industry applications within a fast-paced manufacturing environment. Key activities included equipment auditing, plant layout design, loss analysis, and technical documentation, all contributing to improved operational efficiency. The report highlights critical systems such as boiler operations, chilling plants, water treatment facilities, CO_2 recovery, and effluent management, which collectively ensure sustainable and high-quality production. Insights into brewing and packaging processes, along with stringent quality control measures, are also discussed. Additionally, the experience provided an understanding of the brewery's management hierarchy, illustrating how structured leadership and interdepartmental coordination drive efficiency and operational success. Despite challenges such as time constraints and limited access to long-term projects, the internship significantly enhanced technical expertise, problem-solving abilities, and professional skills. This attachment offered a holistic perspective on the applications of mechanical engineering in the beverage industry and prepared the groundwork for future challenges in the field.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to the Department of Mechanical and Aerospace Engineering, IOE, Pulchowk Campus, for providing me with the opportunity to participate in an industrial attachment. This experience has greatly enhanced my understanding of both technical and managerial aspects of mechanical engineering. I am especially grateful to Dr. Sudip Bhattrai, Head of Department, for facilitating this opportunity, and to Er. Laxman Motra, Deputy Head of Department, for his invaluable support and guidance. I also extend my thanks to Ms. Yashoda Adhikari for assisting with the internship's formal procedures. I would also like to express my appreciation to the Society of Mechanical and Aerospace Engineering Students (SOMAES) for their invaluable assistance throughout the application process.

I am deeply grateful to the entire team at Gorkha Brewery Pvt. Ltd. for accepting my internship application. I would like to convey my immense gratitude to Ms. Arati Bista, Manager, HR & Admin, for her support and guidance. I extend my sincere appreciation to Mr. Kosish Gaihre for his unwavering guidance and support throughout the internship. His exceptional mentorship, constant encouragement, and attentive supervision have been instrumental in my development, and I am profoundly grateful to him. I would also like to extend my gratitude to Mr. Swatantra Ghimire, Mr. Krishna Budathoki, Mr. Ramesh Lamichhane, and all the staff members for challenging me to think critically. Their valuable insights have made this experience both enjoyable and enlightening.

Finally, I am incredibly thankful to my friend Aashish Katwal for helping me secure this internship, as well as to all my friends and seniors who provided valuable suggestions during my internship and while preparing this report.

Saroj Basnet
077BME037

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ABV	Alcohol By Volume
ACF	Activated Carbon Filter
AE	Apparent Extract
BBT	Bright Beer Tank
BU	Bitterness Units
CCP	Critical Control Point
CFVs	Cylindrical Fermentation Vessels
CIP	Clean-In-Place
COD	Chemical Oxygen Demand
CO_2	Carbon Dioxide
DMS	Dimethyl Sulfide
EBI	Empty Bottle Inspection
ETP	Effluent Treatment Plant
GBPL	Gorkha Brewery Private Limited
HACCP	Hazard Analysis and Critical Control Points
HPJ	High-Pressure Jet
IOE	Institute Of Engineering

MRP	Maximum Retail Price
OE	Original Extract
OWMC	Operating Water Module Compact
PLC	Programmable Logic Controller
PU	Pasteurization Unit
RDF	Real Degree of Fermentation
RGB	Return Glass Bottle
RO	Reverse Osmosis
SMBS	Sodium Meta BiSulphite
SOP	Standard Operating Procedure
TDS	Total Dissolved Solids
UASB	Upflow Anaerobic Sludge Blanket
VCR	Vapor Compression Refrigeration
VDK	Vicinal Diketones
VOCs	Volatile Organic Compounds
WIP	Work IN Progress
WTP	Water Treatment Plant
YCRs	Yeast Cropping Reserves
YPTs	Yeast Propagation Tanks

CHAPTER 1: INTRODUCTION

1.1 Scope of Internship

Internships are essential for students to bridge the gap between academic theory and practical experience in a professional setting. They provide a platform to apply engineering concepts, enhance problem-solving skills, and gain exposure to industry practices. At Gorkha Brewery Pvt. Ltd., the one-month internship in the utility department was a valuable opportunity to engage with real-world challenges in a high-paced manufacturing environment.

The scope of this internship encompassed designing efficient plant layouts, conducting equipment audits, documenting essential machine parts, and performing loss analysis to improve overall system efficiency. Working alongside experienced professionals fostered the development of communication and interpersonal skills, which are critical for a successful engineering career. This experience not only broadened my technical understanding but also prepared me for future challenges in the field of mechanical engineering.

Position: Mechanical Engineering Intern
Working duration: 30 days
Working hours: 9 AM to 5 PM
Location: Gaidakot-10, Mukundapur, Nawalpur
Internship Supervisor: Kosish Gaihre, Engineering Manager

1.2 Objectives of Internship

1.2.1 Main Objective

To undertake an internship at Gorkha Brewery Pvt. Ltd. and get technical and managerial insights of an industry.

1.2.2 Specific Objectives

1. To draw plant layouts to display to visitors and new workers.

2. To perform audits of equipment to assess performance and identify areas for

improvement.

3. To investigate and quantify equipment losses and propose practical solutions to minimize them.

4. To get knowledge about the flow of command in an industry.

5. To develop professional skills, such as communication and teamwork, through active collaboration with supervisor and colleagues.

1.3 Limitations of Internship

1. The internship coincided with the peak demand period around Dashain, making supervisors and staff busier than usual.

2. The one-month duration limited opportunities to engage deeply with long-term projects.

3. The experience was confined to the utility department, restricting exposure to other functional areas within the brewery.

4. Some analyses were constrained due to limited access to historical performance data and specialized equipment.

5. There were few opportunities to interact with clients or external stakeholders, limiting exposure to the business aspects of operations.

CHAPTER 2: COMPANY PROFILE AND MANAGEMENT FRAMEWORK

2.1 Company Background

Gorkha Brewery was founded in 1989 as a partnership between the Khetan Group and IFU, Danbrew Denmark. It has grown to become a major player in Nepal's beverage industry. The Khetan Group managed the brewery completely until March 2011, when the Carlsberg Group took over most of the shares, while the Khetan Group still handles local operations. Gorkha Brewery offers a variety of brands, including Tuborg, Carlsberg, Tuborg Strong, San Miguel, and the popular local brand, Gorkha. They have also added non-beer products like Somersby Apple Cider and Himalayan Dragon to meet changing consumer preferences [9]. Known for being innovative, Gorkha Brewery leads the market with a range of products from premium to strong beers and is a significant contributor to Nepal's economy.

2.2 Organization Profile

SN	Category	Details
1	Company Name	Gorkha Brewery Pvt. Ltd
2	Parent Company	Carlsberg Group Management
3	Website	www.gorkhabrewery.com
4	Industry	Food and Beverages
5	Location	Mukundapur, Nawalpur
6	Type	Privately Held
7	Founded	1989 AD

Table 2.1: Organization Profile

2.3 Products of the company

The wide range of products manufactured and sold by Gorkha Brewery solely are listed.

SN	Name	Beer Type	ABV	Origin
1	Carlsberg	Pale Pilsen	5%	Denmark
2	Tuborg Gold	Lager	5.5%	Denmark
3	Tuborg Strong	Lager	6.5%	Nepal
4	San Miguel	Pale Pilsen	5%	Philippines
5	Gorkha	Lager	5%	Nepal
6	Gorkha Craft	Craft	5%	Nepal
7	Gorkha Extra Strong	Lager	8%	Nepal
8	Gorkha Strong	Lager	6%	Nepal
9	Somersby Apple Cider	Cider	4.5%	Denmark

Table 2.2: Products of the Company [8]

2.4 Plant Layout

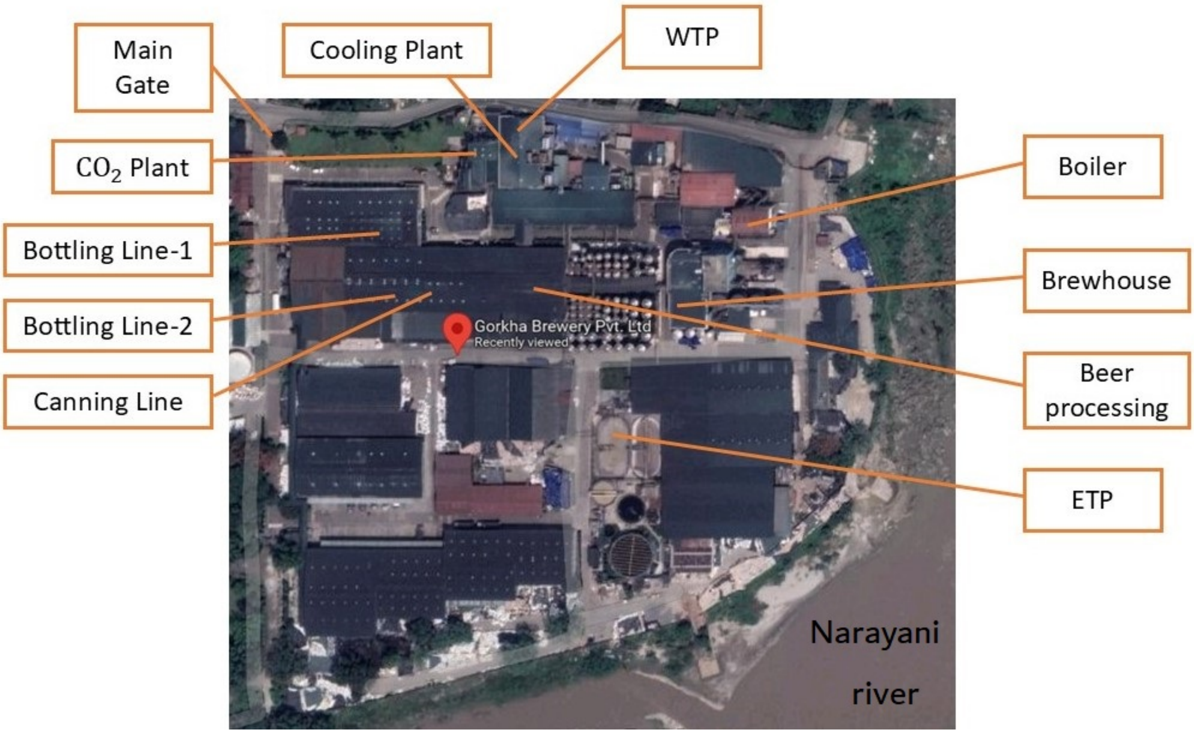

Figure 2.1: Plant Layout of Gorkha Brewery (adapted from Google Maps)

2.5 Organization Structure

The core operations of the brewery are divided into key functional areas. The Production Manager oversees the brewing, fermentation, and packaging processes to ensure quality and efficiency in production. The Utility Manager is responsible for managing critical systems such as energy, water treatment, and cooling, ensuring that the brewery operates with optimal resource utilization. The Quality Assurance Manager ensures that all products meet the required quality standards, supported by Lab Technicians who perform regular testing.

The Maintenance Manager ensures that all machinery and equipment are properly maintained to prevent downtime. Operational tasks such as inventory management and product distribution are handled by Warehouse Workers. This structured hierarchy allows for streamlined communication and efficient problem-solving, enabling Gorkha Brewery to maintain high standards of production and meet market demands effectively.

At Gorkha Brewery, individuals working on a contract basis are involved in a range of essential support functions that help ensure smooth operations. These workers are typically contracted for tasks such as the transportation of raw materials and finished products, playing a crucial role in maintaining the supply chain. Additionally, contractors are often hired to install new machinery, perform regular maintenance, or handle specific repairs that require specialized skills. These workers are not permanent employees of the brewery but are critical to maintaining operational efficiency. Though their roles are temporary, they are integral to the brewery's ability to meet production demands, ensure timely deliveries, and keep equipment running smoothly, all of which contribute to the overall productivity and success of the brewery.

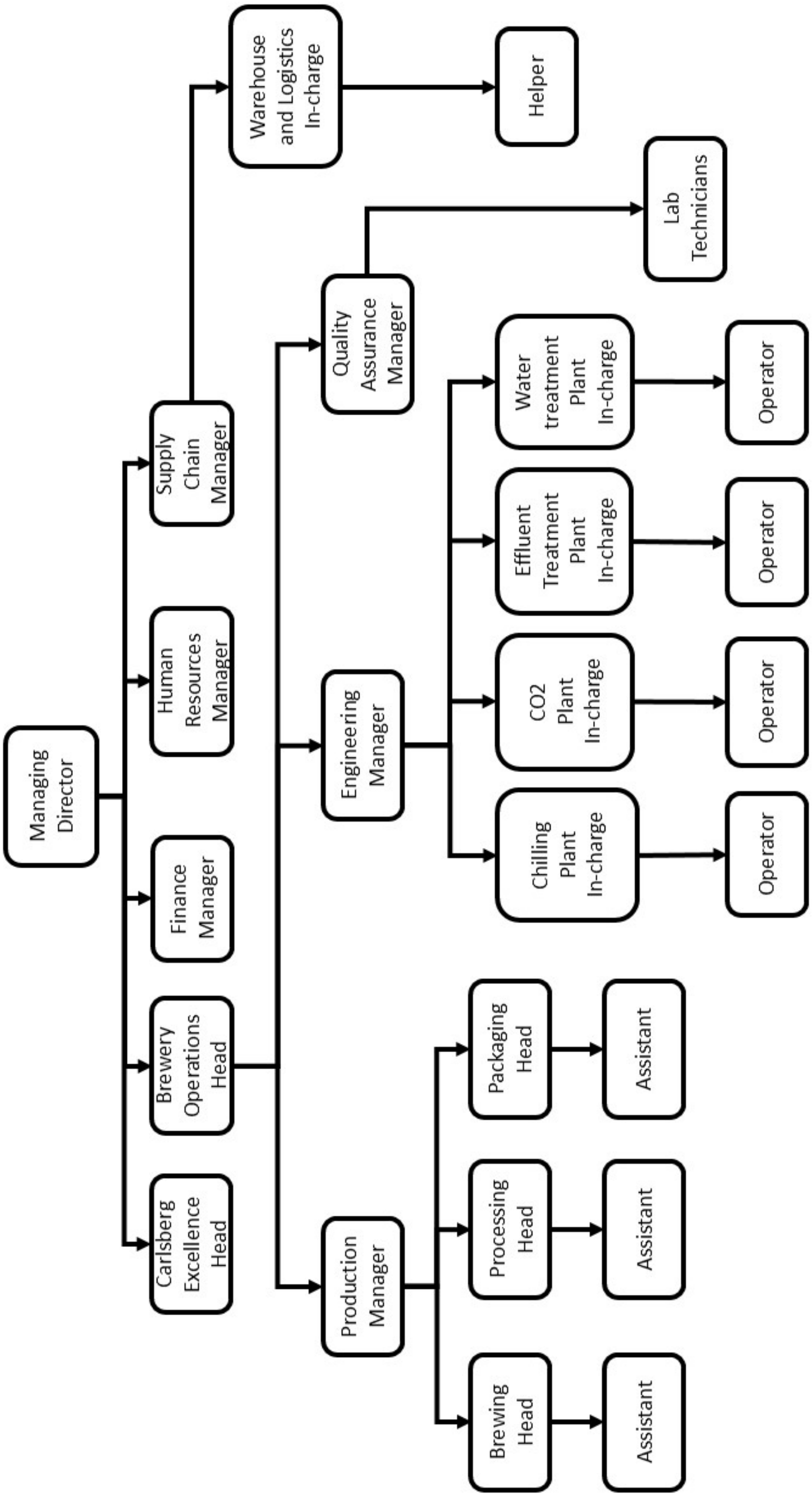

Figure 2.2: Organizational Structure of Gorkha Brewery Pvt. Ltd.

CHAPTER 3: OVERVIEW OF UTILITY SECTION

3.1 Boiler Plant

At Gorkha Brewery, steam is essential in multiple factory processes, particularly in the brew house, packaging, and filler operations as shown in figure below. The necessary steam for these functions is generated using two main types of boilers.

3.1.1 Husk Boiler

The husk boiler utilizes husk as its primary fuel. There are two types of husk boilers employed in the factory:

- **Fire Tube Boiler**: Hot flue gases pass through tubes that are surrounded by water.
- **Water Tube Boiler**: Water flows through tubes surrounded by hot flue gases.

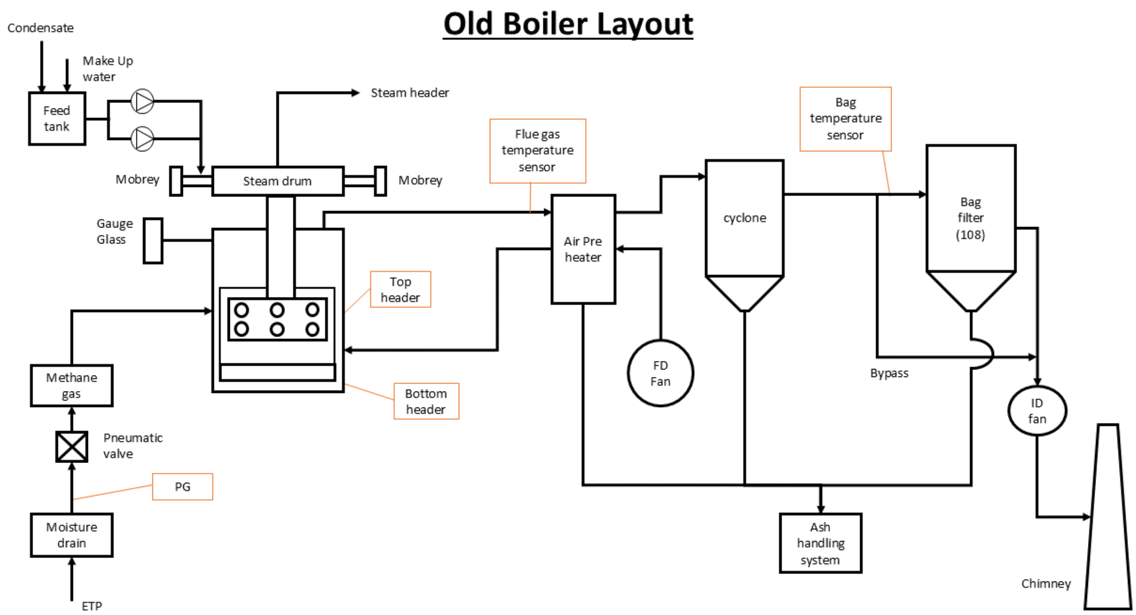

Figure 3.1: Water-tube Boiler Layout

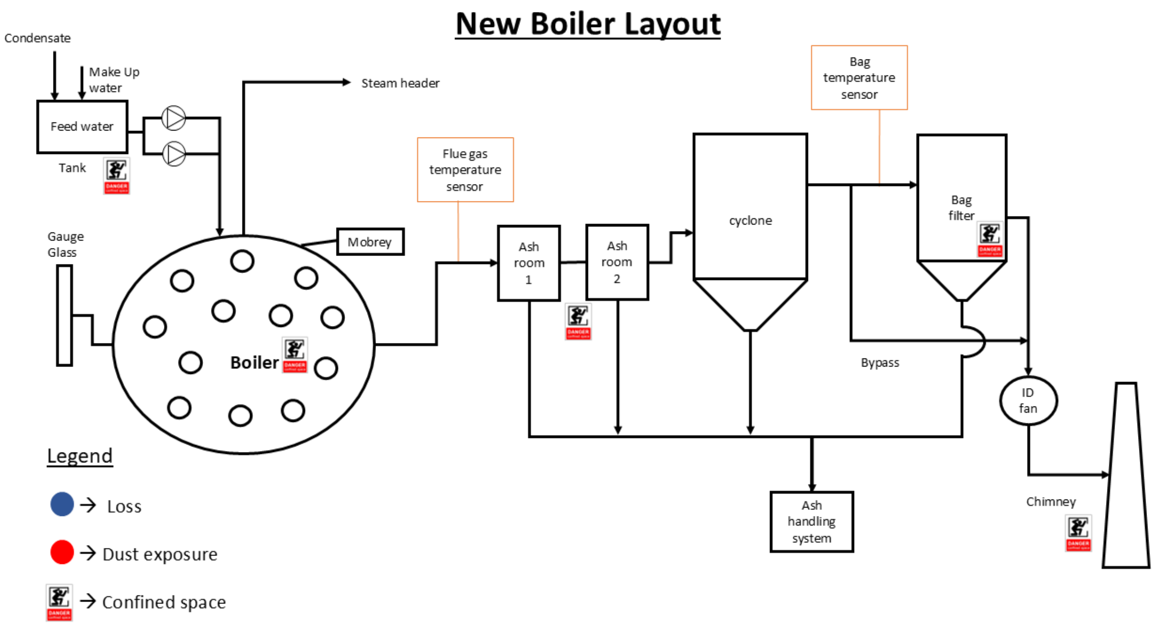

Figure 3.2: Fire-tube Boiler Layout

3.1.2 Oil-Fired Boiler

The oil-fired boiler operates using furnace oil as its fuel. It ensures the continuous supply of steam required for various brewery operations.

Both the husk and oil-fired boilers run 24 hours a day, 7 days a week, maintaining a constant supply of steam to support production needs.

3.1.3 Husk Transfer

After being screened, the husks are blown from the storage area to silos. From there, they are transferred to a hopper using a bucket elevator.

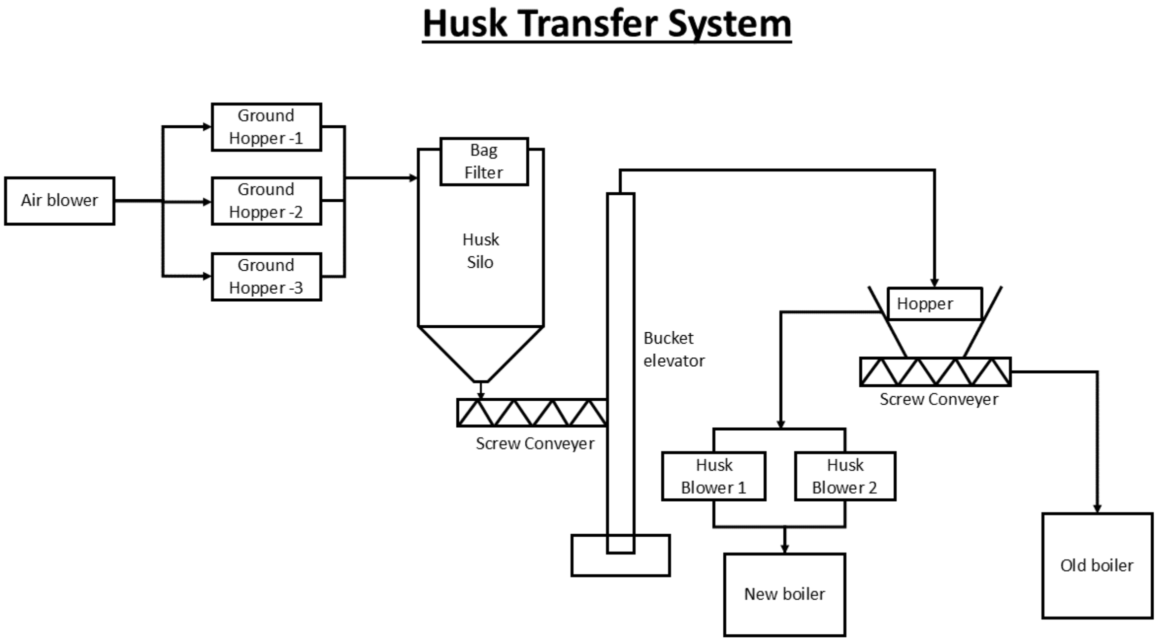

Figure 3.3: Husk Transfer System Layout

3.1.4 Water Tube Boiler

A water tube boiler works by passing water through tubes, which are heated by gases from burning fuel outside the tubes. The heated water rises to a steam drum where it turns into steam. These boilers are safer and more efficient than fire tube boilers because they transfer heat more quickly and can produce steam at higher temperatures and pressures. This particular water tube boiler can produce 5000 kg of steam per hour, which is used in the brewhouse and packaging sections.

3.1.5 Fire Tube Boiler

A fire tube boiler heats water by passing hot gases from burning husk through tubes surrounded by water. This heat causes the water to boil and turn into steam. The steam is stored in a steam drum and later used in the brewhouse and packaging areas. Ash from the burning husk is removed by the ID fan and sent through a cyclone separator and bag filter to remove any residue before the clean smoke is released through the chimney. This fire tube boiler can also produce 5000 kg of steam per hour, just like the water tube boiler.

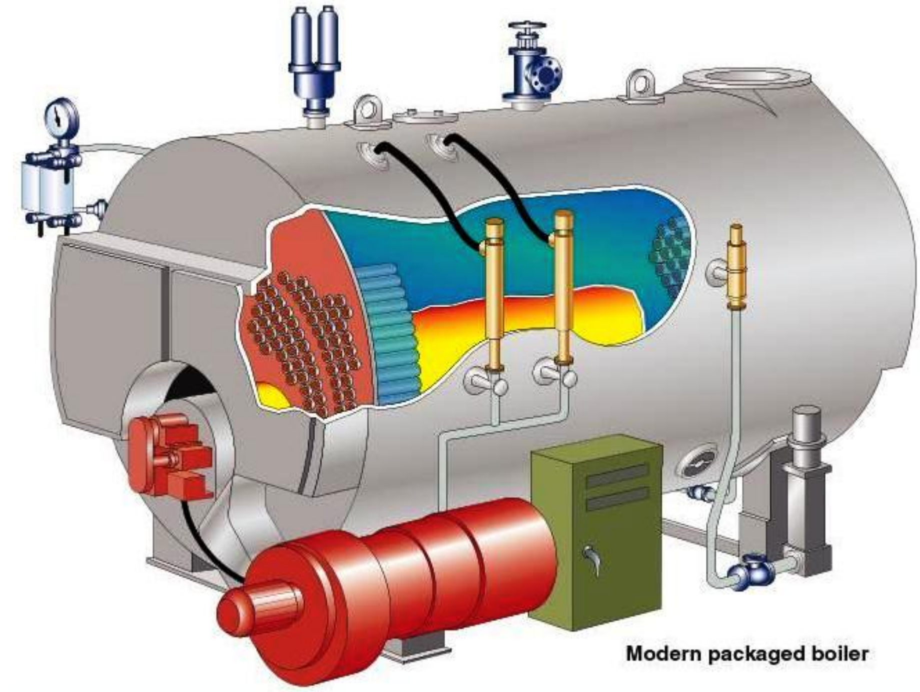

Figure 3.4: Fire Tube Boiler [1]

Some components of boiler are:

3.1.6 Steam Header

The steam header is made up of 20×21 tubes filled with water. The lower section of the header has tubes that are slightly tilted, where burning husk heats the water. To start the firing, a mixture of 50 kg sand and 20 kg coal is mixed with diesel. The lower part is connected to a drum for feeding water and steam recirculation. Both FD and ID fans are used during this process. The steam produced goes through a cycle of recirculation until it becomes superheated or reaches a temperature of 150°C.

3.1.7 Steam Drum

In the water tube boiler, the steam drum helps separate steam and water. As the water heats up in the tubes, steam rises through riser tubes to the steam drum. Inside the drum, a baffle system prevents water droplets from mixing with the steam. The water returns to the tubes, and the steam flows out through the outlet. The steam drum includes safety valves, a water-level indicator, and a level controller to ensure smooth operation.

3.1.8 Air Pre Heater

The air preheater is used to preheat the air needed for burning fuel in the boiler. It works by transferring heat from the flue gas to the air. The flue gas moves through hollow tubes while air circulates outside the tubes, heating up as it passes. This also helps remove any moisture from the air. The FD fan is used to blow the preheated air into the combustion chamber.

3.1.9 Purification of Flue Gas

After combustion, ash-laden air is pulled by an ID fan through the air preheater and into a cyclone separator. The cyclone creates a vortex, separating heavier dust particles. The remaining fine particles are then filtered out using a bag filter, ensuring the smoke released through the 35-meter-tall chimney is clean and free of dust.

3.2 Glycol Chilling Plant

The glycol cooling plant is a critical component in various industries, including food processing, pharmaceuticals, and brewing. In the brewing process, the glycol chilling system is essential for controlling the fermentation temperature, stabilizing yeast activity, and ensuring product quality. The plant operates using a Vapor Compression Refrigeration (VCR) system, with ammonia as the refrigerant due to its efficiency and environmental benefits.

3.2.1 Main components of glycol chilling plant:

- **Compressor:** The compressor is the heart of the refrigeration system, where low-pressure refrigerant vapor is compressed into high-pressure, superheated vapor. This pressurized vapor is then directed to the condenser.

- **Condenser:** In the condenser, the refrigerant releases its heat to the surroundings, resulting in a phase change from a high-pressure vapor to a high-pressure liquid. The efficiency of heat exchange in the condenser significantly influences the system's overall performance.

- **Expansion Valve:** The high-pressure liquid refrigerant is throttled in the expansion valve, causing a significant drop in temperature and pressure. This prepares the refrigerant for heat absorption in the evaporator.

- **Evaporator:** The evaporator is where the low-pressure refrigerant absorbs heat from its surroundings, typically the glycol solution. The heat absorption causes the refrigerant to evaporate, completing the cycle. The chilled glycol is then circulated to the brewing tanks to maintain the desired temperature.

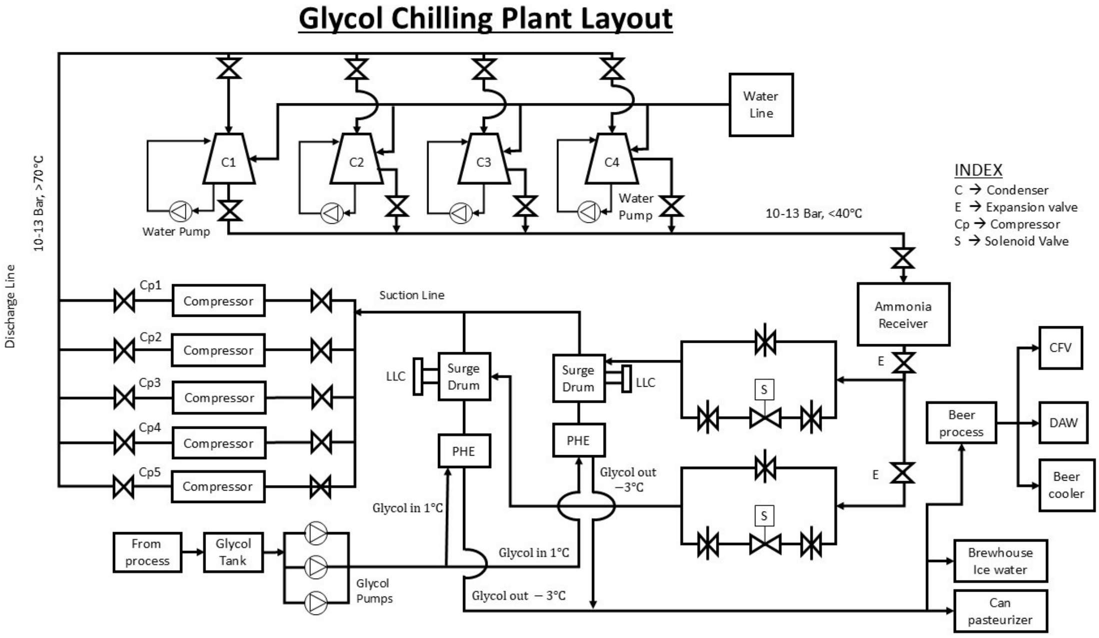

Figure 3.5: Glycol Chilling Plant Layout

3.2.2 Glycol Storage Drum

The Glycol used in the system is stored in a large 27,000L drum. The mixture contains 13% glycol and 87% water, and the solution is diluted by 33%. The glycol temperature is kept between -1°C to 2°C.

3.2.3 Glycol Feed Pump

Three centrifugal pumps are used to transfer glycol between the storage drum and heat exchanger. These pumps are automated and maintain a pressure of 2.8 to 3.2 bar, though pressure may drop during circulation.

3.2.4 Ammonia Surge Drum

The ammonia surge drum balances pressure and stores extra ammonia when cooling demand is low. It prevents liquid ammonia from reaching the compressor, which could cause damage. The drum separates liquid ammonia at the bottom and vapor at the top, while cooling glycol in the heat exchanger.

3.2.5 Plate Heat Exchanger

Three plate heat exchangers use ammonia to cool glycol. This efficient design allows for better heat exchange. The glycol, cooled to 0°C to -2°C, flows counter to the ammonia, which cools to -6°C to -8°C before returning to the compressor.

3.2.6 Compressor

Compressors raise the pressure and temperature of ammonia. The pressure increases from 3.35-3.8 bar to 11-12 bar, and the temperature reaches 75°C. There are six compressors, but only four are used at a time.

3.2.7 Evaporative Cooling Tower

Ammonia is cooled by water and air in a tower, reducing its temperature to 32°C. Water evaporates, cooling the ammonia through a series of pipes, which are made from materials that conduct heat well.

3.2.8 Ammonia Receiver

The cooled ammonia is stored in a reservoir at 32°C and 11.74 bar before being sent to the expansion valve.

3.2.9 Expansion Valve

The expansion valve lowers the pressure of ammonia from 11-12 bar to 3 bar, dropping its temperature from 32°C to -10°C, which makes it effective for cooling glycol.

3.3 CO_2 Recovery Plant

At Gorkha Brewery, the CO_2 recovery plant plays a vital role in maintaining sustainability and reducing the overall carbon footprint. The plant is designed to recover carbon dioxide generated during fermentation and purify it for reuse in various stages of beer production, such as Bright Beer Tanks (BBT), beer processing, and packaging. The plant has two operating capacities: 500 kg/hr and 300 kg/hr, though the latter is currently non-functional. The recovered CO_2, with a high purity of 99.7-99.9%, is filtered and processed before it is recycled back into the system. Key Components and Processes of the CO_2 Recovery Plant are :

3.3.1 Foam Trap

The foam trap is the first stage of the recovery process. During fermentation, foam is produced along with CO_2. The foam trap captures and separates the foam to prevent it from contaminating the CO_2 stream. This is essential for maintaining the purity of the CO_2 and ensuring that no foreign materials enter the recovery process.

3.3.2 Water Scrubber

After the foam is removed, the CO_2 passes through a water scrubber. This unit removes additional impurities, including volatile organic compounds (VOCs) and residual fermentation gases. The water scrubber significantly enhances the quality of the CO_2 by ensuring that no undesirable contaminants make their way into the beer, which could otherwise affect the flavor and quality.

3.3.3 Particulate Separator

In this stage, the CO_2 is passed through a particulate separator, which operates using centrifugal force. The separator removes fine particulate matter from the gas stream, improving the purity of the CO_2. This step is critical for ensuring the quality of carbonation in the beer, as particulate matter can negatively affect the consistency and appearance of the beer's carbonation.

3.3.4 Moisture Separator

To prevent issues in the later stages of the recovery process, the moisture separator removes excess water vapor from the CO_2. Moisture in the CO_2 can cause operational problems in the CO_2 compressor and storage systems, leading to inefficiency or damage. The moisture separator ensures that the CO_2 remains dry and ready for further compression and storage.

3.3.5 Gas Holder Balloon

The gas holder balloon serves as an intermediate storage unit, where recovered CO_2 is temporarily stored before further processing. This storage unit ensures a consistent flow rate of CO_2 into the next stages of the process, stabilizing the supply of CO_2 to meet demand during peak and low production periods.

3.3.6 CO_2 Compressor with Cooler

After being stored, the CO_2 is compressed to reduce its volume, making it easier to handle and store. The CO_2 compressor is equipped with a cooler, which lowers the temperature of the gas during compression to avoid overheating. Cooling the CO_2 ensures that it retains its high purity level, as excessive heat could introduce impurities or cause unwanted chemical reactions.

3.3.7 CO_2 Pre-Cooler

Following the compression process, the CO_2 undergoes further cooling in the pre-cooler unit. This unit uses a glycol-based heat exchanger to lower the temperature of the gas even further, preparing it for liquefaction. This step is crucial for improving the efficiency of the CO_2 liquefaction process.

3.3.8 ACF Deodorizer and Dryer

The ACF (Activated Carbon Filter) deodorizer and dryer serve as a final purification stage before the CO_2 is liquefied. This unit removes any remaining impurities, such as odors or volatile compounds, from the CO_2 stream. The dryer also ensures that any residual moisture is eliminated, ensuring the CO_2 is of the highest quality before liquefaction.

3.3.9 CO_2 Chiller or Liquefying System

Once the CO_2 is fully purified, it is liquefied using a refrigeration cycle, with ammonia as the primary refrigerant. This process involves cooling the gas to sub-zero temperatures until it condenses into liquid form. Liquefied CO_2 is easier to store and transport and can be used more efficiently in various brewing processes.

3.3.10 CO_2 Reboiler

In certain applications, liquid CO_2 is converted back into vapor form using a CO_2 reboiler. This unit heats the liquid CO_2, causing it to vaporize. During this phase change, impurities that were previously dissolved in the liquid CO_2 are separated and removed. This ensures that only the purest CO_2 vapor is reused in beer processing and packaging.

3.3.11 CO_2 Storage Bullet Tank

The liquefied CO_2 is stored in specialized bullet tanks under pressure. These tanks are designed to maintain the CO_2 in liquid form until it is needed for further use in the brewery. The storage system is crucial for ensuring that a constant supply of pure CO_2 is available to meet production demands.

3.3.12 CO_2 Evaporator

Finally, the CO_2 evaporator converts liquid CO_2 back into vapor form when needed for specific processes such as carbonation in beer processing, bottling, and packaging. This controlled phase transition ensures that the CO_2 remains at optimal purity and quality for direct use in beer production.

3.4 Water Treatment Plant: Reverse Osmosis

The Reverse Osmosis (RO) water treatment system is essential for ensuring high-quality water used in various production processes. The system purifies water by applying pressure to force water molecules through a semipermeable membrane, effectively removing impurities and contaminants. Below are the detailed components and steps of the process:

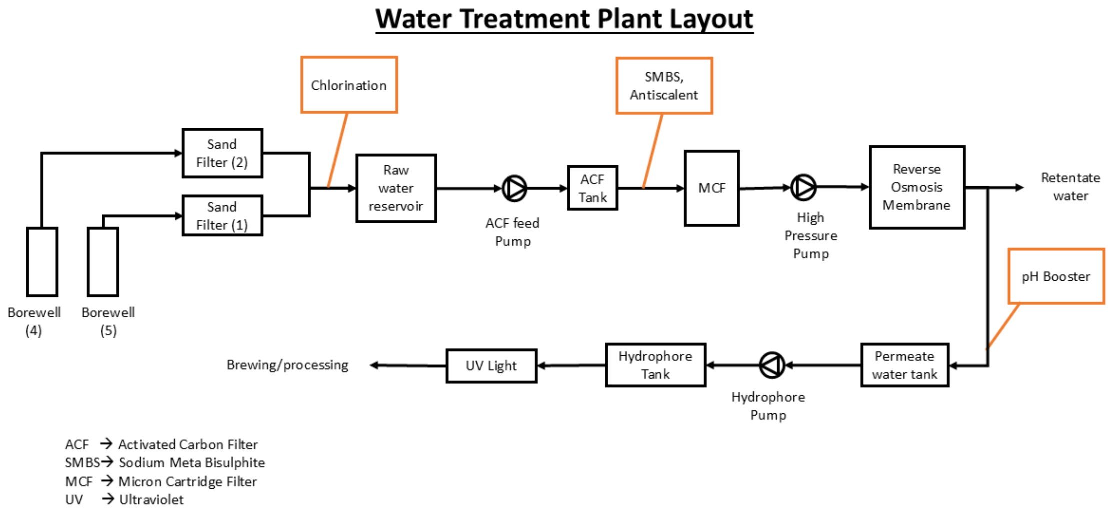

Figure 3.6: Water Treatment Plant Layout

3.4.1 Borewell

Water is drawn from borewell 4 and 5 to the RO plant at a rate of 45 m³/hr, sourced from a depth of 90 meters.

3.4.2 Sand Filter

Water flows through a sand filter tank designed to remove impurities. It operates at a capacity of 50 m³/hr and maintains a pressure of 1 bar. The backwash process, which takes 20-25 minutes, cleans the filter every 24 hours.

3.4.3 Raw Water Tank

Purified water from the sand filter is stored in a 100 m³ cylindrical tank. Chlorine is added here before transferring the water to the Activated Carbon Filter using two centrifugal pumps at 0.65 bar pressure.

3.4.4 Activated Carbon Filter

This filter contains activated carbon that removes chlorine and harmful compounds from the water. It operates at a flow rate of 50 m³/hr and 2 bar pressure, reducing trihalomethanes

(THMs) to below 10 ppb and chlorine to undetectable levels. Backwashing helps maintain the carbon's effectiveness.

3.4.5 Micron Cartridge Filter

A 17-micron filter prepares the water before it reaches the cartridge filter. Antiscalant is added to prevent scaling, while SMBs are used to neutralize chlorine. The system operates at an outlet pressure of 1.2 bar.

3.4.6 RO System

In the reverse osmosis (RO) process, water is pressurized at 10 bar and passed through two stages of filters. The permeate (clean water) is collected, while the retentate (impurities) is discarded. pH is regulated with a booster as needed.

3.4.7 Permeate Tank

The purified water is stored in a 100 m^3 tank before being sent to the hydrophore tank using three centrifugal pumps.

3.4.8 Hydrophore Tank

This tank maintains consistent water pressure of 4.5 bar, ensuring a steady water supply when needed.

3.4.9 UV Light

Lastly, UV light disinfects any remaining pathogens in the water. The final product has a pH of 6.6 to 6.9 and a hardness level of 10 to 15 parts per million, making it safe for use in brewing and other processes.

3.5 Water Treatment Plant: Softener Plant

A water softening plant is designed to remove hardness from water, which is caused mainly by minerals like calcium and magnesium. Hard water can create problems like scale buildup in pipes and appliances, leading to decreased efficiency and higher maintenance costs. The goal of the plant is to make water softer and easier to use.

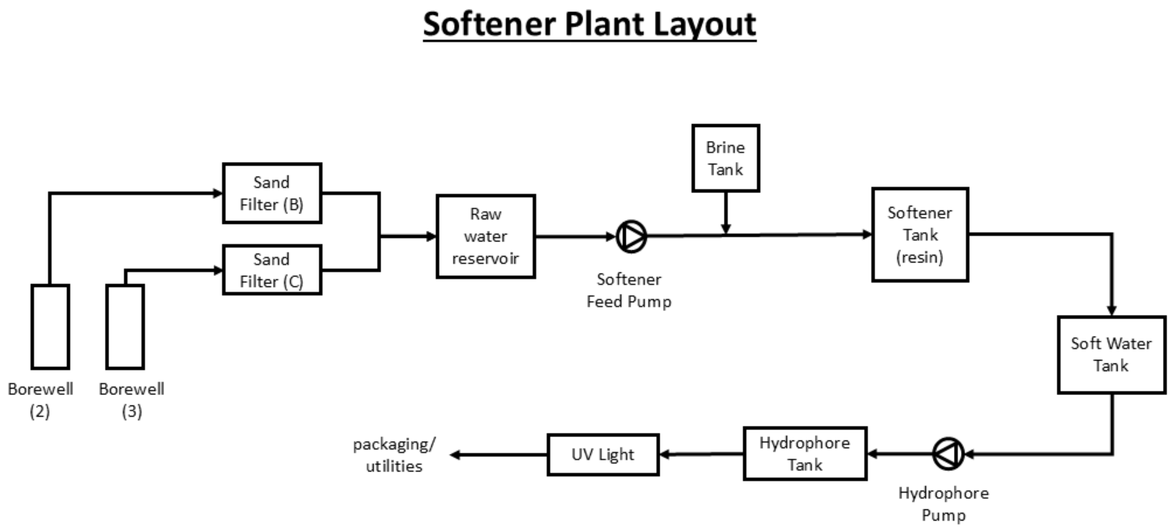

Figure 3.7: Softener Plant Layout

3.5.1 Borewell

Water is pumped from borewell 2 and 3 to Sand Filter B and C at a flow rate of 17 m³/hr.

3.5.2 Sand Filter

A sand filter purifies water by removing large particles. It has a capacity of 17 m³/hr and consists of four layers of filter media: large gravels at the bottom, followed by small gravels, fine gravels, and sand on top. The pressure is maintained at 2-2.5 bar. The filter operates for 24 hours before needing backwash, which takes 20-25 minutes, with an additional 5-10 minutes for rinsing.

3.5.3 Raw Water Tank

This 100 m³ tank holds purified water from the sand filter and pumps it to the softener tank.

3.5.4 Brine Tank

This tank holds a concentrated salt solution, known as brine, used to regenerate ion exchange resin in water softeners. It contains about 550 kg of salt mixed in 1750 liters of water.

3.5.5 Softener Tank

The softener tank has a capacity of 40 m³/hr and operates at 39 m³/hr and 1.2 bar pressure. It softens water by replacing calcium and magnesium ions with sodium ions using food-grade salt. Backwashing is crucial to maintain hardness below 10 ppm and occurs continuously. Regeneration starts when hardness reaches 10 ppm.

3.5.6 Soft Water Tank

This 100 m^3 tank serves as a buffer between the softener tank and the hydrophore tank.

3.5.7 Hydrophore Tank

The hydrophore tank maintains water pressure using compressed air or nitrogen gas. It has a capacity of 10,000 liters and maintains pressure at 4 bar. Water is then sent from this tank to the boiler and packaging sections.

3.6 Water Chilling Plant

The water chilling plant operates using a vapor compression refrigeration system, similar to the glycol cooling plant. However, in this system, ammonia is used to chill water, which is then utilized in the brewhouse and packaging processes. The key components and their functions are as follows:

3.6.1 Ammonia Receiver

This container holds ammonia from the evaporative cooling tower until it reaches the expansion valve. The temperature and pressure are maintained at 35°C and 13 bar.

3.6.2 Expansion Valve

The expansion valve lowers the pressure of the liquid refrigerant in the evaporator, allowing it to expand into vapor. It regulates the refrigerant flow and prevents superheating, reducing pressure from 13 to 4 bar and temperature from 35°C to -1.87°C.

3.6.3 Ammonia Surge Tank

This insulated tank stores ammonia after pressure reduction, acting as both a reservoir and vapor separator. Liquid ammonia settles at the bottom, while vapor rises to the top. The liquid ammonia is sent to the plate heat exchanger to cool hot water from 25°C to -1.87°C, with the output water temperature between 4°C and 7°C. The evaporated ammonia from the heat exchanger and the vapor from the surge tank are then sent to the compressor.

3.6.4 Plate Heat Exchanger

In the plate heat exchanger, heat is exchanged between water and ammonia. The design maximizes efficiency with a larger surface area and a countercurrent flow setup. Hot water at 25°C cools with ammonia at -1.87°C, after which the heated ammonia goes to the compressor, and the cooled water is sent to the brewhouse.

3.6.5 Compressor

The system uses two compressors. The hot evaporated ammonia from the plate heat exchanger and vapor from the surge tank are compressed to around 15 bar and 0°C, with the compressor operating at temperatures of 70-75°C. The water is then directed to the evaporative cooling tower.

3.6.6 Evaporative Cooling Tower

In the cooling tower, high-temperature ammonia from the compressor is cooled. The cooling tower uses a fan and water sparging to release heat, recirculating water to minimize consumption. The cooling process, known as ”evaporative cooling,” allows some water to evaporate, absorbing heat from the remaining water. A serpentine hollow pipe carries the high-temperature ammonia gas for effective heat transfer. The ammonia is typically cooled from 70°C to 35°C before returning to the liquid ammonia receiver.

3.7 Effluent Treatment Plant

Effluent Treatment Plants (ETP) are vital for treating wastewater by removing harmful chemicals and pollutants before releasing the water back into the environment. At Gorkha Brewery, the ETP uses different treatment methods; primary, secondary, and tertiary, each involving biological and chemical processes. These steps ensure that wastewater meets pollution control regulations. Key factors measured during the treatment process include:

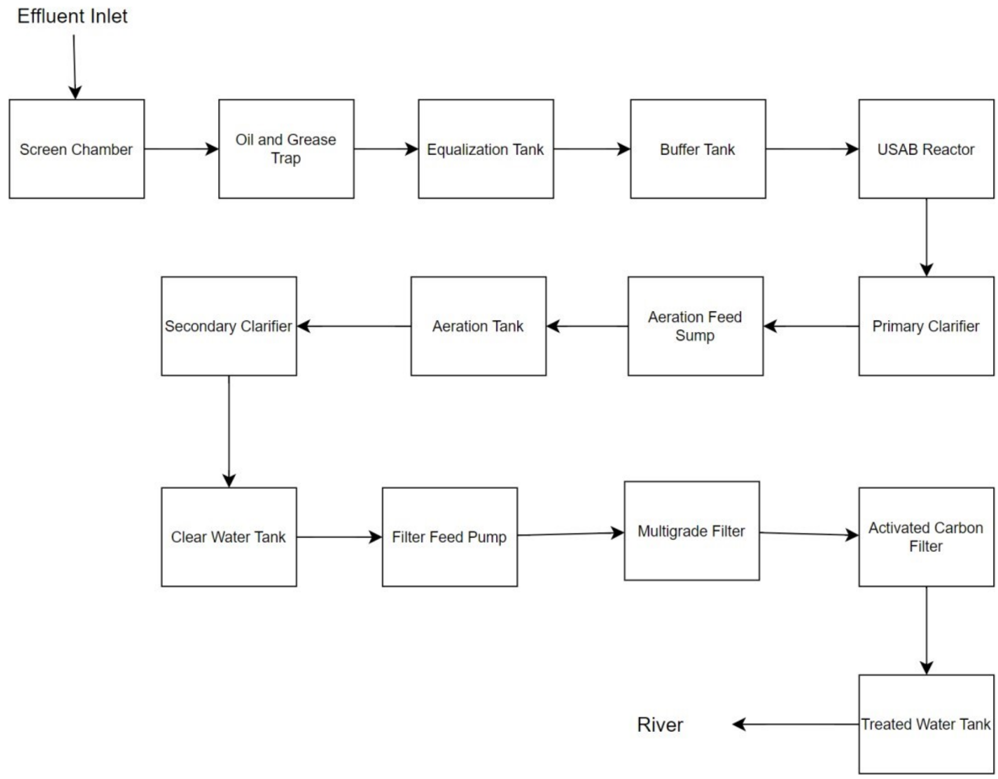

Figure 3.8: Effluent Treatment Plant Layout

3.7.1 Collection Tank

Wastewater from the plant is collected in a tank (2m x 1m) with a capacity of 1200m³/day for initial treatment.

3.7.2 Screening

The wastewater passes through a screening chamber to remove large debris like rags and plastics, protecting downstream equipment.

3.7.3 Oil and Grease Tank

This tank removes fats, oils, and waxes to protect biological treatment processes.

3.7.4 Equalization Tanks

- **Equalization Tank 2:** A 410 m³ tank that regulates flow and pH, using an air diffuser for mixing. It directs water to the calamity tank (if basic) or back (if acidic).

- **Equalization Tank 1 / Calamity Tank:** Adjusts pH with sulfuric acid or sodium hydroxide and ensures proper mixing before sending water to the primary clarifier.

3.7.5 Primary Clarifier

This 10m diameter tank (196m³) uses gravity to separate sludge from effluent. Supernatant goes to the buffer tank, while sludge is sent to the sludge holding tank.

3.7.6 Sludge Holding Tank

Sludge is held here with added air to prevent sedimentation, then dewatered using a mono belt press and chemicals.

3.7.7 Buffer Tank

With a capacity of 211m³, this tank maintains conditions for the UASBR. pH levels are regularly monitored, with chemical adjustments as needed.

3.7.8 UASB Reactor

In this anaerobic digestion stage, wastewater is treated by anaerobic bacteria in three sections, reducing COD and BOD by 70-80% and generating biogas.

3.7.9 Aeration Tank

This 856m³ tank uses aerobic bacteria for further treatment. Fertilizers like urea, zinc, and DAP promote bacterial growth, ensuring oxidation of organic matter.

3.7.10 Secondary Clarifier

Similar to the primary clarifier, this 294m³ tank separates oxidized organic matter by gravity. Recycled sludge returns to the aeration tank, and treated water is discharged according to regulations.

3.7.11 Parameters of Water Quality in Effluent Treatment Plant

1. Total Dissolved Solids (TDS)
2. Alkalinity
3. Volatile Fatty Acid
4. COD (Chemical Oxygen Demand)
5. Mixed Liquid Suspended Solid

6. Total Suspended Solid (TSS)

7. pH

8. Dissolved Oxygen (DO)

9. BOD (Biochemical Oxygen Demand)

CHAPTER 4: OVERVIEW OF BREWHOUSE

The brewing process begins with selecting important ingredients like malted barley, rice, wheat, sorghum, or cassava. Each ingredient adds its unique flavor to the beer. Barley, a common choice, undergoes a process called malting. In malting, the grain's husk is removed, it softens, and unwanted flavors are eliminated, preparing it for mashing.

In the brew house, a place designed for heating, the malt and other ingredients like rice are heated at different stages to extract sugars, forming a liquid called wort, which is the base for beer. The brew house, often called the 'hot up' section, carefully heats the ingredients to release sugars that will later become alcohol. This process is crucial, as it influences the final flavor and aroma of the beer. Understanding malting, where the grains first change, is important to ensure each batch of beer has its distinct character.

4.1 Malting

Barley is the main grain used in the production of beer and other beverages. Malt is made from germinated grains such as barley, wheat, oats, maize, and rice. In brewing, the malting process refers to the treatment of barley, which undergoes several steps in a different industry before reaching the brewery. These steps include steeping, germination, and kilning. During steeping, barley is soaked in water. Once fully wet, the grains are spread out, and they begin to sprout roots and shoots. This process is controlled by passing cool, wet air through the grain bed. The grain produces gibberellin, a plant hormone that activates enzymes in the aleurone layer, breaking down the grain's stored food. To stop further growth, the grains are heated using hot air, known as kilning. Kilning also helps preserve the malt and enhances its flavor and color. Since malt production is a complex process, GBPL imports large quantities of malt from countries like India and Europe, as there are no malt production facilities in Nepal.

4.2 Primary Brewing Ingredients

4.2.1 Adjuncts

Adjuncts are any carbohydrate sources other than malted barley that contribute to the sugar concentration in the wort. These can be sugars or malted and non-malted grains like rice, wheat, sorghum, and oats. They provide starch but do not impact enzymatic activities or flavor. GBPL uses broken rice as an adjunct, which is common in beer brewing except for premium brands like Carlsberg. Rice is preferred because of its low oil content, neutral flavor, and aroma, resulting in a light beer when properly processed. Rice is boiled and mixed with malt in the mash tun.

4.2.2 Hops

Hops are the flowers of the *Humulus Lupulus* plant, used to add bitterness and aroma to beer. They contain resins and essential oils, with α-acids and β-acids contributing to bitterness. During wort boiling, α-acids convert to iso-alpha acids, providing most of the beer's bitterness. GBPL uses hops in various forms, including extracts and pellets, based on each brand's recipe. Hops also aid in stabilizing the beer microbiologically and act as antifoaming agents.

4.2.3 Enzymes

Enzymes are proteins that accelerate chemical reactions without being consumed. Two main types of enzymes in brewing are proteases (protein-cleaving) and diastases (starch-cleaving). GBPL uses these enzymes at different brewing stages depending on their function. After their work, enzymes are inactivated by heating to specific temperatures.

4.2.4 Brewing Water

Water is a key ingredient in beer, used in wort production and for adjusting alcohol content. GBPL uses a reverse osmosis filtration system to treat groundwater, ensuring proper levels of total dissolved solids and hardness. The ideal brewing water has hardness of 200-300 ppm, calcium content of 60-70 ppm, and alkalinity of 25 ppm.

4.3 Stages in Brewing Process

At Gorkha Brewery Private Limited (GBPL), careful attention is given to every step of the brewing process to ensure high-quality beer. Below are the key stages:

4.3.1 Silos and Fumigation

GBPL uses four silos, three for storing malt and one for rice. Grain is delivered by truck and fed into the silos via conveyors. Regular fumigation with methyl bromide or phosphine gas is done to prevent pest infestations.

4.3.2 Foreign Particle Removal

Grains contain foreign particles that need to be removed before processing. GBPL uses flat screens and drum sieves to remove larger particles, followed by destoners to remove stones, and magnets to eliminate metal particles.

4.3.3 Weigh Balance

Programmable Logic Control (PLC)-controlled weigh balances are used to measure the required amount of rice and malt. Each batch takes in 25 kg at a time until the desired weight is reached.

4.3.4 Milling

Rice Milling: Rice is milled into particles smaller than 2 mm for easier liquefaction and better flow through hoppers. The slurry is formed at 64°C to 76°C.

Malt Milling: Malt is milled to balance extraction and separation. GBPL uses a variomill system, which wets the malt before crushing it in rollers to preserve the husk and extract. The mash is then transported to the mash tun.

4.3.5 Rice Cooker

The milled rice is transferred to a rice cooker, with rice typically comprising 48% w/w of malt. Water is mixed with rice, and cooking occurs at 88°C for 50 minutes using steam from a dimple jacket. Termamyl and calcium sulfate are added to reduce viscosity and promote yeast metabolism during resting. After cooking, the rice is transferred to the mash tun.

4.3.6 Mash Tun

In the mash tun, malt, adjuncts, and water are mixed at specific temperatures to convert starches into fermentable sugars and nutrients. The mashing can be done using infusion or decoction methods. GBPL employs a decoction process, heating rice before transferring it to the mash tun. Mash tuns at GBPL are spherical, fitted with heating jackets and low shear agitators for thorough mixing. Mashing starts at around 48°C for proteolysis, then increases to 65°C for saccharification, and finally to 75°C-78°C to reduce viscosity. The starch breakdown is verified using the iodine test.

4.3.7 Lauter Tun

Mash separation is crucial in brewing. GBPL uses a lauter tun for this purpose, which separates crushed malt based on particle size. The lauter tun's larger diameter improves filtration, allowing finer grist and higher extract rates. Rakes help break up the grain bed for better solid-liquid separation, with collector pipes ensuring even wort flow. Sparging water with slight acidity is sprayed over the wort to extract remaining sugars.

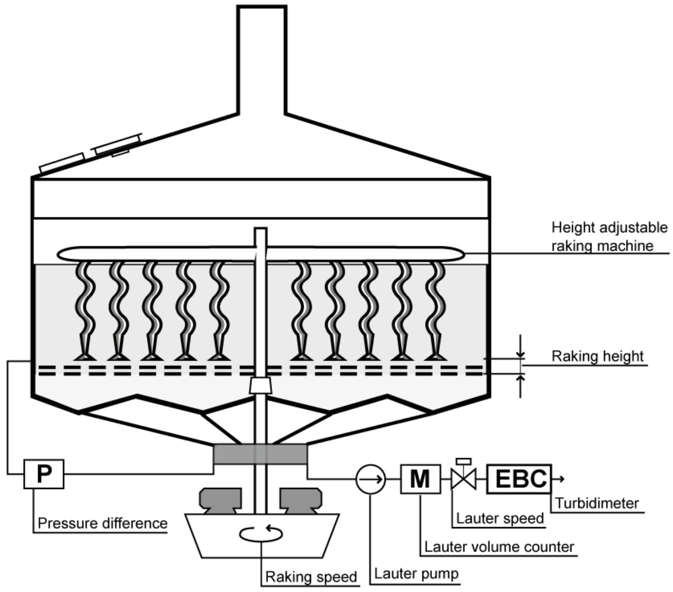

Figure 4.1: Lauter tun [2]

4.3.8 Wort Kettle

In the wort kettle, the collected wort is boiled to eliminate unwanted compounds and enhance flavor. The wort is heated from around 70°C to just above 100°C for 60 minutes. Hops and caramel are added for bitterness and aroma. An internal boiler system circulates wort through tubes, ensuring effective boiling. The evaporation rate is maintained between 4% and 8% to eliminate DMS, a flavor compound.

4.3.9 Whirlpool

Hot wort is clarified quickly to remove trub and hop solids. A whirlpool separator uses gravitational and centrifugal forces for solid-liquid separation. The wort enters tangentially, creating a parabolic flow that facilitates settling. The design of the vessel promotes faster settling of solids.

4.3.10 Wort Cooler

A wort cooler is a key tool in brewing that quickly lowers the temperature of hot wort after boiling. The cooling is done by cold water entering at 4°C and water exits at 80°C and wort enters at 99°C and exits the wort cooler at 16°C. This cooling is important because it prevents bacterial growth, helps clarify the beer by removing proteins and hop residues, and prepares the wort for fermentation at the right temperature for yeast.

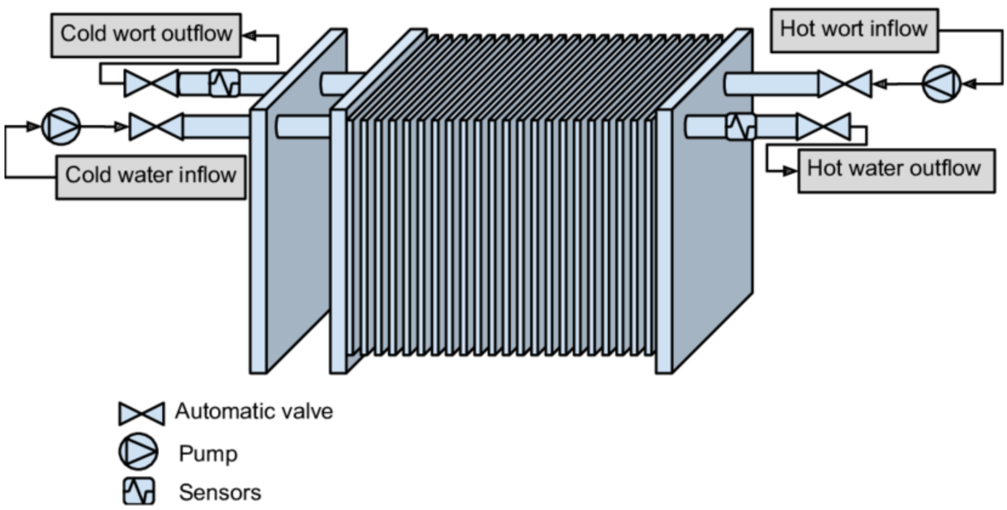

Figure 4.2: Wort Cooler [3]

4.4 Quality Control in Brew House

Quality control in the brew house is essential for effective brewing. This section discusses key parameters and their control.

4.4.1 Gravity/Plato

Gravity, or Plato, measures the sugar content in the wort. A higher sugar level means more food for yeast, leading to better alcohol production. Monitoring Plato helps reduce losses that can affect profits. At Gorkha Brewery Pvt. Ltd. (GBPL), high gravity brewing allows for the production of beer with high sugar content, which is diluted post-fermentation to achieve the desired alcohol level.

4.4.2 pH

The pH of the wort is monitored at every step of brewing. It affects various factors, including the quality and flavor of the beer. For enzymes to work well, they need to be in a specific pH range: endo-beta-glucanases (4.7-5), protein-converting enzymes (5-5.2), and amylases (5.4-5.8). Most mashes are kept between pH 5.4 and 5.6 to ensure proper enzyme activity.

4.4.3 Starch Content and Iodine Test

Starch is the main source of fermentable sugars in brewing. It must be gelatinized by heating before enzymes can convert it into sugars. To check if starch has been converted, iodine (potassium iodide) is added to the mash. A blue-black color indicates starch is present, while no color change means it has been converted.

4.4.4 DMS

Dimethyl sulfide (DMS) is a flavor compound in beer that can taste like cooked corn or vegetables. It comes from malted barley. To prevent DMS from affecting the beer's flavor, it is essential to boil the wort vigorously and avoid holding it in the whirlpool for too long. If there are delays, the brew should be reboiled before transferring to the whirlpool.

4.4.5 Haze

Haze refers to the cloudiness in beer caused by insoluble materials. It results from interactions between proteins, polyphenols, and hop acids. High levels of certain hops can help reduce haze by stabilizing these interactions.

CHAPTER 5: OVERVIEW OF BEER PROCESSING

This chapter explains the beer processing facility, where wort from the brew house is fermented by adding yeast. Often called the 'brain' of the brewery, this area is crucial because it heavily impacts the taste and quality of the beer. The fermentation process requires close attention, especially to the temperature and pressure inside the fermentation tanks. Small changes in these conditions can affect the beer's final quality. The main goal of the beer processing facility is to ensure that each batch meets quality standards before it is packaged, making it a key part of the beer-making process.

5.1 Essential ingredients in Beer Processing

5.1.1 Yeast

Yeast is a key ingredient in brewing, along with water and wort. While wort processing is mostly the same across brands, yeast transforms it into different types of beer. Brewing yeast is chosen for its strong fermentation ability. Bacteria and mold can also ferment, but they are not used because of contamination risks. Yeast is added to the cooled wort either directly in the fermentation tank or as it flows into the fermenter. The tanks are cleaned and sterilized before each use to prevent contamination, as yeast is highly sensitive and contamination could cause big losses.

5.1.2 Deaerated Water

Deaerated water, with oxygen removed, is important in high-gravity brewing to dilute beer to the desired alcohol level. Oxygen-free water prevents oxidation, which can affect beer quality.

5.1.3 Carbon Dioxide

CO_2 is released during fermentation, helping maintain proper pressure and anaerobic conditions. The CO_2 is collected, purified, and reused in the carbonation process to reach the right level in the beer.

5.2 Stages in Beer Processing

The beer processing section at GBPL involves several important steps to ensure high-quality beer production:

5.2.1 YPTs and YCRs

At Gorkha Brewery, Yeast Propagation Tanks (YPTs) and Yeast Cropping Reserves (YCRs) manage different yeast strains for various beer brands. In YPTs, yeast is grown from a small culture (about 10 liters) to larger volumes (hectoliters) while monitoring temperature and contamination. Once the yeast reaches the desired amount, it's used for fermentation. After fermentation, healthy yeast settles at the bottom of the fermentation vessels and is moved to YCRs for storage until the next use.

5.2.2 Cylindroconical Fermentation Vessels (CFVs)

The taste and aroma of beer depend on the yeast strain, wort (unfermented beer), and fermentation process. Fermentation turns sugars from the wort into alcohol and carbon dioxide, as shown in this equation:

$$C_6H_{12}O_6 + \text{Yeast} \rightarrow 2C_2H_5OH + 2CO_2 + \text{Heat}$$

In batch fermentation, a fixed amount of wort is combined with yeast in a controlled environment. Gorkha Brewery uses cylindroconical vessels for uniform heat distribution and effective yeast separation after fermentation. These vessels maintain consistent temperature and pressure during the fermentation process, which lasts several days to a week. Proper mixing and oxygenation of the wort and yeast are also crucial. Data on temperature and gravity is recorded every 24 hours to track fermentation progress.

5.2.3 Centrifugal Separation

Centrifugal separators are used to separate yeast from the beer after fermentation. The green beer (a mix of beer and yeast) is pumped into a rapidly spinning drum, causing the yeast to move to the outer wall while the beer stays in the center. Yeast flows out through openings at the bottom for reuse in future fermentations.

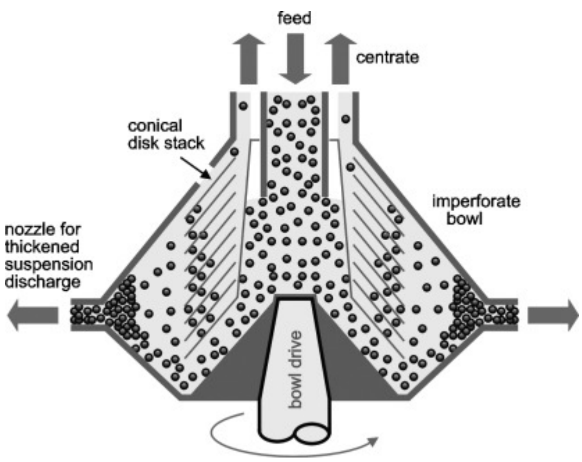

Figure 5.1: Centrifugal Separator [4]

5.2.4 Candle Filtration

After yeast separation, candle filters are used to remove smaller particles and impurities from the beer. The green beer passes through cylindrical filters filled with materials like diatomaceous earth, trapping unwanted particles while allowing clear beer to flow through. A precoat powder may be applied to enhance filtration efficiency.

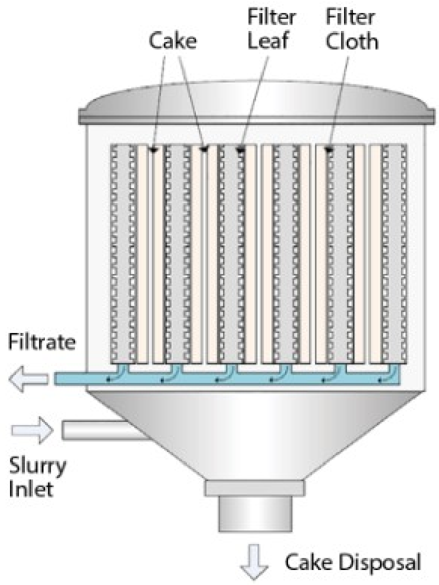

Figure 5.2: Candle Filter [5]

5.2.5 Dilution and Carbonation

To reduce the alcohol content, high-gravity beer is diluted with deaerated water before carbonation. The carbonation process involves injecting carbon dioxide into the beer to achieve a desired level of fizziness, which affects its taste and mouthfeel.

5.2.6 Bright Beer Tanks

After dilution and carbonation, the beer undergoes final filtration to remove residual yeast and impurities. It is stored in Bright Beer Tanks (BBTs) at a low temperature (around 4°C) for several days. During this time, various quality parameters like alcohol content and pH are monitored. CO_2 is added for optimal mixing before the beer is sent to the packaging plant.

5.3 Engineering Perspective on Yeast Separator Machine

The yeast separator machine is a critical component in the beer production line. Its primary function is to separate yeast from the beer post-fermentation, ensuring product clarity and preventing off-flavors. The engineering design of such machines is pivotal for optimizing the brewing process and maintaining high-quality standards.

The machine operates on the principle of centrifugal separation. By spinning the beer-yeast mixture at high speeds, the denser yeast cells are forced to the outer edges of the rotating bowl, allowing the clear beer to be collected from the center.

Key Components and Design Features

- **Rotating Bowl**: The central element where separation occurs, designed with a stack of discs to enhance separation efficiency.

- **Motor and Worm Gear**: These components work in tandem to convert electrical energy into mechanical energy, providing the necessary rotational force to the bowl.

- **Operating Water Module Compact (OWMC)**: A sophisticated control system that regulates the sediment discharge by varying the bowl speed, enabling precise separation control.

- **Nozzle Discharge System**: Strategically placed nozzles facilitate the continuous removal of the yeast sediment from the periphery of the bowl.

5.3.1 Centrifugal Force

The magic behind yeast separation lies in a fundamental principle of physics: centrifugal force. Similar to how water is forced outward when spinning a bucket, within a yeast separator machine, a mixture of liquids with different densities is spun at high speeds within the centrifuge bowl. This force pushes denser materials outward, separating yeast cells from the less dense beer.

5.3.2 Disc Stack Centrifuge

The disc stack centrifuge is the workhorse of yeast separation in breweries. Here's a breakdown of its key components:

- **Bowl**: A high-speed rotating vessel, typically reaching speeds of 5,000-8,000 rpm, where the separation process takes place.

- **Disc Stack**: A series of thin conical discs that increase the separation area, enhancing efficiency.

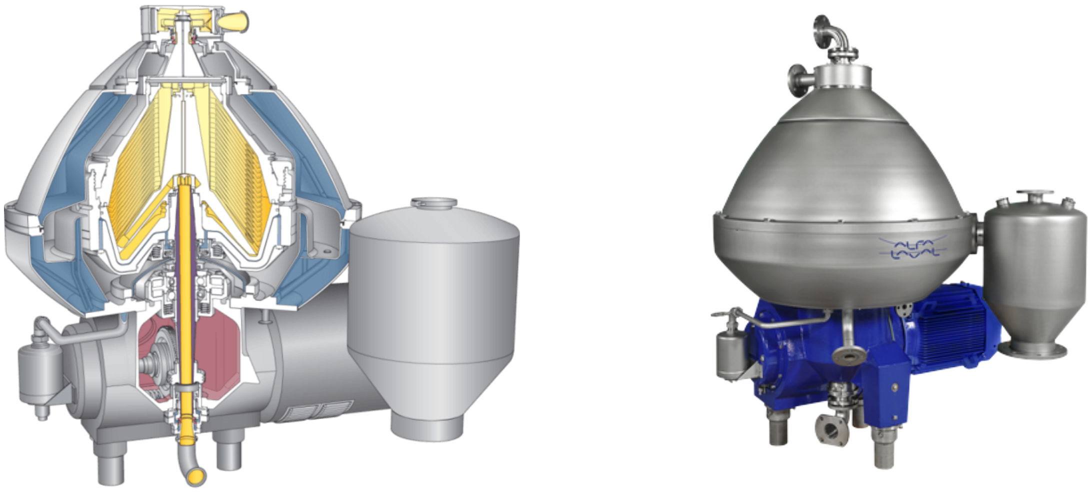

Figure 5.3: Centrifugal yeast separator [6]

- **Sediment Space**: The area where the separated yeast solids accumulate before they are discharged.

- **Clarified Liquid Outlet**: The exit point for the clarified beer.

- **Solids Discharge Mechanism**: Removes the accumulated yeast solids periodically, allowing continuous operation.

5.3.3 Separation Process

The yeast separator machine orchestrates a multi-step process. The beer-yeast mixture enters the bowl through a distributor, high-speed rotation creates centrifugal force, separating the denser yeast from the beer. The separated yeast solids accumulate at the bottom of the bowl, while clarified beer exits through an outlet, and the solids are discharged periodically to maintain continuous operation.

5.3.4 Engineering Challenges and Solutions

- **Vibration Damping**: Rubber buffers mounted on the bowl spindle's top bearing reduce vibrations, improving stability.

- **Lubrication System**: An oil bath lubrication system ensures smooth operation of the worm gear and bearings.

- **Thermal Management**: A cooling coil within the worm gear housing and a cooling jacket prevent thermal degradation of components.

- **CIP (Clean In Place)**: After a fixed volume of beer separation, a cleaning cycle

(CIP) is initiated to ensure hygiene.

5.4 Quality Control of Yeast

5.4.1 Viability

Yeast viability indicates the percentage of live yeast cells that can ferment the wort to produce alcohol and carbon dioxide. It is essential for brewing quality, as viable yeast ensures efficient fermentation. Factors affecting viability include temperature, pH, oxygen levels, and nutrient availability. Extreme temperatures can slow or halt fermentation, impacting the final product.

5.4.2 Yeast Cell Count

Yeast cell count measures the number of yeast cells in a specific volume of liquid. Accurate counts help brewers determine the right amount of yeast for consistent fermentation. This is typically measured with a hemocytometer. Proper yeast levels prevent under- or over-pitching, which can lead to fermentation issues.

5.4.3 Vitality

Yeast vitality reflects the metabolic activity and overall health of the yeast. High vitality is crucial for effective fermentation, resulting in quality beer. Factors such as temperature, nutrient availability, and oxygen levels can influence yeast vitality. Healthy yeast ensures smooth fermentation and enhances the flavor of the final product.

5.4.4 Generation

In brewing, yeast generation refers to the number of times a yeast strain has been propagated. As yeast is reused, some cells may die off while others reproduce. Each new use represents a new generation. Multiple generations can lead to genetic mutations that affect the flavor and quality of the beer. Additionally, yeast health may decline over generations, impacting fermentation efficiency.

5.5 Quality Control in Beer Process

5.5.1 Temperature

At Gorkha Brewery Pvt. Ltd. (GBPL), lagers are fermented at about 16°C. This cool temperature helps create a clean, crisp flavor with fewer fruity notes compared to ales. It also reduces unwanted byproducts like acetaldehyde, which can cause off-flavors.

5.5.2 Pressure

Pressure is important during fermentation as yeast produces carbon dioxide, creating pressure in the vessel. Proper pressure control ensures smooth fermentation. Too much pressure can slow down yeast activity, while too little can lead to unwanted microorganisms. It also affects carbonation levels, making pressure control crucial for high-quality beer.

5.5.3 pH

The pH level affects yeast growth. Yeast thrives in a slightly acidic environment (pH 4.0 to 5.5). If the wort's pH is too low, yeast growth slows down; if it's too high, off-flavors or bacteria may develop. Maintaining proper pH is essential for good beer quality.

5.5.4 Flavors

Beer flavors include bitterness, sweetness, acidity, and umami. Bitterness comes from hops, sweetness from malt, acidity from lactic acid, and umami from ingredients like soy sauce. Controlling these flavors is important to avoid off-flavors.

5.5.5 Vicinal Diketones (VDK)

Vicinal diketones (VDK) are unwanted compounds that can give beer a buttery flavor. While some styles may tolerate a slight diacetyl flavor, high levels are a fault. To remove VDKs, brewers can extend maturation, raise fermentation temperatures, or use yeast strains that produce less VDK.

CHAPTER 6: OVERVIEW OF PACKAGING

Packaging is important for drinks. It keeps them safe, fresh, and tasty. It also helps people know about the drink and makes the brand look good. GBPL makes sure their packaging is clean and done right. They choose good containers and fill them carefully. This keeps the drinks safe and shows that GBPL cares about quality.

Critical Control Point (CCP) is a step in the food production process where control can prevent, eliminate, or reduce food safety hazards. CCPs are vital in a Hazard Analysis and Critical Control Points (HACCP) plan, helping breweries manage potential hazards that affect beer quality and safety. Establishing CCPs ensures products are safe for consumption and meet regulatory standards, fostering consumer trust and brand loyalty.

In the packaging section, there are three CCPs:

1. CCP-1: EBI

2. CCP-2: Bottle Filler

3. CCP-3: Pasteurizer

The bottling and packaging process at Gorkha Brewery mirrors that of other breweries but has unique elements tailored to the Nepali market. Key steps include:

1. **Cleaning and Sanitizing:** Equipment and containers are thoroughly cleaned to prevent contamination.

2. **Carbonation:** Carbon dioxide is added to create fizziness and preserve flavor.

3. **Filling:** Beer is filled into bottles, cans, or kegs, often using PET bottles popular in Nepal.

4. **Sealing:** Containers are sealed to keep the beer fresh.

5. **Labeling:** Labels provide information and often feature Nepalese landmarks and cultural symbols.

6. **Packaging:** Filled and labeled containers are packaged for shipment, designed to withstand harsh conditions.

7. **Quality Control:** Samples are tested to ensure safety and quality, with experts overseeing the process.

The packaging department uses three lines: Return Glass Bottle (RGB)-1, RGB-2, and a Can Line, each filling different brands. RGB-1 has a capacity of 21,000 bottles per hour (bph) and RGB-2 has a capacity of 10,000 bph.

6.1 Bottle Feeding

Bottle and can feeding is the first step in GBPL's packaging process. The inbound department brings empty bottles and cans to the packaging area. It is important to handle them carefully during depalletization.

Bottles, whether new or reused, are placed on conveyor belts by hand. Older bottles are checked for any damage or dirt, and any bad ones are removed. After this, bottles are cleaned and sanitized in the bottle washer to meet hygiene standards before they are filled. This careful process shows GBPL's commitment to providing safe and high-quality drinks, ensuring excellence from start to finish.

6.2 Bottle Washer

A bottle washer cleans and sanitizes bottles before filling. The process includes:

1. **Loading:** Bottles are loaded onto a conveyor.

2. **Pre-rinse:** Bottles are rinsed with water to remove debris.

3. **Soak and Scrub:** Bottles soak in a heated cleaning solution, scrubbed to remove buildup.

4. **Post-rinse:** Bottles are rinsed again with water.

5. **Sanitization:** A sanitizing solution is applied to kill remaining microorganisms.

6. **Inspection:** Bottles are inspected for cleanliness.

7. **Unloading:** Cleaned bottles are transported to the filling line.

Figure 6.1: Bottle Washer [7]

Bottles are lifted into the washer, initially cleaned with warm water, then soaked in a caustic pool (60–65°C), followed by a second dip at around 70°C to remove pollutants. The caustic concentration is 2.5-3% for old bottles and 1.5-2% for new bottles, washing at a rate of 25,200 bph. The bottle washer ensures the quality and safety of bottled beverages by preventing contamination and maintaining high standards of taste and quality.

6.3 Empty Bottle Inspection

Empty bottle inspection is a crucial quality control step at Gorkha Brewery. It ensures that only clean and correctly shaped bottles are used for beer production. Here's how the inspection works:

1. **Incoming Bottle Inspection:** All incoming bottles are checked to ensure they are clean, properly shaped, and free of defects. This is done through visual checks and automated machines.

2. **Rejection of Defective Bottles:** Bottles that do not meet quality standards are rejected. They are either sent back to the supplier or recycled, depending on the defect's severity.

3. **Cleaning and Sanitization:** Approved bottles are cleaned and sanitized using a special bottle washer to remove any contaminants or bacteria.

4. **Automated Inspection:** After cleaning, bottles undergo automated inspection with machines like the Krones bottle inspector. This equipment uses cameras and sensors to find defects such as cracks or foreign particles.

5. **Manual Inspection:** A trained team also conducts manual inspections to ensure quality. This involves visually checking the bottle and performing physical tests for any irregularities.

6. **Final Rejection of Defective Bottles:** Bottles that fail inspection are removed from the production line to ensure only high-quality bottles are used.

The cleaned bottles are further checked using eight cameras that take 360-degree images to find any issues. The inspection includes checking the bottle's side, top, bottom, and sealing surface. Defective bottles are pushed out of the line with a pressure system, while contaminated ones are sent back for cleaning.

Test bottles with known defects are used to check the inspection system's accuracy. If these bottles are correctly rejected, it confirms the inspection machine is working well. Empty bottle inspection is a critical control point at Gorkha Brewery. It ensures the final product is safe and high-quality by preventing contamination before production.

6.4 Filler and Crowner

The filler uses a worm shaft and star wheel system to take bottles off the conveyor. The bottles are lifted using a lift cylinder piston. The filling machines have rotating parts with up to 72 nozzles in one line and 32 in another. The filling process starts when bottles enter the filler. A water pump removes air from the bottles and releases it. CO_2 is introduced to reduce oxygen levels, creating foam.

Once the CO_2 pressure is right, beer is filled at a flow rate of 80 dm^3/min. An umbrella-shaped nozzle is used for filling. After filling, hot water at 80°C is sprayed to remove excess oxygen. Bottles are then capped using a pneumatic lift and delivered for pasteurization. Next to the filler, there is a filled bottle inspector that checks the labels, underfill, and overfill. Any defective bottles are removed using a rejector.

6.5 Pasteurizer

Pasteurization gently heats and quickly cools fresh packaged beer to avoid bacterial growth. This process keeps packaged beer stable and fresh during transport and storage.

The filled beer packages go through a "tunnel" pasteurizer, where they are sprayed with warm water. The bottles pass through eight sections: first, they are preheated, then superheated, and finally pasteurized at 60–65°C. Afterward, they are cooled down. The total pasteurization time is about 40 minutes. The required water temperatures throughout the process are managed using steam from the boiler.

6.6 Labeler

After pasteurization, the beer is ready for labeling. The labeler applies the front, back, and neck labels using a rotary mechanism. A batch code printer adds the expiry date, batch number, and MRP to the back label of each bottle.

6.7 Carton Packing

The next step is carton packing, accomplished with a hydraulic arm equipped with 72 suction nozzles and a pneumatic valve system. The cartons are lined up at the packing section. Bottles are moved using tulips, which have a balloon that expands to grip the bottles. A motor-driven mechanical linkage transfers the bottles from the conveyor to the packing boxes, with each box holding 12 bottles.

6.8 Carton Sealing

Carton sealing is performed using a carton sealer that applies tape or melted glue resins to secure the cartons. An oscillating arm closes the top of the carton before the melted glue is applied. After sealing, a case printer prints the MRP and the number of bottles (12 or 24) on the carton.

6.9 Palleting

The sealed cartons are transported to the pallet room via a conveyor with a friction mat to prevent sliding. Once in the pallet room, workers manually unload the cartons and stack them safely on pallets.

6.10 Warehouse

Forklift operators then move the pallets to the warehouse, which is sheltered with an aluminum shade to protect them from rain and sun. Once stored, the cases are dispatched to retailers using the batch codes printed on each carton.

CHAPTER 7: OVERVIEW OF QUALITY ASSURANCE

The Quality Control (QC) department is a vital part of any industry. Its main job is to ensure that all steps of production follow the necessary procedures and that the products meet government health standards and specifications. At Gorkha Brewery Pvt. Ltd. (GBPL), the QA department is divided into four main labs: the Quality Control Laboratory, the Effluent Treatment Plant Laboratory, the Water Treatment Plant Laboratory, and the Packaging Laboratory.

7.1 Quality Control Laboratory

The Quality Control lab focuses on the following:

1. Visual and lab inspections of incoming raw materials.

2. Testing of wort, fermenting beer, bright beer, and the final product.

3. Ensuring proper health and sanitation standards across all departments.

7.2 Testings Done in QC Lab:

7.2.1 Raw Material Inspection

GBPL regularly receives shipments of barley malt, rice husk, and rice. When these arrive, the QC team visually checks the condition of the raw materials, including their color and packaging.

In the lab, malt and rice are tested for friability (how easily they break down), which indicates if they've been stored properly. Friable grains work well during the mashing process, while less friable ones absorb moisture quickly, reducing their shelf life and making them harder to mill. The moisture content of the grains is also checked using an IR moisture meter, as grains with higher moisture content are harder to mill.

GBPL also receives consignments of carbon dioxide (CO_2), which are inspected by the QC department upon arrival.

7.2.2 Wort Testing

After wort is made in the brewhouse, the QC department takes a sample for testing. The wort is first filtered and then tested for pH levels, Plato value (which measures sugar content), bitterness units (BU), haze, and color.

7.2.3 Fermenting Beer Testing

During fermentation, daily samples of beer are taken to measure yeast cell count and Plato value. Once the Plato value drops to around 2-3° Plato, it signals the end of fermentation. The resulting beer, called green beer, is then tested for VDK (vicinal diketones) levels, which affect flavor.

7.2.4 Bright Beer Testing

Once the green beer is filtered and carbonated, it becomes bright beer. The QC lab tests it for alcohol content, haze, apparent extract (AE), original extract (OE), Plato value, color, bitterness, and CO_2 concentration. Each brand has its specific CO_2 requirements, but it's generally below 5.0 mg/L. Once the bright beer meets the brand's specifications, it moves on to bottling.

7.2.5 Finished Product Testing

The final beer product is tested for pH, Plato, AE, OE, and RDF (Real Degree of Fermentation). If the beer meets all the brand standards, it is sent to the warehouse for distribution.

7.2.6 Sensory Testing

GBPL conducts sensory tests for deaerated water, CO_2, bright beer, green beer, and the final product. This ensures there are no off-flavors in the beer. Before the beer expires, it is also tested again to confirm there are no flavor issues. In CO_2 testing, chilled deaerated water is mixed with recycled CO_2 to check its purity.

7.2.7 Bitterness Unit (BU) Testing

The BU measures the bitterness of the beer. BU testing is done for wort, green beer, bright beer, and the final product. To test BU, a 10 mL sample is mixed with hydrochloric acid and isooctane. After shaking the sample, a UV spectrophotometer is used to measure the BU at an absorbance of 275 nm. For bright beer, an anti-foam agent (octanol) is also added to the sample.

7.2.8 Color Testing

Beer samples are centrifuged and then analyzed using a UV spectrophotometer to measure color. Background readings are first taken with distilled water, and the color of the beer is adjusted accordingly.

7.2.9 Haze Testing

Haze is measured using a haze meter by placing a sample of beer in a glass.

7.2.10 Vicinal Diketones (VDK) Testing

VDK levels indicate the maturity and flavor profile of the beer. High VDK levels can lead to unwanted buttery or caramel flavors. GBPL aims for VDK levels to be below 0.15. To test VDK, a sample of green beer is distilled, and reagents are added before measuring the VDK level using a spectrophotometer.

7.2.11 Testing of RDF, AE, OE, and Alcohol Content

- **Original Extract (OE)** refers to the total sugar content before fermentation.
- **Apparent Extract (AE)** is the remaining sugar content after fermentation.
- **Real Degree of Fermentation (RDF)** measures how much sugar has been converted to alcohol. For example, an RDF of 80% means, 80% of the sugars were fermented.

These parameters are tested using an alcolyzer unit to ensure the beer meets the required specifications.

CHAPTER 8: INTERNSHIP ASSIGNMENTS

During my one-month internship at Gorkha Brewery Pvt. Ltd., I was involved in a variety of tasks that contributed to both my professional growth and the efficiency of the brewery's operations. The assignments I worked on are listed below:

8.1 Data Entry of Task and its Status

During my internship, one of my primary responsibilities was maintaining detailed records of departmental tasks, including the works to be completed, the accountable personnel, and the status of each task. This involved gathering accurate information from various departments and inputting it into the company's system to monitor progress and ensure efficient operations. I also updated task statuses regularly, marking them as ”WIP”, ”Done” or ”Closed” as appropriate. Precision and attention to detail were vital to ensuring the accuracy and reliability of this data, which played a critical role in workflow management and resource allocation.

By organizing and updating this data, I helped improve communication across departments, allowing management to monitor task progress more efficiently. This system also enabled resource allocation based on the workload of each department, improving overall operational efficiency. The task provided insights into how data management and proper documentation can significantly streamline operations in an industrial environment.

SN	Date	Departme	Action	Accountabilit	Due D	Status	ecision/Comr
1	8/2/2024	Utility	Diesel tank discussion	Kosish		Done	
2			Underground tank capacity 35kl	Kosish			
3	8/2/2024		Electrical panel for MTFH-JOB boiler	Kosish			
4			Supply of GI Cable tray				
5			Supply of power cable up to all accessories				
6			Future techniques visit for panel interlo	Madan			
7			Husk transfer interlock	Madan			
8			Sice/Rating of each electrical items.				
9	8/2/2024	Utility maintai	Glycol cooling tower de-scalingNo 3 & No 4			Done	
10			Air compressor cleaning			Done	
11			Item trap replacement of pack 2			Done	
12			Ash Silo bag replacement/level sensor in ash silo				mail to Indpro
13			Ash supply pipeline repairing			Done	
14			800KVA DG Raditor cleaning &tapped setting				
15	22/8/2024	Utility, B & P n	PRV maintainance torbes marshall	Kosish			
16			Actuator valve of Lavter ton and control	JBW/Bimlesh			

Figure 8.1: Sample of Data Entry of Task-status

8.2 Chinese to English Translation of Flowcharts

During my internship, I was assigned the responsibility of translating technical flowcharts from Chinese to English. These flowcharts were essential for understanding and implementing critical processes within the brewery. The tasks involved accurately interpreting the technical terminology and ensuring that the translated content conveyed the intended meaning without any loss of detail.

The flowcharts included key processes such as the abnormal handling of CO_2 evaluation, ammonia system inspection workflow, water treatment process execution and exception handling workflow, emergency response plans, and safety procedures. Each of these processes was integral to the safe and efficient functioning of the brewery. The translations needed to be precise to facilitate clear communication among the English-speaking team members, particularly those directly involved in operations and maintenance.

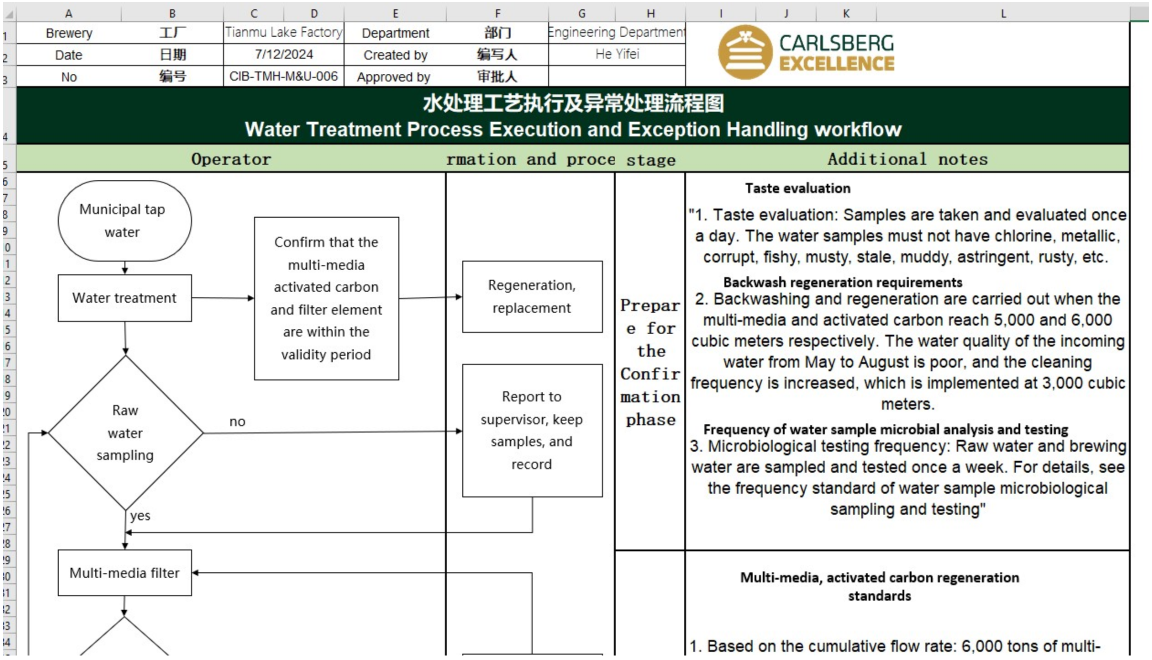

Figure 8.2: Sample of Translated flowchart

To accomplish this, I leveraged multiple tools and resources. I utilized Google Translate and the translation add-in feature in Excel to streamline initial translations, supplemented by ChatGPT for refining complex terminologies and phrases. Additionally, I collaborated with technical staff to gain deeper insights into the context and intricacies of the flowcharts. To ensure accuracy, I cross-referenced technical manuals and other resources to validate the correctness of the translations.

This task required meticulous attention to detail and a solid understanding of both linguistic and technical aspects to produce actionable and reliable translations. By bridging the language gap, my work facilitated effective communication and contributed to improved operational safety and team coordination.

8.3 Flowchart Creation for Key Systems

During my internship, I was tasked with creating flowcharts for several key systems within the brewery, including **air compressor system, boiler plant, ash and husk handling system, glycol cooling system, and steam flow system**. These flowcharts visually represented the processes, helping staff and engineers better understand the workflows, the sequence of operations, and the relationships between various components. By clearly outlining the flow of materials, energy, and steam, the flowcharts made it easier to identify critical points in the processes where improvements could be made.

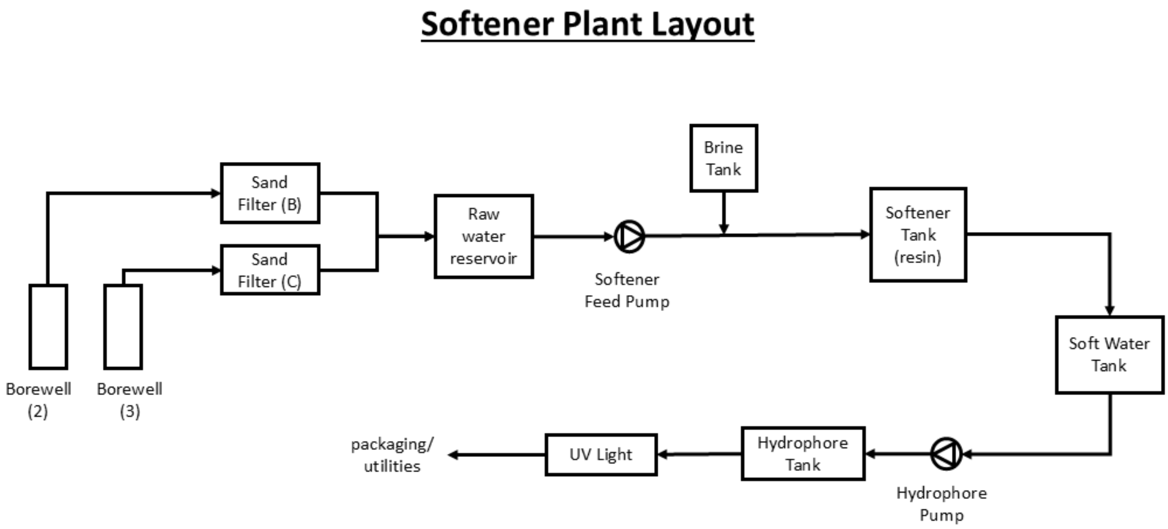

Figure 8.3: Sample of flowchart: Softner plant

I worked closely with the engineering team to ensure the accuracy and clarity of these diagrams. Once finalized, the flowcharts were printed and displayed in various departments across the brewery. This made them easily accessible for both new workers and visitors, providing them with a clear understanding of the brewery's systems. The flowcharts served as valuable reference tools for new employees during their training, helping them quickly grasp the operational processes and safety protocols. For visitors, the displayed flowcharts helped them understand the brewery's processes at a glance. Overall, these visual aids not only improved operational understanding but also supported better communication and enhanced efficiency throughout the brewery.

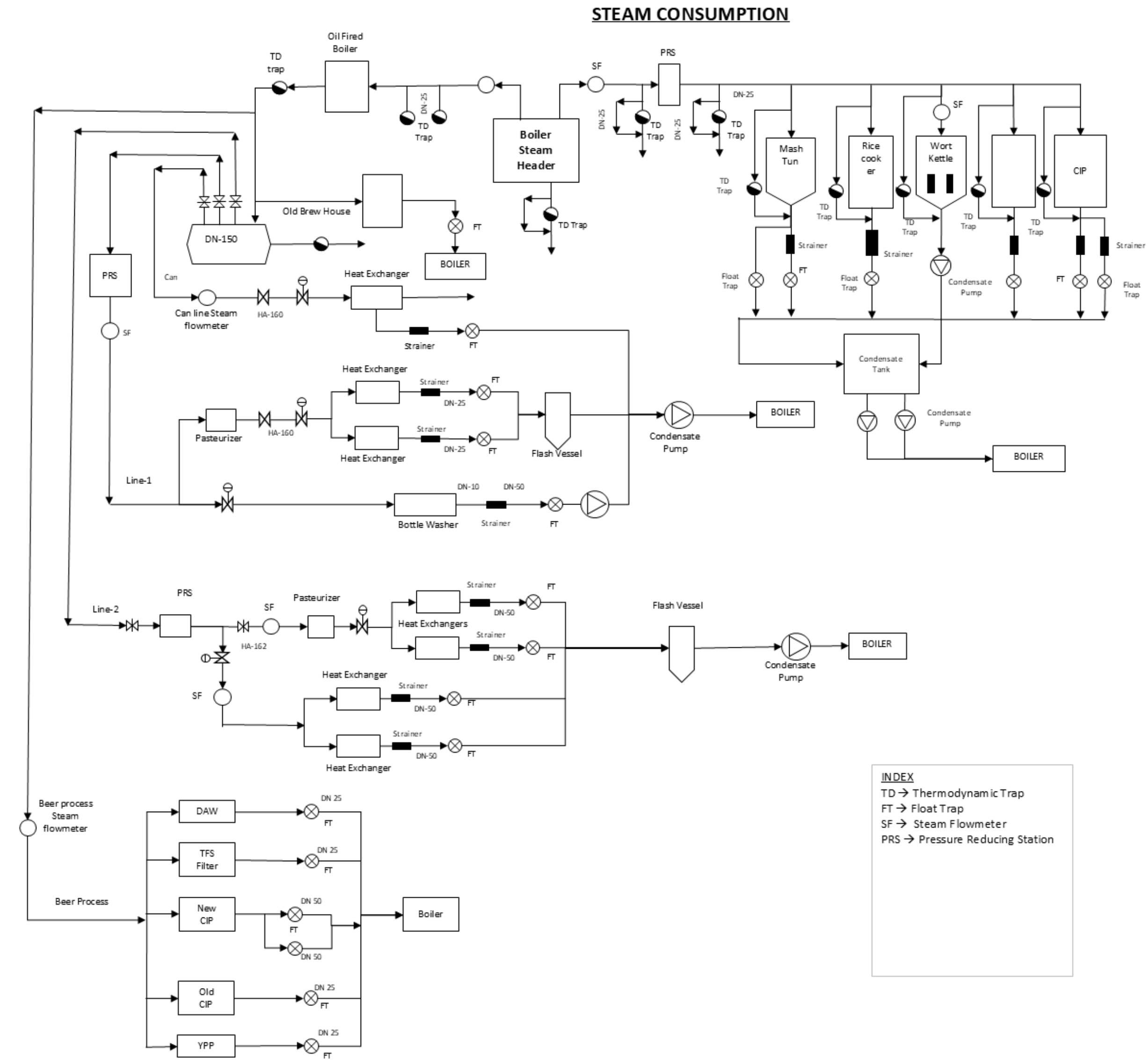

Figure 8.4: Sample of flowchart: Steam Consumption Layout

8.4 Machine Documentation

As part of my internship duties, I was tasked with identifying and documenting the various machines used in the brewery's critical systems, including the boiler, CO_2 plant, Glycol chilling plant, Water Treatment Plant (WTP), and Effluent Treatment Plant (ETP). This documentation process involved gathering key information about each machine, such as the date of manufacture, manufacturer, capacity, model number, and any other relevant specifications. It was crucial to ensure that all machines were properly recorded to maintain an up-to-date inventory of the brewery's equipment.

The documentation was essential for several reasons. First, it allowed the brewery to track the age and condition of each machine, which is important for scheduling regular maintenance and addressing any potential issues before they result in significant downtime. Second, this information helped the engineering team plan for future upgrades or replacements, ensuring that the brewery's equipment remained in optimal working condition and met the growing demands of production. By creating detailed records, I contributed to the brewery's asset management system, supporting efficient decision-making and long-term planning.

Steam Generator				
Name	Biomass Boiler	Biomass Boiler	Diesel Boiler	
Make	Thermax	Thermax	Thermax	
Type			[illegible]	
Equipement Serial No.			[illegible]	
Year	[illegible]	[illegible]	[illegible]	
Capacity (ton/hr)	[illegible]	[illegible]	[illegible]	
Condensate System				
Name	Condensate system(lin	Condensate system(line :	Condensate system	Condensate collecting
Make	Ther[illegible]	[illegible]	[illegible]	[illegible]
Type			[illegible]	
Equipement Serial No	[illegible]		[illegible]	
Year	[illegible]	[illegible]	[illegible]	[illegible]
Capacity (MT)	[illegible]	[illegible]	[illegible]	
Methane gas Burner				
Name	Methane gas burner			
Make	[illegible]			
Type				
Equipement Serial N				
Year	[illegible]			
Capacity (				
Husk handling System				
Name	Husk handling System			

Figure 8.5: Sample of Boiler Equipments Documentation

This task also highlighted the importance of accurate documentation in industrial operations. Properly recorded machine data allows for better coordination between departments, more efficient maintenance schedules, and the ability to quickly identify any equipment-related problems.

8.5 Weekly Running Hours Tracking and Analysis

During my internship, I was responsible for tracking the weekly running hours of various machines across the brewery, including those in the boiler, CO_2 plant, ETP, and chilling plants. I started this task by inputting data from the machine databook into the brewery's computer system, beginning from last December up to the present time. This data was essential for maintaining accurate records of machine usage and performance.

Once the data was entered, I analyzed the weekly and monthly running hours of each machine. I focused on identifying trends or anomalies, such as machines running beyond their recommended operational capacity or showing signs of excessive wear and tear. If a machine was running more than its capacity, it could signal potential inefficiencies, overuse, or a need for preventive maintenance. This analysis was crucial in helping the maintenance team schedule repairs or replacements proactively, thus minimizing downtime and improving overall machine efficiency.

By continuously monitoring and analyzing the running hours, I contributed to optimizing the operational reliability of the brewery. This data-driven approach helped the team ensure that equipment was running at optimal levels, preventing unnecessary wear while enhancing the longevity of the machinery. Additionally, this process supported better maintenance scheduling, ensuring that maintenance was performed when needed rather than reactively addressing failures.

Tracking of running hours on CO2/Air equipment

Accounting object	Units		Jan-25							Total Jan	
		Total 2023	W51	W52	W53	W1	W2	W3	W4		W5
Beer produced	Hl										
Air Compressor											
CO2 Plant											
Mehrer Compressor	hour	23095.9	85.8	49.7	67.1	78.4	63.3	70.2	66.2	480.7	78.7
Spares parts Consumption Cost	NPR									0	
Service Cost										0	
Ammonia Compressor	hour	31865	91.4	59.4	77.4	84.5	71	77.2	69.3	530.2	82.4
Spares parts Consumption Cost	NPR									0	
Service cost										0	
Total spares parts consumption cost	NPR									452798.9	
Total service cost	NPR										

Figure 8.6: Sample of Running hours for Compressor

8.6 Ammonia Safety Standards Review

During my internship, I was assigned the critical responsibility of reviewing documents related to ammonia safety standards and verifying their practical implementation throughout the brewery. Ammonia is a highly hazardous substance commonly used in refrigeration systems, making its safe handling and storage a top priority in the brewery's operations. As part of my duties, I conducted thorough on-site inspections to ensure that ammonia storage areas, pipelines, and associated equipment were in full compliance with established safety regulations.

Key aspects of my review included verifying the proper installation of ventilation systems, checking for the presence and functionality of leak detection systems, and ensuring that all ammonia-related infrastructure was clearly labeled and well-maintained. I also examined the safety protocols in place, such as emergency shutdown procedures and worker training on ammonia handling, to ensure that the brewery had prepared for any potential emergencies effectively.

While I made significant progress in this review process, I was unable to complete the full scope of the work due to limited time. There were some areas that required further inspection and analysis, which I was unable to finalize within my internship period. Nonetheless, my work helped lay the foundation for a more comprehensive safety audit, and I contributed to ensuring that key ammonia safety protocols were in place.

This task required a keen understanding of safety standards and the ability to identify potential risks in complex systems. By conducting these safety checks, I contributed to ensuring that the brewery adhered to both internal safety protocols and industry regulations, which ultimately helped minimize risks and reinforce a culture of safety within the workplace.

	Requirement	Proactive	Total
Yes	39	13	52
No	2	1	3
WIP	12	2	14
N/A	1	1	2
X			13
score	73.58%	81.25%	75.36%

Functional Area	Statement-EN	Audit guideline	Result	Sprint Sequer	Capex (X)
URR – Utilities Roles and Responsibilities	The site using ammonia cooling must clearly define and document ammonia safety responsibilities related to roles present in the site team. The duties to be allocated are: 1. operation and maintenance procedures with supervision over the implementation of those, 2. resourcing the ammonia system with relevant skills and training, 3. providing and maintaining safety equipment and devices in ammonia system, 4. ensuring emergency management procedures are in place, trained and tested.		YES	1	
URR – Utilities Roles and Responsibilities	The detailed allocation of responsibilities by role can be defined as below:		YES	2	
HRC - Hazard, Risk, Consequence	Within risk assessment process the site must ensure as comprehensive as possible identification of process hazards related to ammonia system. Identifying ammonia hazards must involve finding all possible situations of handling and uncontrolled release of ammonia that could potentially cause harm to workers or others and environment, that may occur during routine work, non-routine activities, breakdown and maintenance, or be introduced by employees, contractors, severe external events.		YES	3	
HRC - Hazard, Risk, Consequence	The following hazardous situations and scenarios should be considered: controlled release during operation and maintenance (activities: removal of ammonia from parts of system into other part or outside for maintenance, removal of oil from parts, removal of non-condensable gases from high pressure side, release of over-pressure		YES	4	

Figure 8.7: Sample of Ammonia Process Safety Standard

These assignments gave me valuable insights into the brewery's operations and safety protocols, allowing me to apply my academic knowledge in a real-world setting. Each task enhanced my technical skills and deepened my understanding of the brewery's systems and processes.

CHAPTER 9: CONCLUSION

The industrial attachment at Gorkha Brewery Pvt. Ltd. was an incredibly rewarding experience, offering the chance to connect academic learning with real-world applications. Over the course of the internship, I gained valuable insights into the workings of a modern brewery, from the technical operations of boilers and chilling plants to the detailed processes of water treatment, CO_2 recovery, and effluent management. These systems, crucial to maintaining efficiency and sustainability, provided a solid understanding of the practical side of engineering.

Working closely with experienced professionals not only expanded my technical knowledge but also helped me grow in areas like teamwork, communication, and critical thinking. While the internship came with its challenges such as limited time and restricted exposure to some long-term projects, the experience was still highly enriching. It helped me develop problem-solving skills and understand how to approach industrial challenges effectively.

Overall, this internship was a great learning opportunity that prepared me for the future. It reinforced the importance of innovation and efficiency in engineering while showing me the impact of sustainable practices in today's industries. I'm confident that the lessons I've learned here will guide me as I move forward in my career.

REFERENCES

[1] Boilersinfo. Fire tube boiler. Accessed 10 Oct. 2024. [Online]. Available: https://boilersinfo.com/fire-tube-boiler/

[2] F. Ruchter. (2018) Automation of brewing process. Accessed 15 Oct. 2024. [Online]. Available: https://ruchter.de/portfolio/automation-of-brewing-process/

[3] T. Vergutz, "Fault detection in pid controllers for brewing process," Ph.D. dissertation, 08 2022.

[4] E. Tarleton and R. Wakeman, "Solid/liquid separation equipment," in *Solid/Liquid Separation*, E. Tarleton and R. Wakeman, Eds. Oxford: Butterworth-Heinemann, 2007, pp. 1–77.

[5] P. Institute. (2024) Perlite filter aid in beer filtration. Accessed 15 October 2024. [Online]. Available: https://www.perlite.org/perlite-filter-aid-beer-filtration/

[6] A. Laval. Brux - centrifugal separator for breweries. Accessed 15 Oct 2024. [Online]. Available: https://www.alfalaval.com.au/products/separation/centrifugal-separators/separators/brux/

[7] KHS, "Innoclean dm bottle washer," https://www.khs.com/en/products/machines-equipment/detail/in accessed: 2024-10-15.

[8] G. Brewery. (2024) Brands you love. Accessed 13 Oct. 2024. [Online]. Available: https://gorkhabrewery.com/en/brands-you-love/

[9] ——. (2024) Gorkha brewery. Accessed 13 Oct. 2024. [Online]. Available: https://gorkhabrewery.com/en/