DESIGN OF BAKER'S YEAST PLANT AND PROJECT ECONOMICS

A DISSERTATION

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FOR THE AWARD OF THE DEGREE

OF

MASTER OF TECHNOLOGY

IN

[INDUSTRIAL BIOTECHNOLOGY]

Done at

PRAJ INDUSTRIES LTD, PUNE

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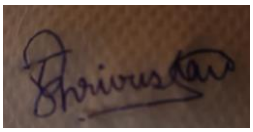

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For Praj Industries Limited

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Jt. General Manager, Human Capital

Yours sincerely

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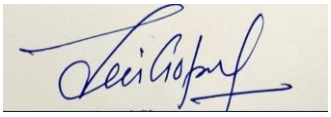

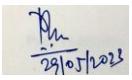

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ABSTRACT

The production of baker's yeast from cane molasses is an essential process in the baking industry. This thesis focuses on the optimization of yeast production from cane molasses and the evaluation of its economic feasibility. The study examines the fermentation process, including the optimization of fermentation parameters such as pH, temperature, and aeration rate to maximize yeast growth and productivity. Additionally, the project economics of the yeast production process are analyzed, including the capital and operating costs, revenue streams, and profitability. The feasibility study also evaluates the economic impact of varying input costs such as molasses, labor, and utilities on the production of baker's yeast. The study concludes with recommendations for the commercial-scale production of baker's yeast from cane molasses, including strategies to reduce production costs, increase product quality, and expand market share. This thesis provides valuable insights into the technical and economic feasibility of baker's yeast production from cane molasses, offering a framework for the development of sustainable and profitable yeast production processes.

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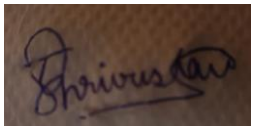

TANYA SHRIVASTAVA

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NOMENCLATURE

μ: Maximum value of specific growth

μ: Viscosity

ρ: Liquid density in Kg/m3

CIP: Cleaning in place

cP: centi-Poise

Da^2: Diameter of the agitator (m)

Di: Diameter (m)

dt: time period of growth of yeast

dx: Growth of yeast

G.V: Gross volume

g: Gravitational constant

H/D ratio: Height to diameter ratio

hp: horse power

Kg/hr.: Kilogram per hour

L: Length (m)

M^3/hr.: Meter cube per hour

MS: Mild steel

MT: Metric tonne

N : revolution per second of the agitator

NR_e: Reynold's no.

P:Power

Pa-S: Pascal-second

PBT: Pitch blade turbine

RPM: Rotation per minute

SIP: Sterilize in place

SS: Stainless steel

Tc: Torque on agitator shaft in Kg-m

Tm : Maximum torque on agitator

W.V.: Working volume

W/W: weight by weight

X_o: initial concentration

Zp: Polar modulus of section of shaft cross section (cm3)

CHAPTER -1

INTRODUCTION

1.1CLASSIFICATION OF SACCHAROMYCES CEREVISIAE

Kingdom	Fungi
Sub Kingdom	Dikarya
Division	Ascomycota
Sub –Division	Saccharomycotina
Class	*Saccharomycetes*
Sub-class	*Saccharomycetidae*
Order	*Saccharomycetales*
Family	*Saccharomycetaceae*
Genus	*Saccharomyces*
Species	*Saccharomyces Cerevisiae*

TABLE NO. 1.1

As members of the fungus kingdom, yeasts are classified as eukaryotic, single-celled microorganisms. Research indicates that yeast has been present for thousands of years, with current recognition of at least 1,500 species. It is estimated that they comprise 1% of all known fungal species.

Yeast's ability to switch from respiration to fermentation makes it a unique microorganism among living organisms. The Crabtree effect is a significant phenomenon to consider when studying yeast. It is observed that even in the presence of oxygen, yeast will opt for the fermentative pathway to metabolise glucose if the glucose concentration is high.

The morphology of yeast cells exhibits variations in shape and size, ranging from oval to round with lengths of approximately 5 to 10 µm and a breadth of 5 to 7 µm. The cell wall is a crucial component of cells as it provides structural support and stability, in addition to facilitating cell-to-cell recognition. The cell membrane functions as a permeability barrier for large solutes and regulates the influx of water into the cell. The protective function of the cell wall extends to safeguarding the yeast cell membrane.

The primary constituents of the yeast cell wall are mannan and glucan. The plasma membrane of a yeast cell is composed mainly of lipids and proteins, with a minor proportion of carbohydrates, and serves as a barrier separating the cytoplasm from the external environment. Cellular regulation is a crucial process as it governs the movement of substances into and out of cells. The cellular organelle known as the nucleus is predominantly composed of deoxyribonucleic acid (DNA) and protein, and is enveloped by a nuclear membrane. The visualisation of the nucleus is achievable through the utilisation of phase contrast microscopy. The periplasmic region denotes the interstitial compartment that exists between the cellular wall and the cellular membrane. The cellular composition comprises of proteins that are secreted but are incapable of traversing the cellular membrane. Certain enzymes situated in this location facilitate the process of catalysing sugars, such as sucrose. The disaccharide sucrose undergoes hydrolysis in the periplasmic compartment catalysed by the enzyme invertase, yielding the monosaccharide; fructose and glucose.

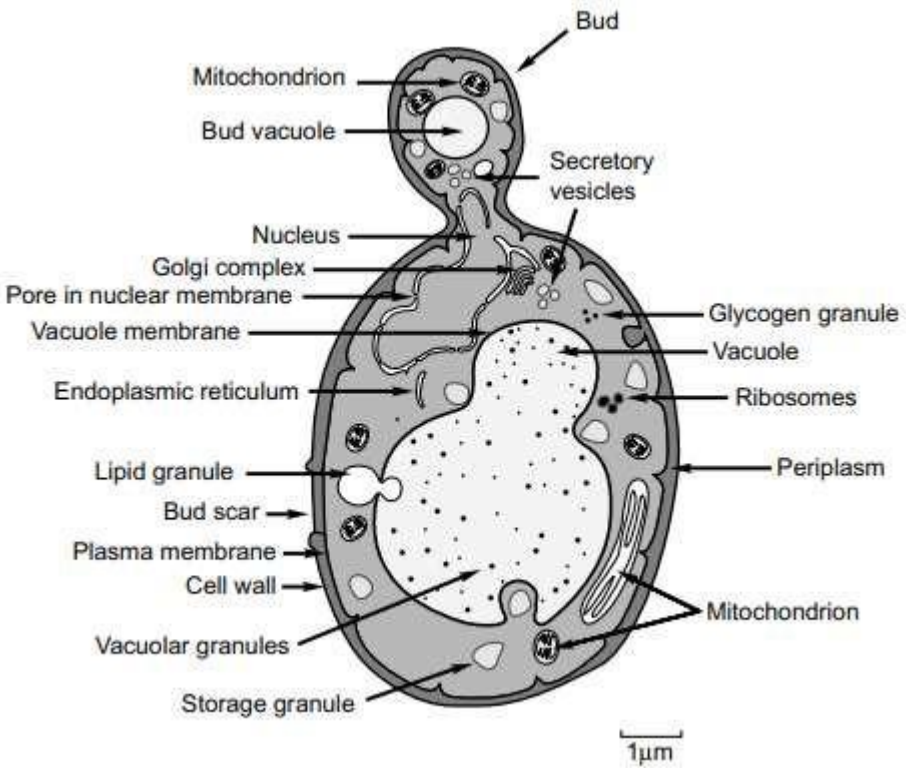


FIGURE NO.1.1.

The visualisation of mitochondria requires the use of electron microscopy. These organelles are composed of two distinct membranes, namely the outer and inner membranes. The inner membrane is folded to form cristae within the mitochondria. The significance of mitochondria lies in the fact that they house the enzymes responsible for the tricarboxylic acid (TCA or Krebs) cycle, electron transport, and oxidative phosphorylation. The presence of self-replicating DNA and protein synthesis systems has been observed in mitochondria. The cytoplasm is the location of ribosomes, which are responsible for protein synthesis. The intramembranous system comprises vacuoles and the endoplasmic reticulum. The morphology of vacuoles undergoes alterations throughout the cell cycle, and they represent the most conspicuous constituent of the cell when observed through a light microscope. Vacuoles are organelles that play a crucial role in storing nutrients and facilitating the breakdown of macromolecules, including proteins. High concentrations of glycogen and lipid granules are commonly observed in the cytoplasm. The visualisation of glycogen under the light microscope can be achieved by staining the cells with iodine.

A yeast cell consists of 75% water and 25% dry matter.

The dry matter consists of:

Carbohydrates	18-44%
Proteins	36-60%
Nucleic acid	4-8%
Lipids	4-7%
Inorganic matter	6-10%
Phosphorous	1-3%
Potassium	1-3%
Sulphur	0.4%
Vitamins	Trace amounts

TABLE NO. 1.1.1. CHEMICAL COMPOSITON OF *S. CEREVISIAE*

Elemental analysis of 100g Baker's yeast would yield the following empirical formula:

$$C_{47}H_{6.3}O_{33}N_8P_{1.2}SALTS_{4.5}$$

1.2. INDUSTRIAL BACKGROUND OF SACCHAROMYCES CEREVISIAE

The use of microorganisms in food processing has been a centuries-old practise, dating back to ancient times. This includes the use of microorganisms in winemaking, beer manufacturing, bread making, and food preservation, among other applications. Interestingly, these practises were implemented prior to the discovery of germs by civilization. The utilisation of yeast in bread-making dates back to approximately 4,000 years ago in Ancient Egypt. Baker's yeast is a widely used type of yeast that is utilised for the purpose of leavening bread on a global scale. Yeasts are a type of unicellular eukaryotic microorganisms that are classified within the kingdom of Fungi. Various applications of fungi are dependent on their origin of isolation. Various sources have been utilised to isolate them, including leaves, flowers, sweet fruits, fruit and berry peels (e.g. grapes, apples, or peaches), grains, fungi, trees, insect dung, and soil exudates. Saccharomyces cerevisiae is a commonly utilised strain of yeast in commercial baking for the production of bread. The yeast products analysed in this research contain approximately 5% lactic bacteria, which have a crucial function in the development of bread taste. Baker's yeast production has significantly increased in the first decade of the twenty-first century, with an annual output of 2.3 million metric tonnes, highlighting its substantial market share. The bioprocess of producing baker's yeast (Saccharomyces cerevisiae) has a long history in commercial production and remains a critical process for the bakery and alcohol industries. India is the second-largest sugarcane grower in the world, following Brazil. According to research, sugarcane production utilises 21% of India's agricultural land. India's top sugarcane and sugar producing states include Maharashtra, Bihar, Haryana, Gujarat, and Tamil Nadu. Sugar mills generate a significant amount of by-products, including cane molasses. Research has been conducted to explore ways of reducing manufacturing costs and utilising more affordable basic components in the formulation of growth media because of the expensive nature of yeast. Diluted cane molasses supplemented with ammonia and other nutrients was determined to be the most effective substrate for this particular application. The feedstock commonly used for bioethanol production has a total dissolved concentration of 80 BriX. Molasses is a viable raw material for ethanol production due to its affordability and accessibility. As a non-crystallisable residue resulting from sucrose purification, molasses does not necessitate starch hydrolysis.

Additionally, molasses is already used in ethanol production, further highlighting its potential as a valuable resource. The utilisation of yeast biomass is commonly observed in animal feed and human nutrition as a protein supplement for both humans and animals. Saccharomyces cerevisiae and S. uvarum are widely studied strains used as sources of single-cell protein. The process of producing yeast biomass for baker's yeast production involves propagating cells from pure culture agar slants to bioreactors of increasing capacity until the final bioreactor volume is achieved. This method is based on the industrial process concept. The primary objective of industrial production is to efficiently convert sugar input into yeast biomass, particularly during the later stages when the volume of biomass is substantial. This is a fundamental principle of the process.

1.**2.1. INDUSTRIAL APPLICATION OF S. CEREVISIAE**

1. Pharmaceutical industry: S. cerevisiae has become a popular model organism for pharmaceutical research and drug discovery. It is used in the development of vaccines, therapeutic proteins, and gene therapies.

2. Bio research: S. cerevisiae is extensively used in genetic research due to its well-characterized genome and ease of genetic manipulation. It is used in studies of gene expression, DNA repair mechanisms, and cell cycle regulation.

3. Environmental technologies: S. cerevisiae is used in environmental biotechnology for the treatment of wastewater, particularly for the removal of heavy metals and organic pollutants. It is also used in bioremediation processes to clean up contaminated soils and water bodies.

4. Biomedical research: S. cerevisiae is used as a model organism in biomedical research for the study of aging, neurodegenerative diseases, and cancer. It has been used to identify genes that affect lifespan, to investigate the mechanisms of Alzheimer's disease, and to screen for potential anticancer drugs.

5. Food industry: S. cerevisiae is used extensively in the food industry for the production of bread, beer, wine, and other fermented foods. It is used to leaven bread dough, to ferment beer and wine, and to produce cheese and other dairy products.

6. Beverage industry: S. cerevisiae is also used in the beverage industry for the production of non-alcoholic beverages such as kombucha and kefir. It is used to ferment the sugars in the beverage, producing a tangy, slightly effervescent drink.

7. Wastewater treatment: S. cerevisiae is used in the treatment of wastewater to remove nutrients such as nitrogen and phosphorus, which can lead to eutrophication and other environmental problems. It is also used to break down organic matter, reducing the biochemical oxygen demand (BOD) of the wastewater.

8. Production of Biofuels: S. cerevisiae can be used in the production of biofuels, such as ethanol and butanol, through fermentation of various carbon sources, including lignocellulosic biomass, agricultural residues, and food waste. This application is of particular interest due to the increasing demand for renewable energy sources and the need to reduce greenhouse gas emissions.

9. Nutritional Supplements: S. cerevisiae is used as a source of various vitamins and minerals, including B vitamins, iron, and zinc. It is commonly used in the production of nutritional supplements and functional foods, as it is a rich source of these essential nutrients.

10. Bioremediation: S. cerevisiae has the ability to remove heavy metals and other toxic pollutants from contaminated soil and water through a process known as bioremediation. This application has significant potential in cleaning up industrial and agricultural waste sites, as well as in mitigating the environmental impacts of mining and other extractive industries.

CHAPTER -2

YEAST GROWTH

2.1 Yeast is a unicellular organism that requires specific nutrients to support its growth and metabolism. These requirements include:

1. *Water*: Yeast cells need water to carry out their metabolic activities.

2. *Carbon source*: Yeast cells use fermentable carbohydrates as an energy source for growth and reproduction.

3. *Oxygen/Lipids:* Yeast cells require oxygen and lipids for membrane biosynthesis. If oxygen is present, yeast can synthesize its own lipids.

4. *Nitrogen source:* Yeast cells need a source of nitrogen, such as amino acids, peptides, or ammonia, for growth and enzyme synthesis.

5. *Vitamins:* Yeast cells require vitamins, including B-complex vitamins, for proper growth and metabolism.

6. *Minerals:* Yeast cells require minerals, such as magnesium, potassium, and zinc, for various metabolic processes.

7. *Inorganic ions:* Yeast cells require inorganic ions, such as phosphate and sulfate, for DNA synthesis and other essential cellular processes.

2.1.1 Vitamins:

Bakers' yeast requires biotin for growth, and compressed yeast contains about 0.75 to 2.5 ppm of this vitamin (dry weight basis). Cane molasses supplies ample amounts of biotin (0.5 to 0.8 ppm); beet molasses does not (0.01 to 0.02 ppm). Therefore, at least 20% of cane molasses has to be blended with beet molasses in the preparation of the feed wort, or the feed has to be supplemented with synthetic biotin.

At current prices for biotin such additions are economically feasible. If urea is used as a source of nitrogen, higher amounts of biotin are required.
Bakers' yeast will adapt to the absence or a deficiency of pantothenate and inositol, but these vitamins are required for optimum growth. They are generally present in sufficient quantities in molasses.

2.1.2. Water:

Yeast, like all living organisms, requires water for growth and development. Water is an essential component of the yeast's metabolic processes, as it is necessary for the proper dissolution of nutrients and sugars that yeast utilizes for energy. The quality of water used for yeast cultivation is critical to yeast growth and fermentation performance. Ideally, the water should be free from impurities, such as minerals, organic matter, and microbiological contaminants. Any impurities in the water can negatively affect the growth and reproduction of yeast, resulting in suboptimal fermentation performance and reduced product quality. In addition to water quality, the pH and temperature of the water are crucial factors that impact yeast growth. Most yeast strains thrive in an acidic environment, with an ideal pH range of 4.5-5.5. The temperature of the water is also important, with most yeast strains growing best at temperatures between 20-30°C (68-86°F).

2.1.3. Nitrogen :

Nitrogen is an essential macronutrient for yeast growth and metabolism. It is required for the synthesis of amino acids, nucleotides, and other important cellular components. Yeast can utilize a variety of nitrogen sources, including ammonium ions, amino acids, and peptides, which are transported into the cell by specialized transporters. The amount and quality of available nitrogen can significantly affect yeast growth and fermentation performance. Inadequate nitrogen levels can result in poor yeast growth, slow or incomplete fermentation, and the production of undesirable flavors and aromas, such as sulfur compounds, acetic acid, and ethyl acetate. Yeast strains can have different nitrogen requirements, with some requiring higher levels of nitrogen than others. Nitrogen requirements can also vary depending on the specific fermentation conditions, such as temperature, pH, and the presence of other nutrients.

To ensure optimal yeast growth and fermentation performance, it is important to provide adequate levels of nitrogen, either through the use of nitrogen-rich ingredients or by adding nitrogen supplements such as diammonium phosphate (DAP) or yeast extract. Diammonium phosphate (DAP) is a common nitrogen supplement used in winemaking and brewing. It provides both nitrogen and phosphorus, which are both essential nutrients for yeast growth. Yeast extract, on the other hand, is a complex mixture of nutrients, including nitrogen, vitamins, and minerals, and can be used to supplement nitrogen in yeast growth media. The nitrogen content of baker's yeast ranges from 6-9%. The optimal concentration is determined by an estimate of the desirable properties. Higher nitrogen levels usually result in more active but less stable yeast, which applies to both compressed and active dry yeasts. The anticipated total yield can be used to calculate the amount of nitrogen to be provided during yeast development.

2.1.4. Oxygen and aeration requirements:

The objective of a baker's yeast plant is to optimise yeast growth while minimising the occurrence of alcoholic fermentation. In order to optimise yeast production, a number of requirements must be fulfilled. Research suggests that in order to avoid catabolite repression, it is necessary to maintain low sugar levels in the fermentor during the fermentation process.

This can be achieved by implementing a carbohydrate-limiting approach. The formation of 1 g of dry yeast mass necessitates the use of 1 g of oxygen. Aeration is the process by which oxygen is introduced into the fermentor. The aeration rate used in this process range is commonly from 0.5VVM to 2VVM.

The role of oxygen as a crucial nutrient in aerobic fermentations has been extensively studied and documented. Compared to other nutrients, supplying it can be challenging due to its limited solubility in water. The provision of oxygen in small shake flasks can be achieved through mechanical agitation of the flask. However, in the case of large-scale commercial fermentors, the supply of oxygen must be facilitated by spargers operating under pressure. In some instances, mechanical stirrers may also be employed to supplement the oxygen supply. The efficiency of a system of transfer of O_2 from air into the fermentor is expressed as the volumetric oxygen transfer coefficient KLa (hr^{-1}), where KL is oxygen transfer coefficient

(m/hr.) and ‘a’ is the interfacial area between the air bubbles and the liquid per unit volume of liquid.

In practice, the rate of oxygen transfer in a given fermentation system and with a given medium is expressed as the mill moles of O_2 transferred per liter per hour. Based on the knowledge it takes 2 g of O_2 to produce 1 g yeast solids. For fermentors without agitation, that is, for simple sparging with air, the rate of oxygen utilization may not exceed 20% of the oxygen.

2.1.5. Carbon source:

Molasses made from sugar cane are most commonly consumed in subtropical regions where sugar cane is cultivated or in locations to where it can be easily transported by sea to other sources of sugar. Molasses made from sugarcane are a common source of raw materials for fermentation in India. This is due to the vast quantities of sugarcane that are produced in the states of Maharashtra, Gujarat, Uttar Pradesh, Haryana, Bihar, Karnataka, and Tamil Nadu, as well as Andhra Pradesh and Andhra Pradesh.

Molasses' value as a food source is a significant factor in determining its market price. The most common application for it in the fermentation sector is in the manufacturing of baker's yeast. Molasses made from sugar cane is now the most cost-effective source of sugars that can be fermented.

Composition of molasses (as percent of total solids)

Composition	Cane Molasses
Fermentable sugar % (w/w)	38-56
F/N ratio	0.8-2
Volatile acidity (ppm)	3500-7500
Caramel (OD @350nm)	0.25-0.5
Butyric acid (ppm)	10-400
F.A.N. (ppm)	500-1500
Sludge content (% w/w)	2-3
Total viable count (cfu/gm)	100-10,000

TABLE NO.2.1.4

Cane molasses is shipped at 80-85 Brix. They have a sugar content that varies between 45% and 55% by weight. As a thumb rule, one can assume that 1000g of molasses will produce 250g of yeast solids.

2.1.6. Minerals:

Molasses is severely low in phosphorus, which is commonly represented as P_2O_5. In general, the concentration of P_2O_5 should be one-third that of nitrogen, or between 2% and 3%. Phosphorus can be given as phosphoric acid or its salts, such as ammonium phosphate. Although molasses contains enough potassium, calcium, and sulphur, some magnesium must be added to the growth medium. The presence of several trace elements is required for yeast development. These have been challenging to establish. The existence of a trace metal in yeast does not prove that it is necessary.

2.1.7. Inorganic ions:

1. Yeast requires certain inorganic ions for its growth and fermentation processes.

2. The specific requirements for these ions can vary based on several factors, including the yeast strain being used, the composition of the growth media, and interactions with other constituents.

3. Among the important cations required by yeast are zinc, manganese, magnesium, calcium, copper, potassium, and iron. These cations play critical roles in enzyme function, DNA synthesis, and protein synthesis.

4. The availability and concentration of these cations can significantly impact yeast growth and fermentation. Zinc deficiency can lead to reduced yeast growth and ethanol production, while excess copper can be toxic to yeast cells.

5. Interactions between different cations can affect their availability and uptake by yeast, further emphasizing the importance of maintaining a balanced composition of the growth media.

2.1.7. Effects of metal ions on yeast viability and vitality

Metal ion	Effect on yeast
Calcium (Ca2+)	Amino acid uptake inhibition above 1 mM and growth inhibition above 25 mM. Reduced rate of ethanol production.
Copper (Cu2+)	Causes changes in the yeast plasma membrane which can lead to the leakage of low molecular weight compounds and disturb the uptake of nutrients.
Iron (Fe2+)	Fe lowers activity of malate, pyruvate and succinate dehydrogenases.
Potassium (K+)	Growth inhibition observed above 10 mM with total inhibition at about 2 M. Fermentation rate may be decreased above 4 – 10 mM
Magnesium (Mg2+)	Total inhibition of growth
Sodium (Na+)	No apparent metabolic role; at high concentrations, specific growth rate is decreased due to the diversion of energy to maintain an electrochemical gradient of Na+ against passive diffusion or facilitated diffusion into the cell.
Zinc (Zn2+)	Deprivation in S. cerevisiae prevents budding and arrests cells in G1 phase of cell cycle. Excess Zn added to wort inhibits fermentation and yeast growth.

TABLE NO. 2.1.7.

2.2. YEAST REPRODUCTION

Yeasts reproduce asexually either by fission or by budding. Depending on this character they are grouped as fission yeasts, Schizosaccharomyces and budding yeasts, Zygosaccharomyces.

2.2.1. Binary Fission:

Fission yeasts divide into two daughter cells while the parent cell elongates, the nucleus separates into two daughter nuclei, and eventually a transverse partition wall is put down fairly in the middle starting from the periphery to the centre.

After cell division, the resulting daughter cells have the potential to either remain in close proximity and undergo further division, or separate and divide independently.

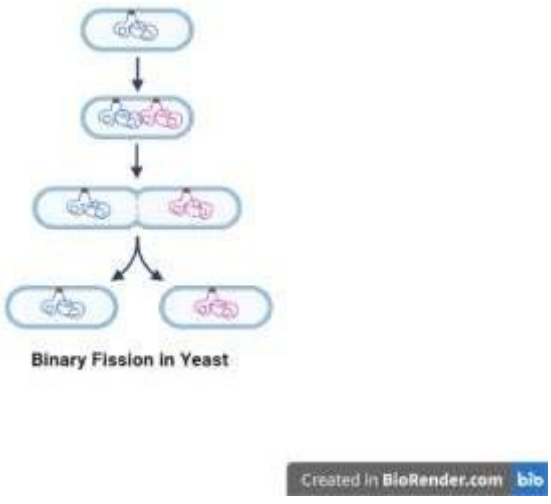


FIGURE NO.2.3.1

2.2.2.Budding:

According to research, budding yeasts are more prevalent than fission yeasts. During the initial stages of budding, a minute section of the cell wall, typically located in close proximity to the end, undergoes a process of softening. According to some sources, the nucleus of a mother cell undergoes mitotic division. During cell division, one of the daughter nuclei moves into the growing bud, causing it to enlarge until it reaches the same size as the original mother cell. Following cell division, the daughter cell undergoes separation from the mother cell, allowing for the possibility of repeated replication without limit.

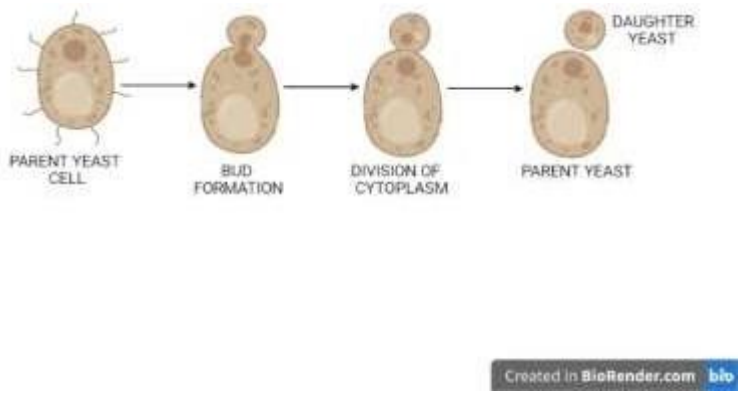


FIGURE NO.2.3.2.

The yeast cell requires energy for three main activities.

1. Chemical energy: to create additional yeast cell components and other complicated biological substances.

2. Transport: The movement of nutrients into and out of cells requires energy.

3. Mechanical energy: In order to move internal structures, cells need energy (such as from budding)

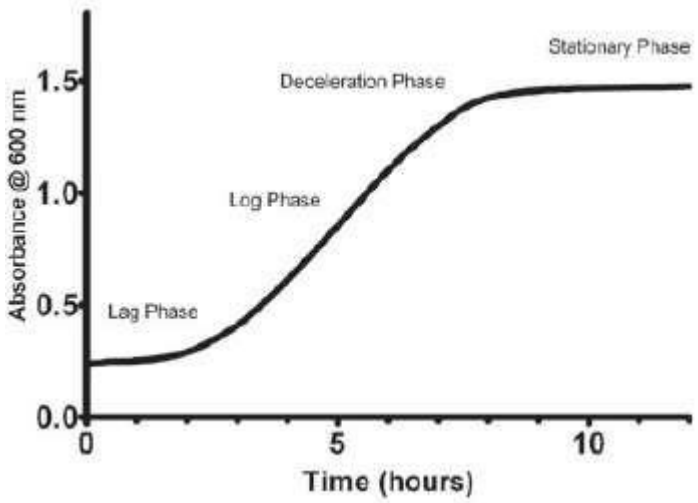
Life Span of Yeast:

The estimation of yeast cell lifespans can be conducted through either the assessment of their replicative potential or the determination of the maximal survival duration of non-dividing cells, also known as chronological lifespan. The study of ageing encompasses two distinct lifespans: the replicative lifespan, which is determined by the total number of cell divisions, and the chronological lifespan, which is determined by the passage of time. These two lifespans are commonly utilised in research to investigate various aspects of the ageing process. This chapter focuses solely on replicative lifespan as it pertains to the budding event and budding patterns. Asymmetric division is a well-documented phenomenon in yeast cells during the process of budding. This process results in the production of daughter cells that possess a full lifespan capacity, originating from mothers.

As a result of cell division, the age of the mother cell is incremented by one, whereas the daughter cell's initial age is established as zero. The replicative lifespan is commonly assessed in experiments by quantifying the total number of bud scars, with an average replicative age of around 30-50 cell divisions.

2.3. BATCH GROWTH OF YEAST

CELL GROWTH PHASES



2.3.1. Lag phase:

In this phase, the yeast undergoes adaptation to its environment and initiates its metabolic processes, including the synthesis of enzymes. During the period of zero growth, there is a significant increase in biochemical activity as the yeast cell adapts to the new environment in the fresh media, following the previous culture conditions. The initial stage leads to in the initial division of the cell.

2.3.2. Acceleration Phase:

During the growth of cells, there is a phase known as the lag phase, which is followed by the acceleration phase before exponential growth begins. The rate of division exhibits a continuous increase. Research indicates that in a brewery environment, the maximum amount of cell multiplication that can occur is typically between 15 to 10-fold, which equates to approximately three generations of cells. It is possible that a small percentage of cells may undergo a fourth generation.

The inability to obtain necessary membrane components is a limiting factor for potential growth. Research has shown that industrial baker's yeast can undergo a 20-fold multiplication when added to well-aerated wort under vigorous aerobic conditions. This is due to the excess of essential lipids generated during the process. The yeast can undergo slightly over four generations under these conditions.

2.3.3. Log phase (exponential growth):

During the log phase of growth, the rate of growth remains constant and reaches its maximum level. During this time, there is a rapid increase in the number of cells through logarithmic cell division. The generation time refers to the duration in which the quantity of cells in a population increases twofold. The generation time ranges from 90 to 120 minutes under ideal conditions. The log phase of yeast can be maintained through the utilisation of 'fed batch' culture conditions, which involves the gradual provision of nutrients in accordance with the yeast's growth. The production of baker's yeast involves the objective of optimising cell mass and minimising ethanol production.

2.3.4. Deceleration phase:

The research indicates that during this phase, the growth rate experiences a decline due to a decrease in nutrients such as carbohydrates and/or an increase in growth inhibitors such as ethanol.

2.3.5. Stationary phase:

During the stationary phase, the population of yeast cells remains stable, indicating a stationary state in terms of the number of viable yeast cells. The balance between the formation of new cells and cell death is a topic of research. During the stationary phase, yeasts are capable of enduring extended periods without any additional nutrients.

2.3.6. Declining phase:

During this phase the death rate of the yeast cells exceeds the birth rate and the total cell number decreases.

When the lag phase is ended the yeast cells propagate unhampered as long as the substrate contains sufficient amounts of all necessary nutrients and the incremental growth of yeast (dx) in the period (dt) can be expressed as:

$$dx = \mu x.\, dt$$

Here, μ is a constant, called the specific growth rate. As long as μ is constant the differential equation above can be integrated giving, with the initial concentration X_o

$$x = X_o{}^{ut}$$

In some cases the incremental growth factor H is used, being equal to the ratio between the yeast quantities after 1 h of growth divided by the yeast quantity at the start of the hour:

$$\frac{Kt+1}{Kt} = e^{u} = H$$

Another expression often used is the generation time, i.e. the time it takes for the yeast quantity to double. From the above equation, we get:

$$2 = e^{\mu T} \text{ or } T = (\ln 2)/\mu = 0.693/\mu$$

For 'active' yeast production, μ is in the range 0.05-0.25 h^{-1}, and in this range the best yield is obtained as the total amount of carbohydrate in the substrate is used for yeast propagation.

The constant μ is substrate dependent and can be expressed by the Monod equation:

$$\mu = \mu m \frac{S}{K+S}$$

With μ being the maximum value for the specific growth rate, S is the concentration of the growth-inhibiting substrate and K is a constant.

2.4. PHYSIOCHEMICAL ENVIRONMENT AND YEAST GROWTH

2.4.1. Temperature

The impact of temperature on yeast growth is a crucial aspect to consider in research, as it is a significant physical parameter. According to research, industrial baker's yeasts exhibit optimal growth within the temperature range of 28-33°C. The temperature range specified is not suitable for industrial processes involving the production of alcoholic beverages and bio-ethanol. The fermentation processes of cider, beer, white and rosé wine are often conducted at temperatures below their optimal range, typically between 10 °C and 25 °C, in order to improve and maintain their flavour. Studies have shown that biofuel production processes are more effective when conducted at temperatures of 40°C or higher, particularly in cases where fermentation processes involve simultaneous saccharification of lignocellulosic feed stocks.

PHYSIOLOGICAL FUNCTION	EFFECT
Cell viability	At high growth temperature of many yeast cells, there is also higher cell death.
Cell morphology	Atypical budding, irregular cell growth & increased cell size.
Cell division & Growth	Growth of non-thermotolerant yeast inhibited at temperature above 40ºC.Actively dividing cells in S-phase are more thermo sensitive as compared to resting cells. Heat shock transiently arrests cells in G-1 phase of the cell cycle.
Plasma membrane	Increased fluidity & reduced permeability of essential nutrients.

Effect of high temperature on yeast growth

2.4.2. pH

Yeast has a preference for acidic conditions, with an optimal pH range of 5.0 to 5.2. However, strains used in brewing and distilling are adaptable to a wider pH range of 3.5 to 6.0. During fermentation, yeast releases H+ ions, leading to a decrease in pH of the surrounding medium. Bakers' yeast is capable of withstanding a relatively broad spectrum of hydrogen ion concentrations, and can grow within a pH range of 3.6 to 6, with the ideal range being 4.5 to 5. Maintaining a lower pH helps to minimize the risk of bacterial contamination.

2.4.3. Oxygen availability

Yeast is capable of growing in both aerobic and anaerobic environments, but the presence of oxygen can significantly impact growth rates and metabolism. In aerobic environments with sufficient oxygen, yeast can produce energy more efficiently through oxidative phosphorylation, resulting in faster growth rates and higher biomass yields. In contrast, in anaerobic environments with limited oxygen, yeast must rely on fermentation to generate energy, which can result in slower growth rates and lower biomass yields. Oxygen availability can also affect the production of secondary metabolites, such as ethanol, which is an important product of yeast fermentation.

2.4.4. Osmotic stress

Yeast is capable of growing in high-sugar environments due to its ability to regulate osmotic balance. However, excessive osmotic stress can lead to inhibition of yeast growth and cell death. Yeast cells can respond to osmotic stress by accumulating intracellular solutes, such as glycerol, to maintain osmotic balance. However, prolonged exposure to high-sugar environments can cause glycerol accumulation to plateau, leading to increased osmotic stress and decreased growth rates. Other factors, such as salt concentration, can also affect osmotic stress and impact yeast growth.

CHAPTER -3

DESIGN BASIS AND PROCESS DESCRIPTION

PROJECT	**:**	Baker's Yeast Plant
LOCATION	**:**	Pune

3.1. DESIGN BASIS

Project Design Basis (PDB) refers to the set of requirements, specifications, and criteria that define the objectives and scope of a project. The PDB is typically developed during the initial phases of project planning and serves as the foundation for the design and execution of the project.

The PDB outlines the key parameters that must be considered when designing and executing the project, including:

1. Technical requirements: This includes the specific goals of the project, the design specifications for the equipment and facilities, and the performance criteria that must be met.
2. Operating parameters: This includes the expected operating conditions, such as temperature, pressure, and flow rates, as well as the expected product quality and production capacity.
3. Safety and environmental considerations: This includes the safety and environmental requirements that must be met, such as the use of proper safety equipment and protocols, compliance with regulatory requirements, and the minimization of environmental impacts.

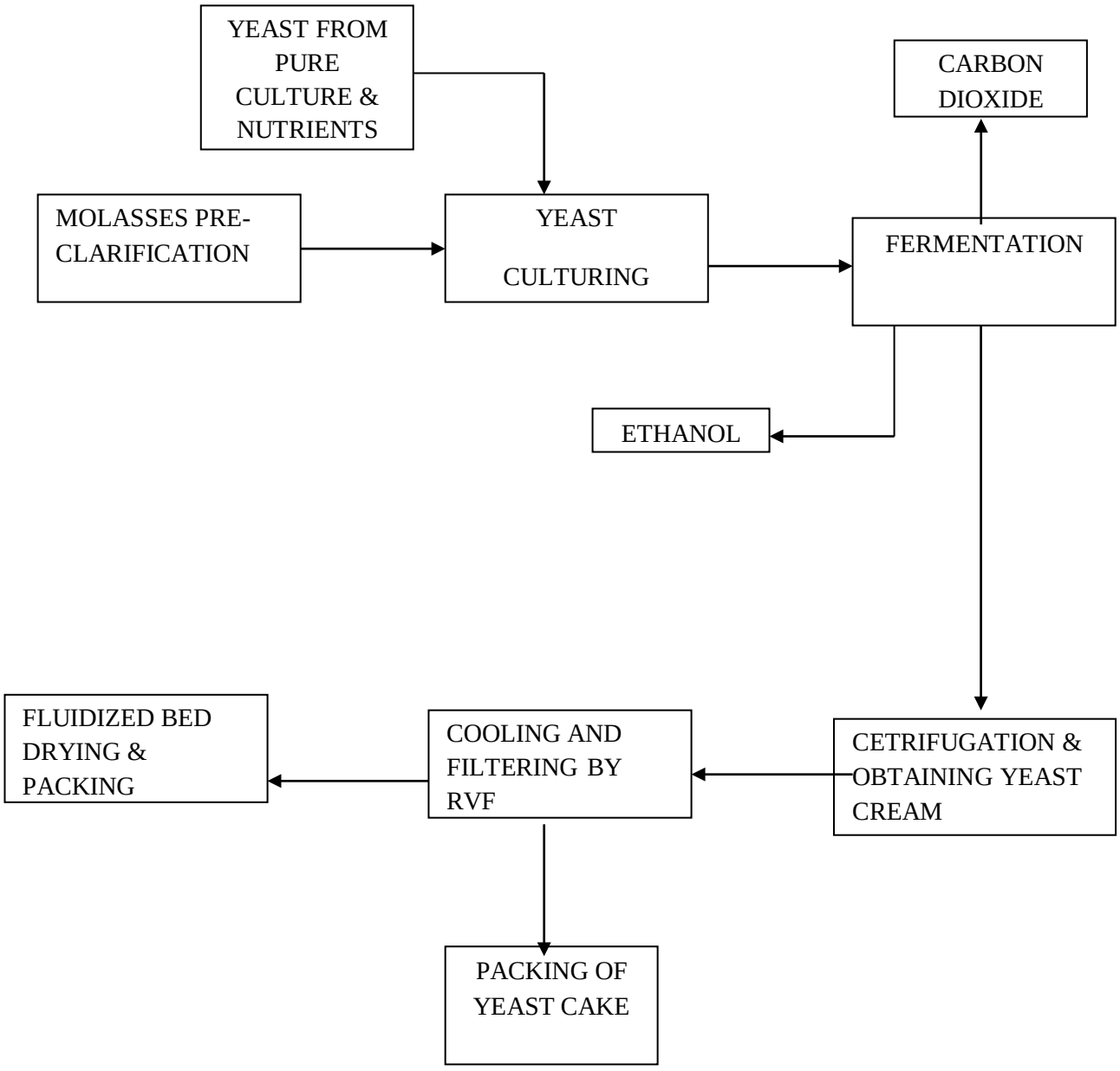
1	Plant Capacity Details	No. of working days- 300 (1410 TPA on compressed yeast basis) Production of compressed cake - 2MT/Day Production of active dried yeast – 1MT/Day
2	Input Specification	Molasses – 45% FS, Brix- 80
3	Output Specification	Compressed Yeast (Wet Cake)-Total Solids 35% w/w ADY-Total Solids 95% w/w
4	Yield	0.55 Kg of Yeast (Dry Basis) per kg of fermentable sugar
5	Sections	Molasses Pre-treatment System treated Molasses Storage System Seed Preparation Section Fermentation Section Centrifuge Filter Press Drying Wet Cake Storage Section ADY Storage Section CIP SIP

6	**Molasses pre-treatment**	Sludge Content in molasses: 6% total w/w Sugar loss in molasses clarification system: 2.5% Dilution of molasses: Up to 28Brix pH Correction:4.5 Heating of molasses: 75 °C **Sterilization of molasses:** Sterilization Temperature- 120 °C Flashing Temp.-90 Deg. C
7	Treated molasses Storage System	Molasses collection tank No.-1 Residence time- 3hrs.

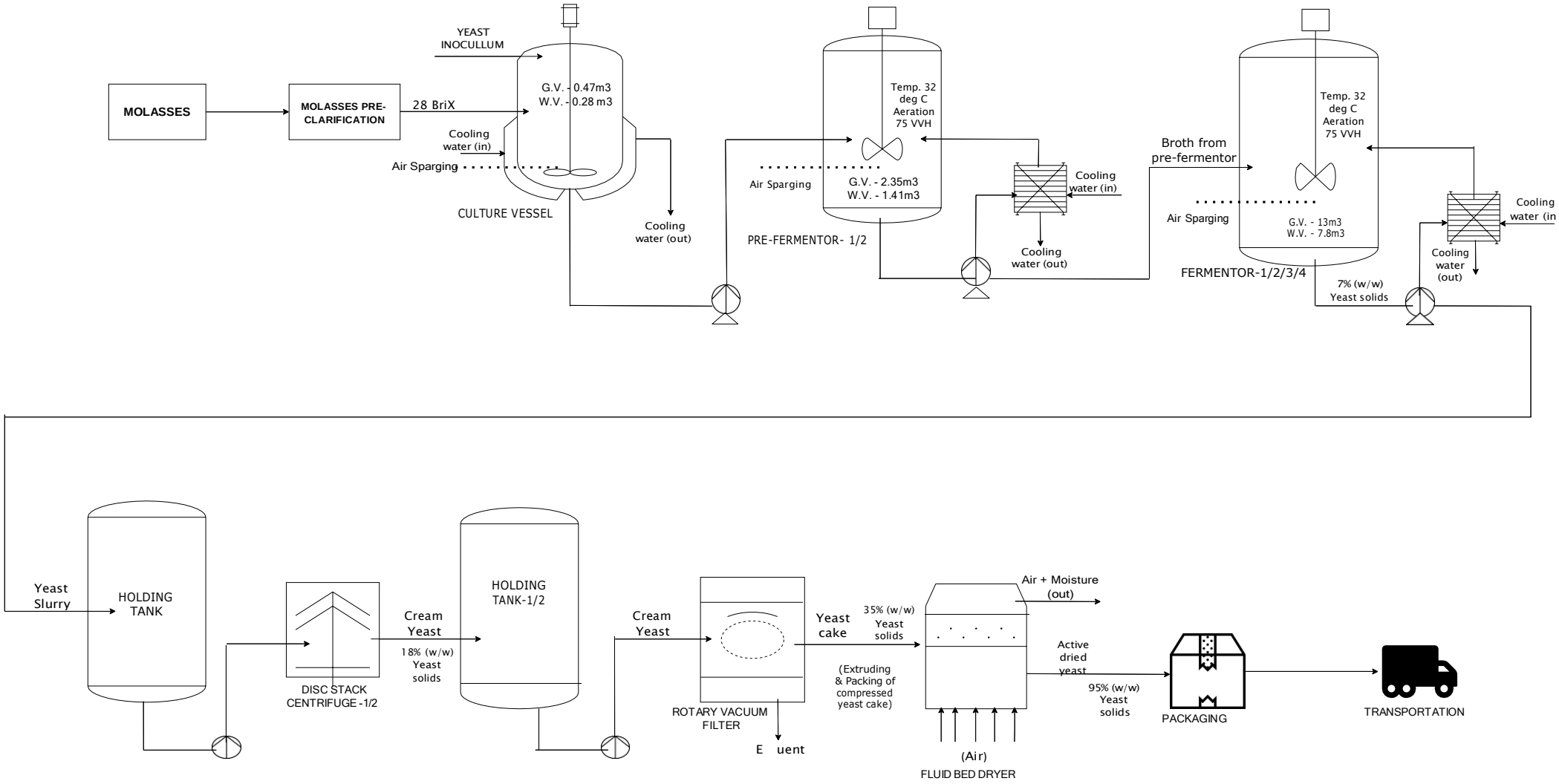
8	Seed preparation	Fed Batch System **Key Equipment:** Broth Mixers, Culture Vessels, Seed Preparation Tank, Plate heat exchanger coolers **Aeration Ratio: 75VVH**
9	Centrifuge	Continuous- Disc Stack Yeast Centrifuge no. in series. – 2 Yeast Cream con. Outlet of centrifuge- 35% w/w total solids
10	Fermentation Section	Fed batch System **Key Equipment:** Slurry Tanks,Coolers,Fermentors **Aeration Ratio: 75VVH** Yeast conc. In fermented wash- 7% w/w Pre-fermentor Cycle – 12 hrs.
	Filter Press	12 hr./day Operation Type: **RVF (Rotary Vacuum Filter)** 35% w/w compressed yeast cake
	Drying	One extruder is present before drying Dryer type: Fluidized Bed Dryer 95% w/w active dried yeast
	Compressed Yeast (Wet Cake) Storage Section	4 Days Storage Storage Temperature- 4 Deg. C Yeast solid conc. in cake = 35%w/w
	CIP	3 steps CIP
	SIP	As and when required

TABLE 3.1. DESIGN BASIS

3.1.1. BLOCK DIAGRAM



PROCESS FLOW DIAGRAM



3.2. PROCESS DESCRIPTION

3.2.1. Molasses Handling and Storage

The raw molasses in yeast factories is stored in large storage tanks and no preservative is required due to higher solids concentration (80 BriX). It is common to have enough stock to cover several months of production. However, it is critical that the temperature of the molasses in the tanks not rise too high. Molasses have a typical viscosity of 40,000-50,000CP (centipoise). For such higher viscosity positive displacement pumps like gear type, screw type etc. are used.

Fig no. 3.2.1. Molasses Storage tank

3.2.2. Molasses pre-clarification

Raw molasses is pumped from collecting vessel via pump into heating vessel. Before entering heating vessel raw molasses is passing from a static mixer where it is diluted with hot sweet water from sludge preparation.

The mixture is heated up by live steam to about 90 degree C and is flowing into sedimentation vessel.

Most of the sludge is sedimented in this tank and extracted to sludge dilution tank. Sedimented molasses is flowing into intermediate tank and pumped through the plate cooler to fermentation. Hot water from distillation is fed with a pump into sludge dilution tank.

Also Diluted Sulphuric acid is fed into this tank. Sludge solution flows into sludge sedimentation vessel and sedimented sludge is extracted to drain.

Clear sweet water from sludge sedimentation vessel is flowing into intermediate tank and is pumped by pump into static mixer for molasses dilution.

BriX Concentration requirement for 7% (w/w) yeast solids;

If 2 kg Fermentable sugar yields 1 Kg Yeast,

Then in another words, for 1 kg Yeast production 2 Kg fermentable sugar (FS) will be required.

For 7 % (w/w) Yeast solids 14% (w/w) Fermentable sugar will be required.

η = 85% (Pump efficiency)

$$7\ \%\ (w/w) = \frac{14}{0.85}$$

= 16.47% FS

If molasses is of 80 BriX

And from 80 BriX 45% FS is being obtained.

$$= \frac{80}{45} * 16.47$$

= 28 BriX is required

3.2.3. Fermentation

Pure stock cultures are maintained in a laboratory, a small flask of sterile fresh culture is prepared after one or more sub cultivations. This sample is then inoculated into the first pure culture tank known as pure culture vessel.

The pure yeast culture is mixed with the clarified molasses in the culture vessel where mixing of the substrate is done. Large amount of heat is produced during aerobic fermentation of yeast so the culture vessel is jacketed to regulate the heat and temperature.

With the help of a gear pump the broth is transferred to the pre-fermentor, the temperature is regulated at 32 degree C and aeration is 75VVH. The pH is adjusted to 4.5 with automated supply of Diluted Sulphuric acid at regular intervals. The media is fermented for 12 hours.

The two tanks mentioned above (culture vessel and pre-fermentor) are normally placed in a separate room, where all precautions can be taken to avoid microbial contamination, and the substrates (i.e. the water and the air) can be sterilized before use.

The broth from pre-fermentor is then transported to the fermentor for 12 hours where substrate is being fed continuously. The heat generated from fermentation is removed by recirculating the fermented mash through external heat plate exchanger.

A major part of fermented mash leaving the main fermentor is fed to nozzle separators and the yeast is removed. 7% (w/w) yeast cell mass is being produced.

Baker's yeast fermentation produces 3.5–4.4 kcal/g of produced yeast solids, which is a lot of heat. In order to achieve the necessary extensive cooling, jacketed fermentors or plate heat exchangers are typically used. The stirring speed of Pitch blade turbine agitator is taken as 200rpm, aeration rate is 0.5-2 VVM.

3.2.4. Centrifugation and washing of yeast cells

After the yeast is fermented and 7% (w/w) yeast cell mass is produced, the broth is then pumped out to the holding tank where it is kept for 8 hours.

From holding tank the solid yeast cell mass is then transferred to Centrifuge -1 (Disc stack centrifuge) where centrifugation occurs and the yeast solid concentration is increased from 7 %(w/w) to 18% (w/w). It is then transferred to another holding tank.

The colour of yeast is still in dark brown colour. To make the colour lighter according to market standards, the yeast solid is diluted back to 7% (w/w) by adding potable water to it.

The yeast solid cell mass is again transferred to a centrifuge –2 where centrifugation occurs and the yeast solid concentration is increased from 7%(w/w) to 18% (w/w).

The colour obtained now is finally beige in colour.

3.2.5. Filtration (by Rotary Vacuum filter)

After centrifugation of yeast is done and cream is separated from water, the cream is passed through a Rotary vacuum filter with the help of a pump. The filter consists of a rotating, hollow, segmented drum covered with a fabric or metal filter which is partially immersed in a trough containing the broth to be filtered. The yeast slurry is fed on to the outside of the revolving drum and vacuum pressure is applied internally so that the filtrate is drawn through the filter, into the drum and finally to a collecting vessel. The filtrate (water) that passes through filter cloth is collected through collection pipes and sent to effluent treatment plant.

The final concentration of yeast solids present after filtration was 35% (w/w).

3.2.6. Extrusion and *Cake packaging*

After the Yeast is filtered, the shape is not defined and it is sloppy in nature. The yeast cake is mixed with oils, emulsifiers like Sorbitan Monostereate (SMS) in 1 %(w/v) ratio, and a small amount of water, then compressed and extruded into blocks and packed in 1kg- or 0.5-kg packages for bakers, or in smaller units of 50 g, 100 g or similar for home-baking and, eventually, the yeast may be granulated and packaged in 25-kg bags for large-scale consumers.

The compressed yeast cake is packed in bags which have doesn't have permeability to the carbon dioxide and air as yeast cake becomes foul on being exposed to air and its quality and taste will degrade. The yeast cake is stored at temperature ranging from 4-8 degree C. The compressed yeast must be kept cold during production, packaging, storage and shipping as it is highly perishable condiment and starts to spoil at high temperatures. The yeast count in the compressed yeast typically ranges from 6 to 13 × 10^9 cells/mL at 33% total solids.

It has a shelf life of about 4 to 6 weeks under storage conditions generally referred to as cool and dry.

3.2.6.1. Stability of Compressed yeast:

At 5° to 8°C in the refrigerator, compressed yeast has a good level of storage stability. Stability is somewhat influenced by processing conditions; for example, storage stability is favoured by yeast with low nitrogen contents and a low percentage of budding cells (less than 5 to 10%).

Over the course of a week, gassing activity typically declines by 3 to 5%. Moisture loss during storage is possible. A small rate of endogenous carbohydrate respiration results in a relative rise in the nitrogen content of stored yeast and a slight drop in this fraction.

Compared to yeast with nitrogen levels of 7% or below, compressed yeast with nitrogen concentrations exceeding 8% (based on solids) has a shorter shelf life.
A liquid yeast cream could be successfully stored at 4 to 6 degrees Celsius for 10 days and at 20 degrees Celsius for one day. The activity of Finnish compressed yeast did not decrease during storage at 23°C, but it drastically decreased after two weeks.

Approximately one-third of the gassing activity was lost after two days of storage at 35°C. Maltose fermentations typically result in a larger loss of activity than those involving the fermentation of glucose, fructose, or sucrose.

3.2.7. Fluidized Bed dryer

After obtaining compressed yeast from centrifugation, the yeast cake blocks are then passed through an extruder and yeast 'noodles' are obtained. The noodles are then placed in a sieve, covered and shaken to break them.

The strained yeast obtained is in granular form. The drying process consists of three phases. In the first phase dryer is loaded with granulated material to be dried. Then drying temperature is increased to initiate constant drying phase.

3.2.7.1. Active Dried yeast packaging

The vast majority of batch ethanol plants rely on active dry yeast. Additionally, it is used to supplement fermentors and establish continuous plants. This yeast is dried at 45 to 55 °C in an environment of inert gas, often nitrogen, while under partial vacuum. The lengthy shelf life of dried yeast (92–96% dry weight) eliminates the need for cold storage, though it can be chilled for improved protection.

A viable cell density of 2.2×10^{10}cells/g is typical for active dry yeast.

The dry yeast is normally packaged in 10g, 50g, 100g, and 500g packs of laminated aluminium foil in vacuum or inert gas. If CO_2 is used this gas will be adsorbed to the yeast particles and thereby cause a vacuum.

The baker's active dried yeast, Saccharomyces cerevisiae is a granular product and the drying operation reduces the moisture content from 65–70% to 4–6%. The yeast has a shelf life of 1 year.

CHAPTER -4

4.1. FERMENTOR DESIGN CRITERIA

The basic design of any equipment in biopharmaceutical or pharmaceutical industry should be considered as below:

4.1.1. Sterilizability – To destroy live bacteria or microorganism present as contaminant in given equipment, it is done by bringing to a high temperature of steam, dry heat or boiling liquid and also ensuring that no microbes other the production organism is to enter the equipment after it has been sterilized. Generally, the shape of double mechanical seal present is similar to the petri plate structure, which resembles swan neck like structure, it seals the equipment in such a way that there is no outlet for the contaminating agents to enter.

4.1.2. Cleanability- It is the ability to be cleaned easily without damage. The process fluid present in the system cannot introduce any unacceptable material to any equipment.

4.1.3. Controllability- The vessels and the subsystem is designed in such in a way which makes it possible to control the environmental variables within operative range required. That means the mechanical harmony with control system.

4.1.4. Typical Fermented Broth consists of the following:

Cells (live and dead)

Peptides

Nucleic Acids

Proteins

Unutilized Carbon sources

Cellular Enzymes

Lipids etc.

General	Scope applies to components and systems that are in contact with the product, raw materials or product intermediate during manufacturing.
Design	• Process compatibility, CIP,SIP , drain ability and dead leg criteria • Design Conformance testing to be performed during FAT & SAT
Materials	Materials Selection to maintain purity and integrity of the product/process Materials fluid
Dimension and tolerances	Pressure ratings, wall thickness, dimensions and tolerance as per ASME BPE 2016 guideline.
Process Instrumentation	• Accuracy and response time to be matched with the process requirements. • Designed in such a way that a failure will not cause contamination hazards to the process and environment
Sealing components	Design and construction to ensure process compatibility, permeation resistance, surface finish, particle generation and lubrication requirements.
Process contact surface finishes	All process contact surface to be electro polished and passivated. All SS 316L process contact surface shall be electro polished to RA $\leq$ 0.38 µm.
Certification	• MOC, Surface finish, sizing, calibration, performance, drawings, catalogues. Vendor to submit QAP along with DQ for approval

TABLE NO. 4.1. PRELIMINARY DESIGN CRITERIA

A fermentor is a vessel that provides a controlled environment for the growth and maintenance of microorganisms or cells. This technology has been utilized in various fields, including pharmaceuticals, food and beverage production, bioremediation, and bioprocessing. Fermentors come in various sizes and designs, ranging from small laboratory-scale systems to large-scale industrial systems, and are typically constructed of stainless steel or glass. The key features of a fermentor include temperature and pH control systems, agitation systems, aeration and gas control systems, sampling ports, and monitoring and control systems. The temperature control system ensures that the temperature inside the fermentor is maintained at a specific level for optimal growth and metabolism of the microorganisms. Similarly, the pH control system maintains the pH level of the fermentation medium, which is critical for the growth and metabolism of microorganisms. The agitation system helps to distribute oxygen and nutrients evenly throughout the fermentation medium, and prevent the formation of dead zones. The aeration and gas control system ensures that oxygen is supplied to the microorganisms in the appropriate concentration. The sampling port and monitoring and control systems enable the measurement and adjustment of various parameters, such as cell density, product concentration, and nutrient levels, to ensure optimal fermentation conditions.

4.2. INPUT PARAMETERES:

1. Working Volume - It is defined as 75% of total amount of space occupied by the 3D Structure of the fermentor as determined by the principles of geometry and it is expressed in the terms of litres. The percentage of space is generally determined by the aeration rate and foaming tendency of the media. The working volume of yeast fermentor is generally in the ratio of 60:40, i.e. 60% space is occupied and rest 40% is left for aeration.

2. Geometric Volume- It is defined as total space occupied by 3D structure of the fermentor as expressed by principles of geometry and expressed in terms of litre.

3. H/D ratio- For a microbial fermentor general ratio of the fermentor is 2:1, 2.5:1 as aeration requirement is very high.

4. Other Parameters- Vessel Diameter , Tan height

FERMENTOR V/S FERMENTER

A fermentor is equipment in which fermentation takes place whereas; a fermenter is a catalyst which helps to initiate the fermentation process. A fermenter is generally of microbial origin like Saccharomyces cerevisiae etc.

PARAMETERS AND CONTROL DEVICES

PARAMETERS	**CONTROL DEVICES**
Temperature	• Heat Exchangers (in some cases) • Temperature sensor • Circulation pump (in some cases) • Valves
pH	•pH sensor • Acid & alkali dosing pump • Acid and alkali dosing bottle • Valves
Pressure	• Pressure sensor • Gas Inlet & Outlet valves
Conductivity	Conductivity sensor
Level	• Level sensor (Load Cells, Differential Pressure Transmitter, Radar Level sensor) • Transfer Out Valves & Transfer In Valves
Agitator RPM / Mixer RPM	• Motor • Variable Frequency Drive

TABLE NO. 4.2.

Sequences applicable for Microbial Fermentor

SEQUENCES	PURPOSE
Valve Test	To ensure proper functioning of valves
Pressure Hold Test	To ensure that fermentor is a leak-free device
Mechanical Seal Sterilization	To sterilize mechanical seal and keep it pressurized for next steps
Inlet air filter sterilization	To sterilize inlet air filter and keep it ready for next steps
Exhaust air filter sterilization	To sterilize exhaust air filter and keep it ready for next steps
Empty Vessel Sterilization	To sterilize the fermentor in empty condition, by direct passage of clean steam
Full Vessel Sterilization	To sterilize the fermentor along with media, by indirect passage of plant steam in jacket
Independent Sterilization of transfer lines	To ensure that all transfer lines have been sterilized and are ready for transfer
Calibration	Calibration of sensors [pH, Level, DO]
Inoculation	To inoculate seed culture
Fermentation	Control of Temperature, pH, Dissolved oxygen, Agitator RPM , Foam, Pressure , Gas flow rate, Level, such that it is optimal for growth of microorganisms.
Sampling	To sterilize sampling line and withdraw sample in sterile condition
Harvesting	To sterilize harvest line and withdraw broth in sterile condition.
Cleaning-In-Place (CIP)	To ensure proper cleaning of equipment and to avoid any carryover of previous batch.

TABLE NO. 4.3.

Fig 4.1. A typical 100 liter fermentor by Praj HiPurity Systems

4.3. UTILLITIES

In industrial processes, utilities refer to services or systems that support the operation of the plant or equipment. There are two main categories of utilities: clean utilities and black utilities.

Clean utilities are systems that come into direct contact with the product or process and must be free of any contamination. These utilities include purified water, steam, compressed air, nitrogen, and other gases used in the production process.

Black utilities, on the other hand, are systems that do not come into direct contact with the product or process and do not need to be free of contamination. These utilities include HVAC systems, electrical power, lighting, and wastewater treatment.

4.3.1. CLEAN UTILITIES

- Clean Steam (CS) – Used for empty vessel sterilization (ESIP) and other online on line sterilization during the process like transfer line sterilization and sampling line sterilization.
- Water for injection (WFI) – used during dilution of media and final rinse of Cleaning in place (CIP).
- Purified Water (PW) – Used in different cycles of CIP.
- Filtered Process air - Used for maintaining Dissolved Oxygen (DO) concentration in fermentor and pressurized vessels.
- Filtered Gases – Used in fermentor of various operations like pH maintenance, DO calibration etc.

CLEAN UTILITY PARAMETERS

UTILITIES	PURPOSE	TEMP.	PRESSURE	VELOCITY
Pure Steam	ESIP / Independent SIP	133.54 ◦ C	2 bar (g)	24 to 30 m / sec
CIP Solution	Cleaning of equipment	80 ◦ C to 90 ◦ C	2 bar (g)	2 to 3 m / sec
Purified Water	Cleaning of equipment	30 ◦ C	2 bar (g)	2 to 3 m / sec
WFI (Water for Injection)	CIP / Batch preparation	85 ◦ C to 90 ◦ C	2 bar (g)	2 to 3 m / sec
Process Air	Aeration of batch / Pressurization / Drying / Bone drying	30 ◦ C	2 bar (g)	16 to 20 m / sec
Instrument Air	Operating pneumatic valves	30 ◦ C	6 bar (g)	16 to 20 m / sec
Nitrogen	Pressurization / Drying / Gassing	30 ◦ C	2 bar (g)	16 to 20 m / sec
Oxygen	Pressurization / Drying / Gassing	30 ◦ C	2 bar (g)	16 to 20 m / sec
Carbon Dioxide	Pressurization / Drying / Gassing	30 ◦ C	2 bar (g)	16 to 20 m / sec

TABLE NO. 4.3.1.

4.3.2. BLACK UTILITIES

- Plant Steam (PS) – Used for full vessel Sterilization (FSIP) and temperature maintenance during process or CIP.
- Chilled Water (CHW) - Used for cooling after ESIP or FSIP. These are also used for temperature maintenance purpose.
- Cooling water (COW) - Used for cooling after ESIP or FSIP. These are also used for temperature maintenance purpose.
- Chilled glycol (CHG) - Used for cooling after ESIP or FSIP. These are also used for temperature maintenance purpose.
- Chilled Brine (CHB) - Used for cooling after ESIP or FSIP. These are also used for temperature maintenance purpose.
- Hot Water (HW) – Used for temperature maintenance during the process.
- Superheated Water (SHW) - Used for full vessel sterilization in case plant steam is not available. This can also be used as heating mediums in heat exchanger and maintaining the temperature of the vessel by passing through the jacket.
- Raw Water (RW) - Used for generation of soft water and in kill tank systems for cooling after inactivation.
- Soft Water (SW) - Used for purified water generation and for cleaning in kill tank systems.

BLACK UTILITY PARAMETERS

UTILITIES	PURPOSE	TEMP.	PRESSURE	VELOCITY
Plant Steam	FSIP / Process Temperature maintenance	143.63 ◦ C	3 bar (g)	24 to 30 m / sec
Chilled Water	Cooling after FSIP / Temp. maintenance	6 ◦ C to 10 ◦ C	3 bar (g)	2 to 3 m / sec
Cooling water	Cooling after FSIP / Temp. maintenance	20 to 30 ◦ C	3 bar (g)	2 to 3 m / sec
Warm Water	Temp. maintenance	35 ◦ C to 50 ◦ C	3 bar (g)	2 to 3 m / sec
Soft Water	Cooling after FSIP / Temp. maintenance	20 ◦ C to 30 ◦ C	3 bar (g)	2 to 3 m / sec
Brine	Cooling after FSIP / Temp. maintenance	- 10 ◦ C to 5 ◦ C	3 bar (g)	2 to 3 m / sec
Thermic Fluid	Cooling after FSIP / Temp. maintenance	Any temp.	3 bar (g)	2 to 3 m/ sec

TABLE NO. 4.3.2.

4.4. CIP – CLEANING IN PLACE

CIP is a method of cleaning the interior surfaces of process equipment and fittings, without disassembling them. Industries like Milk, Brewery, food, pharmaceutical, cosmetics etc. rely hugely on CIP for hygiene purposes. There are generally 3 step CIP process and 5 step CIP process. 3 Step CIP process is involved in food and brewery industry whereas, 5 step CIP is involved in pharmaceutical, cosmetic industry where sterility is required.

For Baker's yeast plant generally 3 Step CIP is considered:

Step 1: Pre-rinse

The first step in the CIP process is a pre-rinse, which involves flushing the equipment with water to remove any residual product or debris. This step aims to remove the bulk of the soil and prepare the surface for further cleaning. The water used in this step should be warm and have a pH level appropriate for the cleaning solution used in the subsequent steps. Typically, the pre-rinse is carried out for 5-10 minutes, depending on the nature and extent of the soiling.

Step 2: Cleaning

After the pre-rinse, the equipment is ready for the cleaning step, which involves the use of a cleaning solution. The cleaning solution is typically a mixture of water and cleaning agents such as caustic soda, acid, or a combination of both. The cleaning solution is circulated through the equipment for a specific period of time, usually 30-60 minutes, at a temperature and pH level suitable for the type of soiling and equipment being cleaned. The cleaning solution removes the remaining soil, including proteins, fats, and carbohydrates, from the equipment surfaces.

Step 3: Rinse

The final step in the CIP process is a post-rinse, which involves flushing the equipment with water to remove any residual cleaning solution. This step is important to ensure that no cleaning agent or residue remains on the equipment surface, which could contaminate the next batch of product. The post-rinse typically lasts for 10-15 minutes, and the water used should be at the same temperature and pH level as the pre-rinse.

4.5. SIP – STERILIZATION IN PLACE

It is a widely used process in various industries, particularly in the biopharmaceutical and food industries, for the sterilization of equipment and vessels. SIP refers to the sterilization of equipment and vessels in their installed location using high-temperature steam, without the need for disassembly or removal from the process line. This method is advantageous as it minimizes the risk of contamination, reduces downtime, and saves costs associated with disassembly and reassembly of equipment.

SIP typically involves these main steps: . Pre-SIP cleaning, SIP, and post-SIP verification. The pre-SIP cleaning step is crucial to remove any debris, product residues, or biofilms that may interfere with the sterilization process. The cleaning process is typically performed using a cleaning-in-place (CIP) system, which involves the circulation of cleaning solutions through the process equipment.

After the pre-SIP cleaning step, the equipment is ready for sterilization. The SIP process involves the introduction of high-temperature steam into the equipment, typically at a temperature of 121-122°C and a pressure of 1-3 bar, for a predetermined period of time. The exposure time required for complete sterilization depends on various factors, including the equipment design, size, and configuration, and the type and amount of microorganisms present. The equipment must be held at the sterilization temperature for a sufficient time to ensure complete kill of all microorganisms, including spores.

CHAPTER-5

5. MATERIAL BALANCE

The law of conservation of mass leads to what is called a mass or a material balance.

Mass In = Mass Out + Mass Stored

Basis: 1MT/day active dried yeast

2MT/day compressed yeast cake

Losses to be considered:

1. Pre-treatment = 1.5% loss of sugar
2. Fermentation efficiency = 85% efficient
3. Washing and centrifugation = 1% yeast loss
4. Process plant/ dryer = 1% yeast loss

Considering moisture content of 5% in ADY (active dried yeast)

Moisture content in compressed yeast cake = 65%

So, total yeast on dry basis will be;

= (1000 x 0.95) + (2000 x 0.65)

=1650 kg yeast solids will be produced per day

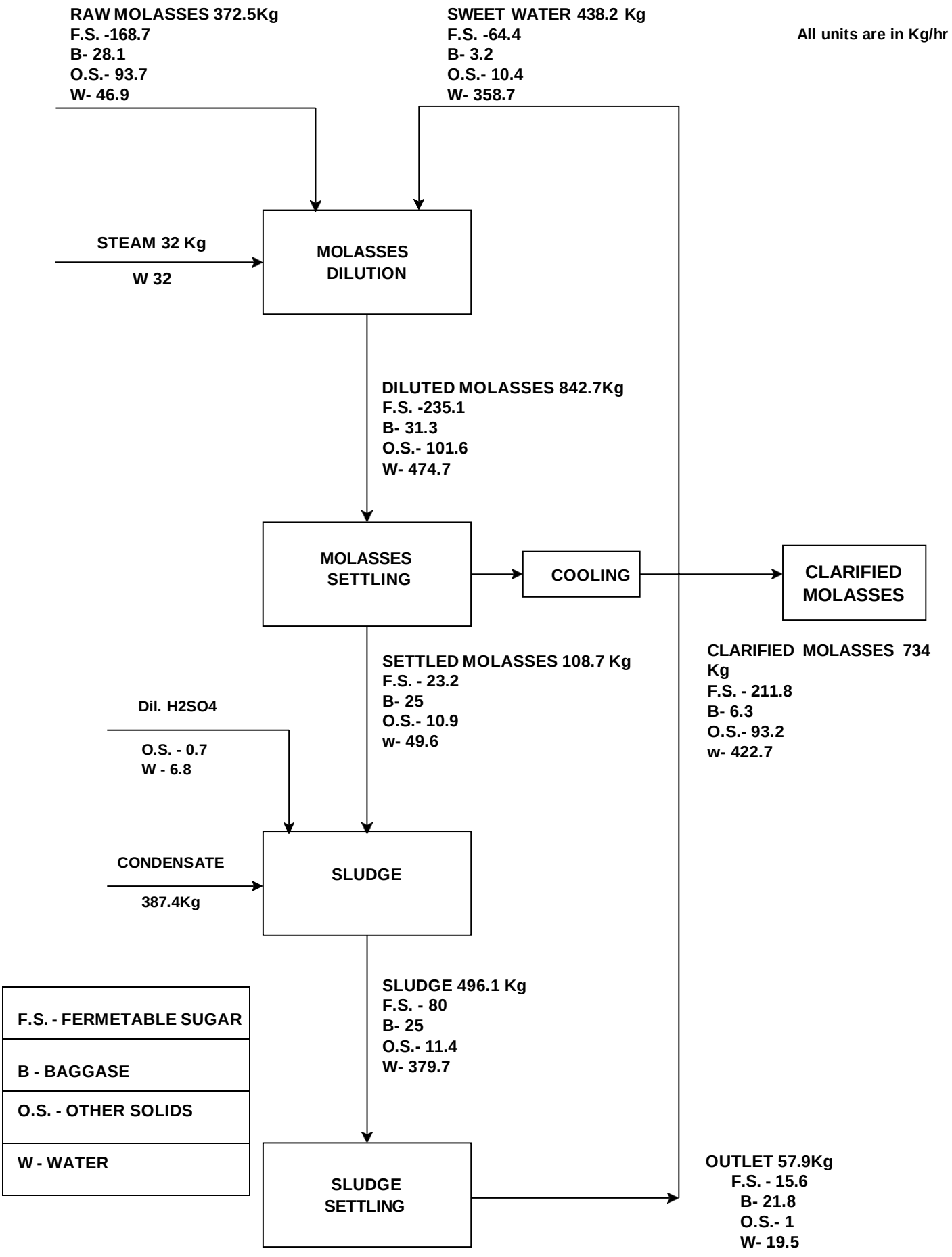
Molasses required per day;

$$= \frac{1650}{0.5\ x\ 0.45\ x\ 0.85\ x\ 0.985\ x\ 0.98}$$

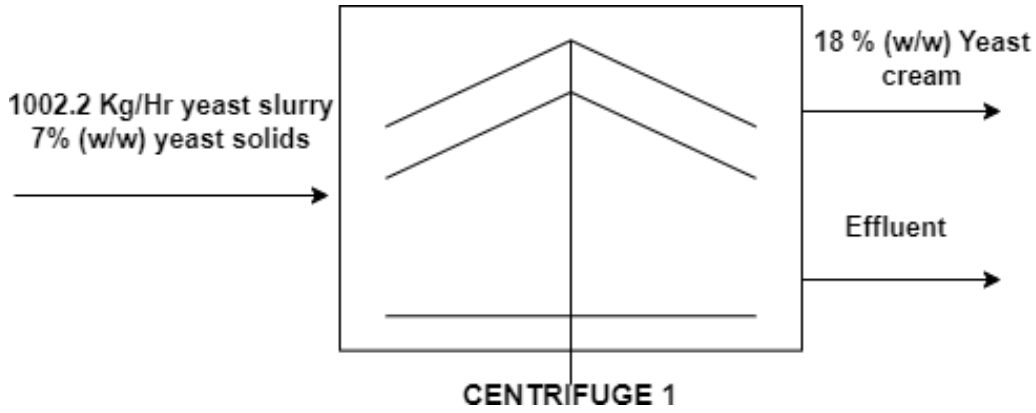
= 8937.5 kg per day

Or we can say 372.5 kg/hr. molasses is required

5.1. MOLASSES - PRECLARIFICATION



5.2. CENTRIFUGATION



Fermented Wash = $\frac{1650}{24 \; x \; 0.07 \; x \; 0.98}$

= 1002 kg/ hr.

Kg/Hr. Yeast = Kg/Hr. Yeast cream + Kg/Hr. Effluent

905Kg/Hr. = Kg/Hr. Yeast cream + Kg/Hr. Effluent

1002.2 Kg/Hr. × 0.07(yeast solids) × 0.9950 (0.5% weight loss of yeast solid in centrifugation process) = 69.8Kg/Hr.

Now to find the concentration at 18% (W/W)

69.8÷ 0.18

= 387.78 Kg/Hr.

To find amount of water needed to dilute the concentration of Yeast solids from 18 %(W/W) back to 7% (W/W)

First, Total Concentration is needed to be found.

$C1V1 = C2V2$

$0.18 \times 387.38 = 0.07 \times V2$

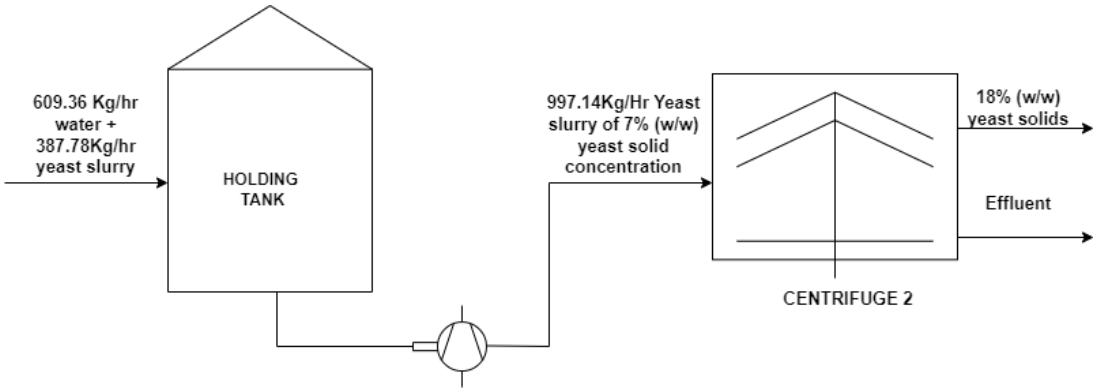
$V2 = 997.14 Kg/Hr.$

Water needed;

Total Concentration = Water + x

997.14- 387.78Kg. /Hr. = Water

= 609.36 Kg/Hr.



After the yeast is centrifuged to 18% (w/w) solid, the yeast is still dark in colour, to ensure the colour is beige; the yeast is diluted again to 7% (w/w) by adding water in it (609.36 Kg/Hr.)

The 7% (w/w) Yeast solid is then passed through the Centrifuge-2 which is placed in parallel to Centrifuge-1. The effluent generated is discarded.

Kg/Hr. Yeast = Kg/Hr. Yeast cream + Kg/Hr. Effluent

997.14Kg/Hr. = Kg/Hr. Yeast cream + Kg/Hr. Effluent

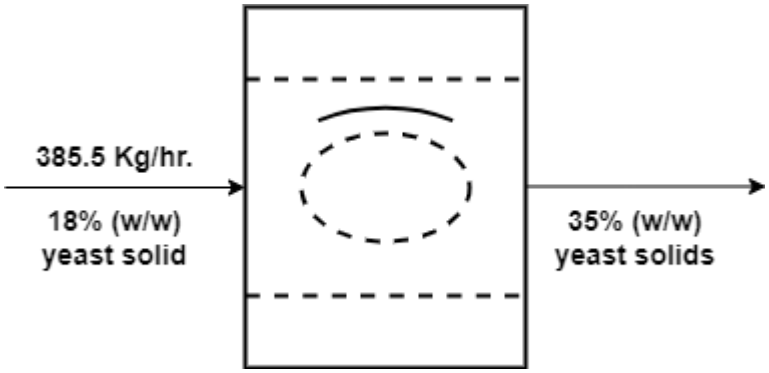
997.14 kg/Hr. × 0.07(yeast solids) × 0.9950 (0.5% weight loss of yeast solid in centrifugation process) = 69.4Kg/Hr.

Now to dilute the concentration to 18% (w/w)

69.4÷ 0.18

= 385.5Kg/Hr.

5.3. ROTARY VACCUM FILTER



Total Yeast in Kg/hr. = Yeast Cake in Kg/hr. + Effluent

385.5 Kg/hr. = Cake + Effluent

Considering, 0.5% yeast solids loss;

385.5 x 0.18 x 0.9550

= 69.04 Kg/hr.

For 35% (w/w) solid yeast cake production;

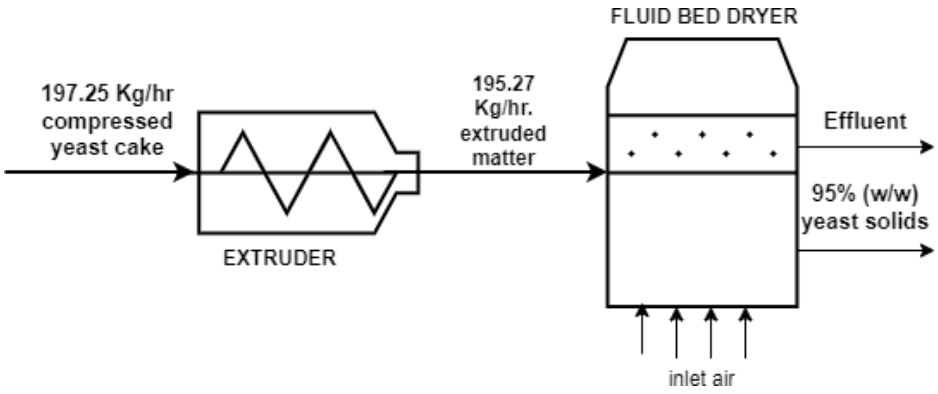
= 69.04÷ 0.35

= 197.25 Kg/hr. compressed yeast cake

Effluent = 385.5-197.25 Kg/hr.

Effluent = 188.25 Kg/hr.

5.4. FLUIDIZED BED DRYER



Assuming 1% loss of product in extruder and 0.5% loss of yeast solids;

197.25 x 0.99 x 0.9950 x 0.35 = 68 Kg/hr.

For 95% ADY = 68/0.95

= 71.5 kg/hr. ADY

Feed – Product = Evaporation

=197.25-71.5

= 125.75 Kg/hr.

If, 1kg Air can dry up 0.0261 kg moisture (from psychometric chart)

So, air required to dry up 125.7 Kg moisture

= 125.75/0.0261

= 4818 kg/hr.

Steam required;

= 125.75/ 0.7 (70% efficiency)

=179.64 kg/hr. steam is required

CHAPTER -6

ENERGY BALANCE

1 Kg molasses contains 450g sucrose and yields 250g yeast dry matter and evolves 950 Kcal heat as it is an exothermic reaction.

Reaction:

$0.674C_{12}H_{22}O_{11} + 0.43NH_3 + 3.82O_2 + 0.015P_2O_5$

$C_{4.02}H6.5O_{2.11}N_{0.43}P_{0.03} + 4.81H_2O + 4.07CO_2$

Or,

1 kg molasses + 15.2g NH_3 + 254g O_2

250g Yeast + 180g O_2 + 372g CO_2 + 950Kcal

For 1000 g of dry yeast,

Heat evolved (Kcal/g) = 4611Kcal/Kg

Avg. rate of Heat Load = (Working volume of reactor) × (Heat evolved per unit weight of dry yeast) × (Concentration) / Reaction time

6.1. Culture Vessel;

Heat Load,

$$Q = \frac{0.282 \times 4611 \times 1.2}{24}$$

$$= 65.3 \text{ kcal/hr}$$

Cooling water required;

Cooling water is usually at 30 ˚C temperature and the normal working temperature of the bioreactor is 32 ˚C. Thus, the temperature difference will be 2 ˚C.

Also, the specific heat of water is 1 kcal-kg^{-1}K^{-1}. Thus, the rate of cooling water required will be:

$$Q = \text{m} \times C_p \times \Delta T$$

$$\therefore \text{mi} = \frac{Q}{C_p \times \Delta T}$$

$$= \frac{65.3}{1 \times 2}$$

$$= 32.6 \text{ litre/hr}$$

6.2. Pre-fermentor;

Heat load,

$$Q = \frac{1.41 \times 4611 \times 1.2}{24}$$

$$= 325.07 \text{kcal/hr}$$

Cooling water required for Pre-fermentor;

$$Q = \mathrm{m} \times \mathrm{C}_p \times \Delta\mathrm{T}$$

$$\therefore \mathrm{m} = \frac{\mathrm{Q}}{\mathrm{C}_p \times \Delta\mathrm{T}}$$

$$= \frac{325.07}{1 \times 2}$$

$$= 162.5 \text{ litre/hr}$$

6.3. Fermentor;

Heat load,

$$Q = \frac{7.8 \times 4611 \times 1.2}{24}$$

$$= 1798.29\text{kcal/hr}$$

Cooling water required;

$$Q = \mathrm{m} \times \mathrm{C}_p \times \Delta\mathrm{T}$$

$$\therefore \mathrm{m} = \frac{\mathrm{Q}}{\mathrm{C}_p \times \Delta\mathrm{T}}$$

$$= \frac{1798.2}{1 \times 2}$$

$$= 899.1 \text{ litre/hr}$$

$$0.674C_{12}H_{22}O_{11} + 0.43NH_3 + 3.82O_2 + 0.015P_2O_5$$

$$\downarrow$$

$$C_{4.02}H_{6.5}O_{2.11}N_{0.43}P_{0.03} + 4.81H_2O + 4.07CO_2$$

OR

1kg molasses + 15.2g NH_3 + 254g O_2 + 4.43g P_2O_5= 208g yeast dry matter + 180g H_2O + 370g CO_2 + 950 kcal

Conversion Equation in Batch Reactors

For any reactant A of the reaction, conversion of A is defined as:

$$X_A = \frac{\text{moles of A reacted}}{\text{moles of A fed}}$$

And the initial concentration of A in batch be N_{A0}.

$$\left(\begin{array}{c}\text{Moles of A reacted}\\ \text{(consumed)}\end{array}\right) = \left(\text{Initial moles of A fed}\right) \times \left(\frac{\text{Moles of A reacted}}{\text{Moles of A fed}}\right)$$

$$= N_{A0} \times X_A$$

The number of moles of 'A' that remains in the reactor after time, t, N_A is:

$$\left(\begin{array}{c}\text{Moles of A in}\\ \text{reactor at t}\end{array}\right) = \left(\begin{array}{c}\text{Initial moles of A fed}\\ \text{to reactor}\end{array}\right) - \left(\begin{array}{c}\text{Moles of A consumed}\\ \text{by reactor}\end{array}\right)$$

$$N_A = N_{A0} \times N_{A0}X_A$$

$$N_A = N_{A0}\,(1 - X_A)$$

which can be rearranged to give;

$$X_A = \frac{N_{A0} - N_A}{N_{A0}}$$

Taking an infinitesimally small change in N_A (i.e. $N_{A0} - N_A \rightarrow 0$), then we can say,

$$dX_A = -\frac{dN_A}{N_A}$$

As this is a batch fermentor volume (V) is constant with time, we have:

$$X_A = \frac{C_{A0} - C_A}{C_{A0}}$$

$$\text{So, } dX_A = -\frac{dC_A}{C_{A0}}$$

Above equation can be differentiated with respect to *t* to give,

$$\begin{aligned} \frac{dN_A}{dt} &= \frac{d}{dt}[N_{A0}(1 - X_A)] \\ &= \frac{dN_{A0}}{dt} - N_{A0}\frac{dX}{dt} \\ &= -N_{A0}\frac{dX}{dt} \end{aligned}$$

The mole balance rate of reaction for batch fermenter is:

$$r_A V = \frac{dN_A}{dt}$$

Thus, combining above two equations, we get,

$$\begin{aligned} -N_{A0}\frac{dX}{dt} &= r_A V \\ \therefore -C_{A0}\frac{dX}{dt} &= r_A \end{aligned}$$

It's a first order reaction, thus:

$$-r_A = k \times C_A = k \times C_{A0} \times (1 - X_A)$$

So,

$$C_{A0} \frac{dX}{dt} = kC_{A0}(1 - X_A)$$

$$\therefore dt = \frac{dX}{k(1 - X_A)}$$

$$\therefore t = \int_0^{X_A} \frac{dX}{k(1 - X_A)}$$

$$\therefore kt = -\ln(1 - X_A)$$

$$\therefore k = -\frac{1}{t}\ln(1 - X_A)$$

The raw material involved in this process is Sucrose, NH_3, O_2 and P_2O_5. So, for 1kg of molasses 480g fermentable sugar, 15.2g ammonia, 254g oxygen gas and 4.43g Phosphorous Pentoxide Summing up to to 753.63g.

And its volume (V) can be calculated from density as:

$$V = \left(\frac{480}{1.588} + \frac{15.2}{0.597} + \frac{254}{1.2121} + \frac{4.43}{0.34}\right)$$

$$= 550.31 \text{ cm}^3$$

Similarly, total number of moles (n) of reactant will be:

$$n = \left(\frac{480}{342} + \frac{15.2}{17} + \frac{254}{32} + \frac{4.43}{142}\right)$$

$$= 10.329 \text{ mol}$$

Thus, initial concentration will be:

$$C_{A0} = \frac{n}{V} = \frac{10.329}{550.31}$$
$$= 0.0188 \text{ mol/cm}^3$$

From reaction, after 12 hours, the conversion (X_A) is 20%.

Thus, rate constant for this reaction will be,

$$k = -\frac{\ln(1 - 0.2)}{12}$$
$$= 0.018 \text{ hr}^{-1}$$

The rate constant of reaction is $0.018 hr^{-1}$.

CHAPTER -7 DESIGNING AND SIZING

7.1 DESIGN OF FED-BATCH AGITATED BIO REACTOR

Basis: 1 MT/day Active dried yeast and 2 MT/day compressed yeast cake on dry basis

7 %(w/w) yeast cell mass

7.1.1. FERMENTOR

Fermented Wash = $\frac{1650}{24 \; x \; 0.07 \; x \; 0.98}$

= 1002 kg/ hr.

Specific gravity = $1+\frac{7 \; x \; 4}{1000}$

= 1.028

$\frac{1002}{1.028}$ Kg/ hr.

= 974.98 lph

= 0.97498 m^3/hr.

Reactor volume = 0.97498 m^3/hr. x 32 hr.

=31.19 m^3 (working volume)

Gross volume (0.6 ratio) = $\frac{31.19}{0.6}$

= 51.98

Or, 52m^3

Reactor volume = $52m^3$

$52 = \frac{\pi}{4} \times Di^2 \times 1.2 \times Di$ (H/D = 1.2)

$= 52 \times 4 / (3.14 \times 1.2) = Di^3$

Di = 3.8m

L= 4.56m

Considering 4 fermentors of volume; $52/4 = 13m^3$

Di = 2.3m

L = 2.76m

7.1.1 PITCH BLADE TURBINE AGITATOR DESIGN

Reactor volume = $13\ m^3$

Working volume/ Gross volume (0.6) = $7.8\ m^3$

Viscosity of liquid (Yeast slurry) = 200cP

Specific gravity = 1.2

Diameter (W.V.) = 2.02m Length (W.V.) = 2.42m

Average power no. for PBT: 1.4

RPM = 200

No. of impellers = Max liquid height x average specific gravity/ tank diameter.

= 2.42 x 1.32/2.02

= 1.5 or 1 impeller.

Diameter of agitator = 0.3 x 2.02 = 0.60m (The diameter of impeller / agitator varies between 0.3 to 0.5 times of tank diameter.)

Power required for agitator:

Agitator's Reynolds No. NRe = ρ N Da2/ μ, ρ = Liquid density Kg/m3, N = rps of agitator, Da = Diameter of agitator (m), μ = Viscosity in Pa-s (1 Pa-s = 1000 cP)

$= (1100*(200/60)*(0.60)^2)/ (20/1000)$

Reynolds's no. = 67532.5

Power (P) in hp = Np ρ N^3 Da^5/ (g x 75), Gland loss 10% = 0.1 P, Power input = P + 0.1 P = P', Transmission loss: 20 %, hence motor hp = P' + 0.2 P' = 1.2 P'

Power (P) = $(1.4*1100*(200/60)^3*(0.6)^5)/ (9.8*75)$

= 6.03

Power (P') = 6.63+0.1(6.63)

=6.63

Horse Power (hp) = 1.2 x 6.63

= 7.9 hp

Shaft diameter calculation:

Torque on agitator shaft: kg-m: Tc = hp x 75 x60 / (2πN'), N' in rpm

=7.9x75x60/ (2x3.14x200)

Tc= 28.53 kg-m

Maximum torque Kg-m (Tm) = 2.5 Tc

= 71.3 kg-m

Polar modulus of section of shaft cross-section (cm3) = Zp = Tm/550, where 550 value is maximum shear stress of solid shaft in Kg/cm2

= 71.3/550

= 0.129 cm^3

$Zp = \pi d^3/16$, d= diameter of shaft in cm

= 0.871cm

=1.1x0.87

= 0.95

Selected shaft diameter =1cm

7.1.2. PRE-FERMENTOR

It is 20% of fermentor

i.e., 2.6m^3

$2.6 = \frac{\pi}{4} \times Di^2 \times 1.2 \times Di$ (H/D = 1.2)

Di =1.4m, L=1.68m

7.1.3. CULTURE VESSEL

It is 20% of pre-fermentor

i.e., 0.52m^3

$0.52 = \frac{\pi}{4} \times Di^2 \times 1.2 \times Di$ (H/D = 1.2)

Di= 0.81m, L=0.97m

7.2. MOLASSES STORAGE TANK

Total yeast solids on dry basis production per day = 1650 kg

Molasses requirement per day;

$$= \frac{1650}{(0.5)x\,(0.45)x\,(0.85)x\,(0.985)x\,(0.98)}$$

= 8940 kg/day

Specific gravity of molasses = $1+\frac{80\,x\,4}{1000}$ = 1.32

= 8940/1.32

=6772.7 lpd

For 30 days storage of molasses;

= 6772.7 x 30

= 203181.8 liter per month

Or, 203.18m^3

Gross volume considering 10% head space;

= 203.18/0.9

=225.7 m^3

7.3. EQUIPMENT LIST

MOLASSES STORAGE SECTION

S. No.	Description	Technical Specification	Qty.		MOC
			Opr.	Standby	
1.	Raw Molasses Storage tank	Type: Conical Top Sloping bottom Volume - 112 m^3 Diameter – 4.9mm Length- 5.9mm	2		CS
2.	Raw Molasses Transfer Pump	Type : Screw Capacity – 0.33 m^3/hr.	1	1	CS
3.	Weighed Molasses Transfer Pump	Type : Screw Capacity – 0.33m^3/hr.	1	1	CS
4.	Molasses Weighing system	Standard	1		SS

MOLASSES PRE-CLARIFICATION SECTION

S. No.	Description	Technical Specification	Qty.		MOC
			Opr.	Stand by	
1.	Dilute Molasses Tank (T-101)	Type: Dished roof conical bottom Volume : $5m^3$ Diameter: 1740mm Length : 2080mm	1	0	SS
2.	Sludge Collection Tank (T-103)	Type : Rectangular Volume: $0.5m^3$ Length: 790mm Width : 790mm Height : 948mm	1	0	SS
3.	Settling tank (T-102)	Type : Rectangular Volume : $3.5m^3$ Diameter: 1500mm Length : 1800mm	1	0	SS
4.	Clarified Molasses Tank (T-105)	Type: Conical Top Sloping bottom Volume : $5m^3$ Diameter: 1740mm Length : 2080mm	1	0	SS

5.	Sweet Water Collection Tank (T-104)	Type : Dished End Top & Bottom Volume : $1m^3$ Diameter: 1020 mm Length : 1224mm	1	0	SS
6.	Broth Mixer for Molasses Pre-Clarification (BM-01)	Type : Static Mixer	1	0	SS

7.	Agitator for Sludge Collection Tank	Type: Top Entry	1	0	SS
8.	Dilute Molasses Feed pump	Type : Centrifugal Capacity : 638.4 lph	1	1	CS
9.	Sludge Transfer pump	Type : Centrifugal Capacity : 450lph	1	1	CS
10.	Sweet water transfer pump	Type : Centrifugal Capacity : 450lph	1	1	CS
11.	Clarified Molasses transfer pump to fermenter	Type : Centrifugal Capacity :660lph	1	1	

FERMENTATION SECTION

S. No.	Description	Technical Specification	Qty.		MOC
			Opr.	Stand by	
1.	Culture Vessel	Type: Conical bottom flat top Volume : 0.47m^3 Diameter: 810mm Length : 972mm	1	0	SS
2.	Pre- fermentor	Type : Torispherical top and bottom Volume: 2.35m^3 Diameter: 1400mm Length: 1680mm	2	0	SS
3.	Fermentor	Type : Torispherical top and bottom Volume: 13m^3 Diameter: 2300 mm Length: 2760mm	4	0	SS
4.	Blower	Air flow rate – 1056 m^3/hr.	2	1	SS
5.	Holding tank	Type: Torispherical top and bottom Volume : 5m^3 Diameter: 1740mm Length : 2090mm	2	0	SS

6.	Nutrient dosing tank (urea)	Torispherical top and bottom Volume : 0.1m^3 Diameter: 460mm Length : 550mm	1	0	SS
7.	Salt Dissolving tank	Torispherical top and bottom Volume : 0.1m^3 Diameter: 460mm Length : 550mm	1	0	SS

CENTRIFUGATION SECTION

S. No.	Description	Technical Specification	Qty.		MOC
			Opr.	Std by	
1.	Centrifuge-1	Type : Disc Type Capacity – 934.8lph	1	0	SS
2.	Holding tank - 1	Type: Conical top flat bottom Volume : 5m^3 Diameter: 1740mm Length : 2080mm	1	0	SS
3.	Centrifuge-2	Type : Disc Type Capacity – 930.1lph	1	0	SS
4.	Holding tank-2	Type: Conical top flat bottom Volume : 5m^3 Diameter: 1740mm Length :2080 mm	1	0	SS

FILTER PRESS

S. No.	Description	Technical Specification	Qty.		MOC
			Opr.	Std by	
1.	Filter Press	Type : RVF Inlet : 18% (w/w) Outlet : 35 % (w/w) (2 MT Compressed yeast cake per day)	1	0	

FLUIDIZED BED SECTION

S. No.	Description	Technical Specification	Qty.		MOC
			Opr.	Stand by	
1.	Dryer Package including extruder	Type : Fluidized Bed dryer Inlet : 35% (w/w) Outlet : 95 % (w/w) (1 MT ADY per day)	1	0	

WET CAKE STORAGE SECTION

S. No.	Description	Technical Specification	Qty.		MOC
			Opr.	Stand by	
1.	Wet Cake Storage Section to be maintained at 4 Deg. C	Type : RCC Structure Length : 15m Height : 2.5 m Width : 13.5m	1	0	
2.	Extruder before product going to stored	Std	1	0	

ACTIVE DRIED YEAST STORAGE SECTION

S. No.	Description	Technical Specification	Qty.		MOC
			Opr.	Stand by	
1.	ADY Storage Section to be maintained at 25 Deg. C (Air conditioned room)	Type : RCC Structure Length : 4.5m Height : 2.5 m Width : 4.5m	1		

CIP AND SIP SECTION

S. No.	Description	Technical specification	Qty.		MOC
			Opr.	Stand by	
1.	Hot Water Tank	Torispherical ends Volume: 6.87 m^3 Diameter : 1900mm Height: 2320mm	2		SS
2.	Hot Recovered Water tank	Torispherical ends Volume: 6.87m^3 Diameter : 1900mm Height: 2320mm	2		SS
3.	Hot Caustic Tank	Torispherical ends Volume: 6.87 m^3 Diameter : 1900mm Height: 2320mm	2		SS

CHAPTER-8

PIPING AND INSTRUMENTATION DIAGRAMS (P&IDS)

In the field of process engineering, a piping and instrumentation diagram, often known as a P&ID or PID, is a detailed diagram that displays the pipe and process equipment in addition to the instrumentation and control devices.

The following are the typical steps involved in the creation of a P&ID:

1. An initial block flow diagram is drawn.

2. An initial process flow diagram (PFD) is drawn up.

3. Detailed descriptions of the high-level controls are written.

4. Draught P&IDs are generated with the help of process flow diagrams serving as backdrops.

5. Areas for controllers, MCCs (motor control centres), and/or SCADA (supervisory control and data acquisition) are drawn at the top of the P&IDs.

6. The P&IDs will then have control feature symbols and labels added to them.

7. The wiring diagrams for connecting the electrical devices with the controllers, MCCs, and/or SCADA are drawn on the P&IDs.

8. The comprehensive control descriptions have been finished.

9. The control loops are specified, most frequently using a table-based structure.

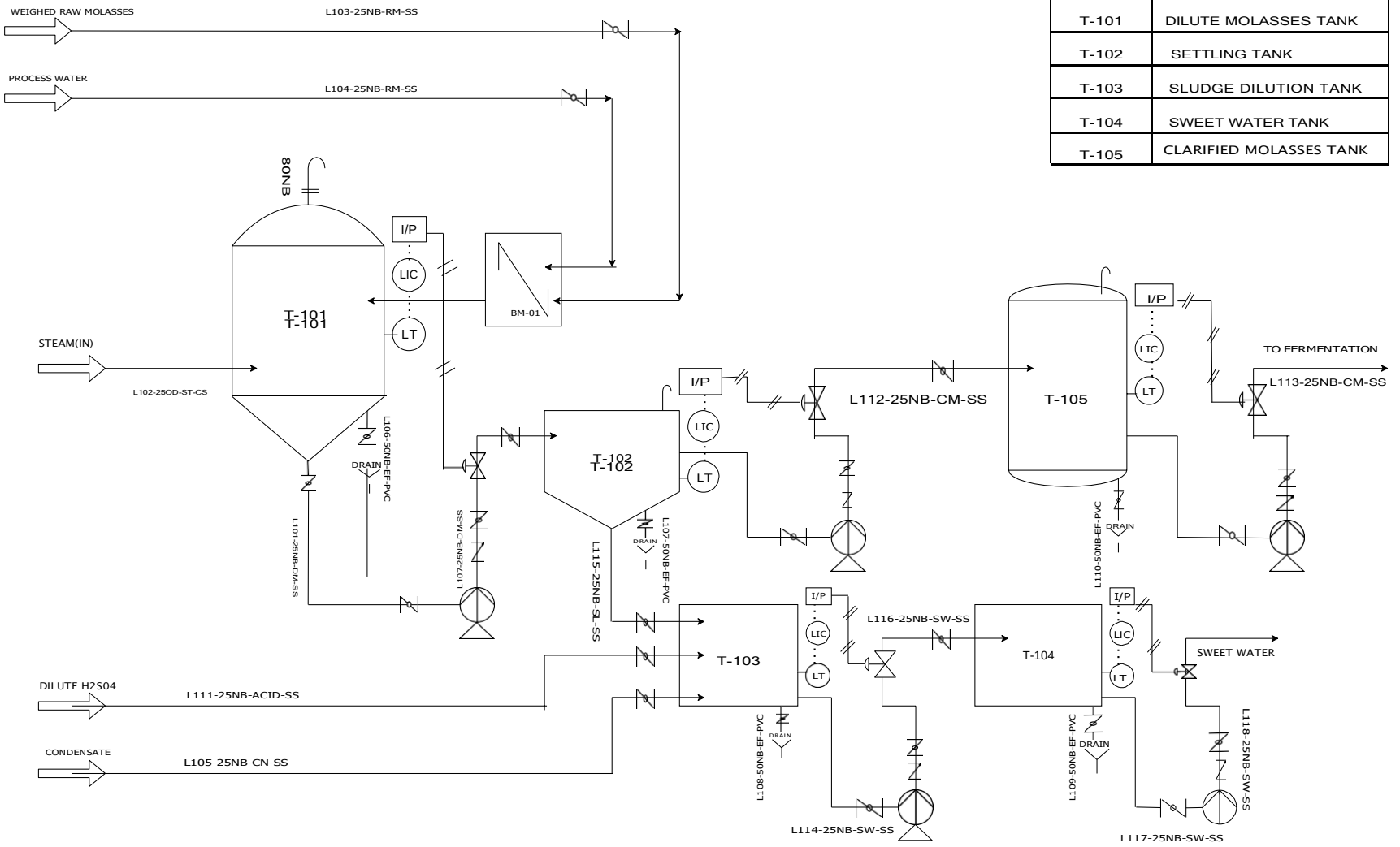
10. The identification numbers listed on P&IDs are linked with the corresponding control descriptions and control loops.

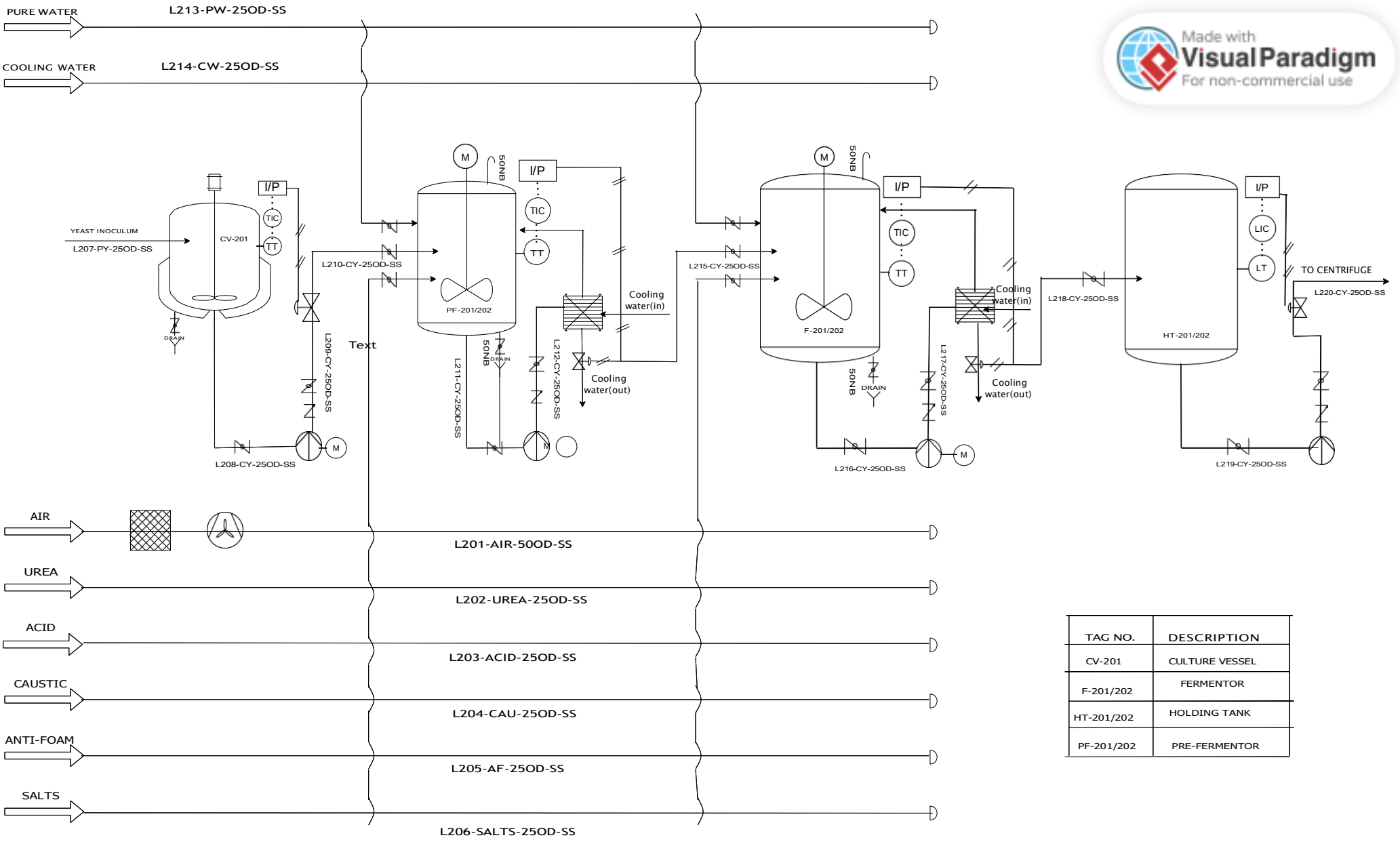
8.1. FLUID LIST

SNO.	FLUID NAME	FLUID CODE	MOC	MATERIAL CODE
1.	DILUTE MOLASSES	DM	STAINLESS STEEL	SS
2.	CLARIFIED MOLASSES	CM	STAINLESS STEEL	SS
3.	PROCESS WATER	PW	CARBON STEEL	CS
4.	STEAM	ST	STAINLESS STEEL	SS
5.	EFFLUENT	EF	STAINLESS STEEL	SS
6.	CREAM YEAST	CY	STAINLESS STEEL	SS
7.	CHILLED WATER	CHW	CARBON STEEL	CS
8.	COOLING WATER	CW	CARBON STEEL	CS
9.	AIR	AIR	STAINLESS STEEL	SS
10.	UREA	UR	STAINLESS STEEL	SS
11.	ACID	ACID	STAINLESS STEEL	SS
12.	BASE	BASE	STAINLESS STEEL	SS
13.	PURE YEAST	PY	STAINLESS STEEL	SS

Table 8.1.

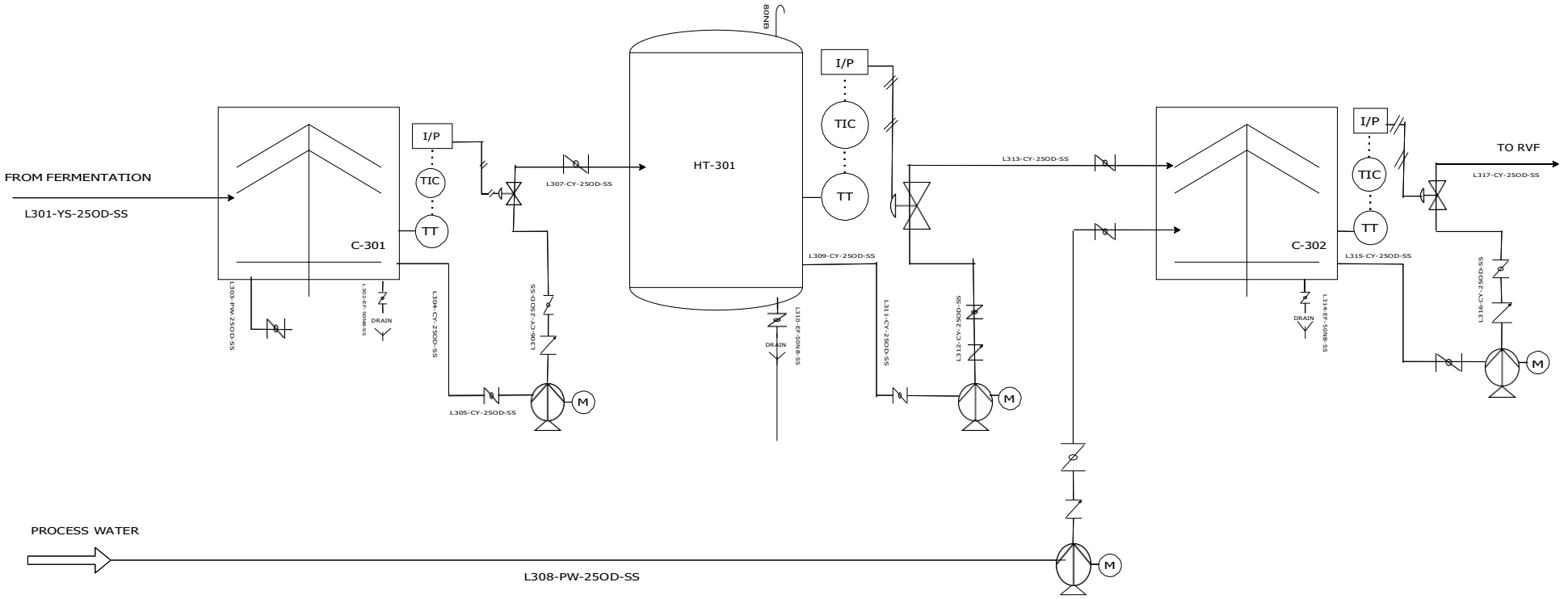
TAG NO.	DESCRIPTION
BM-01	BROTH MIXER
T-101	DILUTE MOLASSES TANK
T-102	SETTLING TANK
T-103	SLUDGE DILUTION TANK
T-104	SWEET WATER TANK
T-105	CLARIFIED MOLASSES TANK

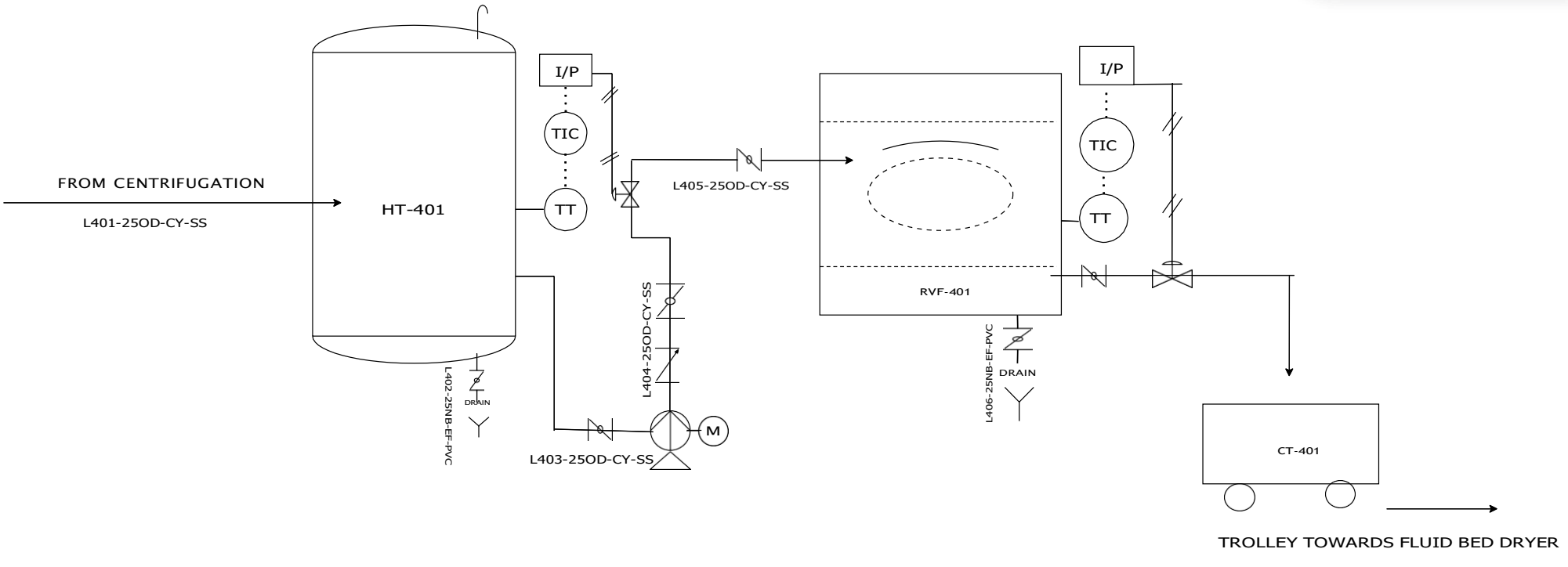




TAG NO.	DESCRIPTION
CV-201	CULTURE VESSEL
F-201/202	FERMENTOR
HT-201/202	HOLDING TANK
PF-201/202	PRE-FERMENTOR

TAG NO.	DESCRIPTION
C-301	DISC STACK CENTRIFUGE
C-302	DISC STACK CENTRIFUGE
HT-301	HOLDING TANK





TAG NO.	DESCRIPTION
HT-401	HOLDING TANK
RVF-401	ROTARY VACUUM FILTER
CT-401	CAKE TROLLEY

CHAPTER -9

PLANT LAYOUT AND LOCATION

Here are some key parameters to consider for plant layout and location in the production of baker's yeast:

1. Accessibility: The plant should be easily accessible by road, rail, or sea to ensure efficient transportation of raw materials and finished products.

2. Availability of raw materials: The plant should be located near the source of raw materials such as molasses, sugar cane, or beet juice to reduce transportation costs and ensure a steady supply.

3. Water supply: The plant requires a reliable and sufficient water supply for the production process, cleaning, and sanitation.

4. Power supply: The plant should have access to a reliable power supply for the operation of equipment and machinery.

5. Waste management: The plant should have a system for the proper disposal of waste and effluent.

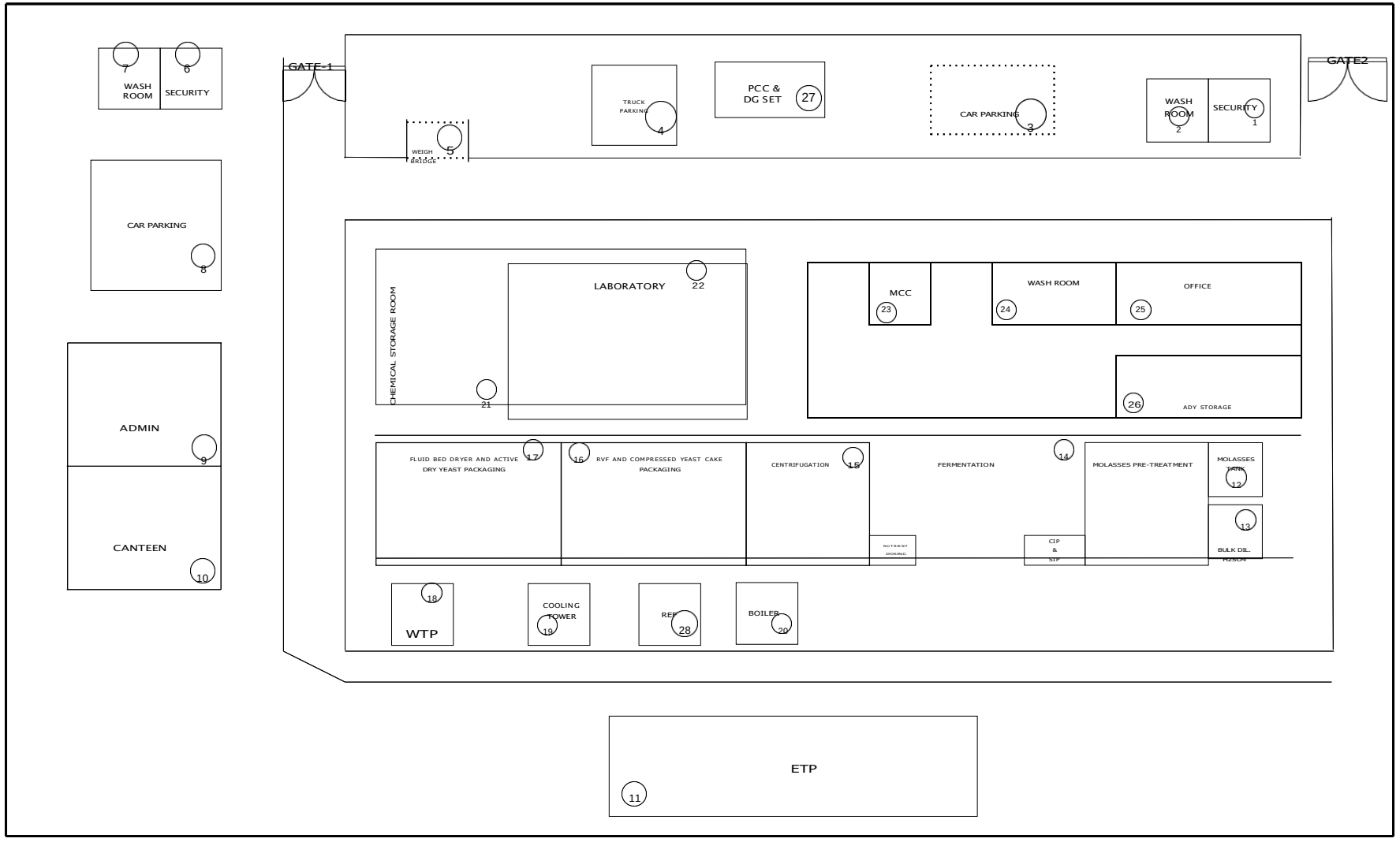
6. Environmental regulations: The plant should comply with all local and national environmental regulations regarding emissions, waste disposal, and water usage.

7. Size and capacity: The plant layout should be designed to optimize the flow of materials and personnel to increase productivity and efficiency. The size and capacity of the plant should also be based on the projected demand for baker's yeast.

8. Safety and security: The plant should be designed to ensure the safety of workers and the security of the facility and its products.

9. Proximity to market: The plant should be located near the target market to reduce transportation costs and ensure timely delivery of products.

10. Climate: The plant should be located in an area with a suitable climate to ensure proper temperature and humidity control during the fermentation process.



TAG NO.	DESCRIPTION	SIZE (mxm)
1	SECURITY	-
2	WASHROOM	-
3	CAR PARKING	-
4	TRUCK PARKING	-
5	WEIGH BRIDGE	-
6	SECURITY	-
7	WASHROOM	-
8	CAR PARKING	-
9	ADMIN OFFICE	
10	CANTEEN	-
11	ETP	-
12	MOLASSES TANK	-
13	BULK DIL. H2SO4	-
14	FERMENTATION	-
15	CENTRIFUGATION	-
16	RVF AND COMPRESSED YEAST CAKE PACKAGING	-
17	FLUID BED DRYER AND ACTIVE DRY YEAST PACKAGING	-
18	WATER TREATMENT PLANT	-
19	COOLING TOWER	-
20	BOILER	-
21	CHEMICAL STORAGE ROOM	-
22	LABORATORY	-
23	MCC- MOTOR CONTROL CENTER	-
24	WASH ROOM	-
25	OFFICE	-
26	ADY STORAGE	-
27	PCC & DG SET	-
28	REFRIFERATION	-
29	TOTAL AREA	200M*150M

CHAPTER- 10

PROCESS DATA SHEET/ ENQUIRY SPECIFICATION OF KEY EQUIPMENT

10.1. PROCESS DATA SHEET FOR FERMENTOR

PROCESS DATA SHEET FOR YEAST FERMENTOR										
Process & Design Data										
Contents	**FLOUR SLURRY**									
Content Density	Kg/Cu. M		1400	Pressure (Shell)			Kg/Sq.Cm.(A)			
Capacity (Gross)	m3		13.00	Design		#	Normal Oper.		ATM.	
Capacity (Net)	m3		7.8	Max. Oper.		1.1	Min. Oper.		ATM.	
Shell Inside Diameter	mm		3350	Temperature (Shell)			Deg. C			
Shell Ht (T/L to T/L)	mm		3750	Design		#	Normal Oper.		65	
Corrosion Allowance	mm		Nil	Max. Oper.		100*	Min. Oper.		5	
Configuration	Vertical-Cylindrical			Design		NA	Normal Oper.		NA	
Support Type	Lugs			Max. Oper.		NA	Min. Oper.		NA	
Support Resting	On Structure			Temperature			Deg. C			
Type Of Sparger	Not Applicable			Design		NA	Normal Oper.		NA	
Sparger Pipe	Dia.	NA	mm	Max. Oper.		NA	Min. Oper.		NA	
Holes on Pipe	Dia.	NA	mm	Nos.	NA	Min.	Pitch	NA	mm	
H.T.A	m2	-		Insulation Type			Hot			
				Insulation Thickness			50	mm		
Basic Materials Of Construction										
Shell	AISI 304			Nozzle Pipes			AISI 304			
Top Head	AISI 304			Nozzle Flanges			Carbon Steel			
Bottom Head	AISI 304			Gaskets			EPDM			
Jacket	NA			Internals			AISI 304			
Sparger Pipe	NA			Insulation			Glasswool-Al Cladding			

THICKNESS								
Shell	-	mm	Top Head	-	mm	Bottom Head	-	mm
Jacket	-	mm	-	-	mm	-	-	mm

NOTES
1) All dimensions are in "mm" unless otherwise specified.
2) Equipment to be provided with suitable earthing
3) Nozzle standouts shall be kept as minimum as possible.
4) NA.: Not Applicable
5) Chloride content of test fluid should not exceed more than 25 PPM
6) * - Subjected to this temperature for 30 minutes during sterilisation
7) # - To be finalised after detailed engineering.
8) Surface should be ground smooth with hygienic finish.
9) Baffle dimensions and quantity to be provided by Agitator Supplier.

					Client	
					Job No.	
					Plant	**BAKER'S YEAST PLANT**
					Tag No.	**F-201**
					Equipment Name	**YEAST FERMENTOR**

10.2. ENQUIRY SPECIFICATION FOR CENTRIFUGATION

	SCOPE OF WORK, INSPECTION AND TESTING				
	Equipment : Yeast Separator with Hydro-cyclone				
	SCOPE OF WORK				
	The scope of work for the equipment listed above shall include design, manufacture,				
	Supply of material and engineering work as detailed below.				
	Description	**Purchaser**		**Manufacturer**	
1	Centrifuge Unit				
2	Motor			✓	
3	Gear box with transmission devices			✓	
4	Frame			✓	
5	Fixing bolts			NA	
6	Base plate / Skid Frame			✓	
7	Safety instruments			✓	
8	Instrument panel			✓	
9	Tools and Spare parts (as per list attached)			✓	
10	Painting			✓	
11	Drawings and documents			✓	
12	Hydro-cyclone			✓	
13	Butterfly valve (1 No.) and three-way valve (1 No.) with actuators			✓	
14	S.S. flexible hose (1 No.)				
15	Paddle type flow switch (1 No.)				
16	S.S. Yeast cream and De-yeasted wash funnel (1 No. each)				
17	Inlet and Outlet Bends				
18	Nozzles (1 Set)				
	SCOPE OF INSPECTION (PURCHASER TO TICK WHEREVER APPLICABLE)				
	The following inspection and test shall be carried out at manufacturer's s site and / or records				
	to be submitted by manufacturer				
	Description	**Inspection**			
		Required			
1	Visual inspection of Equipment	YES			
2	Appearance and Dimensional inspection	YES			
3	Material test and Chemical analysis	YES			
	SCOPE OF TEST				
	Description		**Witness**		
		Required	**Required**		
1	Performance test	YES	YES		
2	Sound level test	YES	YES		

	TECHNICAL SPECIFICATION OF CENTRIFUGE-1					
Title : Yeast Centrifuge						
Manufacturer : .A.L.	Model :	DISC STACK				
Qty. : Operating + Stand By	1	+		Nil	Duty :	Batch
Electric Supply : 415V +/- 10%, 50Hz +/- 5%, 3 Phase, 4 Wire						
OPERATING CONDITIONS						
Fluid	Yeast			Capacity	kg/hr	1002
Inlet Solids concentration	%	7		Operating Temperature	Deg C	4
outlet solids concentration	%	18				
CONSTRUCTION FEATURES						
Disc caulks	mm	*				
Inlet Connection size	mm	*				
Concentrate outlet size	mm	*				
Liquid outlet size	mm	*				
MAIN MOTOR						
Motor rating	KW / rpm	*		Degree of protection		IP 54
Type	Weather-proof			Insulation class		Class F
MATERIAL OF CONSTRUCTION						
Casing	SS-316					
Decanter Frame	Mild steel					

Title : Hydrocyclone						
Equipment code : -						
Manufacturer : Cel**** *	Model :					
Qty. : Operating + Stand By	ONE	+		Nil	Duty :	Batch
Mfg.Std. :		Perf. Std. :			Location :	Indoor
Electric Supply : 415V +/- 10%, 50Hz +/- 5%, 3 Phase, 4 Wire						
OPERATING CONDITIONS						
Fluid	Yeast Slurry			Capacity-Maximum	m^3/hr	0.88
Specific gravity	-	1.028		Operating Temperature	Deg C	32
Pressure drop	Kpa	*		Reject flow	lpm	*
Elutriation water	lpm	*		Elutriation pressure	Kpa	*
CONNECTION SIZES						
Inlet	mm	*				
Reject	mm	*				
Liquid outlet	mm	*				

		TECHNICAL SPECIFICATION OF CENTRIFUGE-2					
Title : Yeast Separator							
	Manufacturer : A.L. Model :						
	Qty. : Operating + Stand By 1	1+0			Nil	Duty :	Batch
	Electric Supply : 415V +/- 10%, 50Hz +/- 5%, 3 Phase, 4 Wire						
	OPERATING CONDITIONS						
	Fluid	Yeast			Capacity	kg/hr	997
	Inlet Solids concentration	%	7		Operating Temperature	Deg C	4
	outlet solids concentration	%	18				
	CONSTRUCTION FEATURES						
	Disc caulks	mm	*				
	Inlet Connection size	mm	*				
	Concentrate outlet size	mm	*				
	Liquid outlet size	mm	*				
	MAIN MOTOR						
	Motor rating	KW / rpm	*		Degree of protection		IP 54
	Type	Weatherproof			Insulation class		Class F
	MATERIAL OF CONSTRUCTION						
	Casing	SS-316					
	Decanter Frame	Mild steel					

10.3. ENQUIRY SPECIFICATION OF ROTARY VACUUM FILTER

	TECHNICAL SPECIFICATION OF ROTARY VACUUM FILTER (RVF)					
Title : RVF						
Manufacturer :	Model :					
Qty. : Operating + Stand By	1	+0		Nil	Duty :	Continuous
Electric Supply : 415V +/- 10%, 50Hz +/- 5%, 3 Phase, 4 Wire						
OPERATING CONDITIONS						
Fluid	Yeast Cream			Capacity	kg/hr	385.5
Inlet Solids concentration	%	18		Operating Temperature	Deg C	4
outlet solids concentration	%	35		Pressure	*	
Type of Solid	YES	NO				
Compressible	YES					
Oily		NO				
Slimy		NO				
fibrous		NO				
PROCESS GOALS						
Filtrate	YES		Discharge to drain		Recycle	
Cake	**YES**		Landfill		Recycle	
MAIN MOTOR						
Motor rating	KW / rpm	*		Degree of protection		IP 54
Type	Weather-proof			Insulation class		Class F
MATERIAL OF CONSTRUCTION						
Casing	SS-316					

10.4. ENQUIRY SPECIFICATION OF FLUID BED DRYER

QUESTIONNAIRE					
DRYING SYSTEM- FLUID BED DRYER					
Ref. No.	00				
Company	**N/A**				
Type Of Industry	**BIOTECH**				
Represented by	N/A				
Address					
Telephones	0		Mobile		
Project					
Material	**Compressed yeast cake**		Process utilised		
Upstream Eqpt.		Centrifuge	**RVF**	✓	
Downstream Eqpt.	Conveyor		Bagging System	✓	
Type of Dryer	✓ **Fluidized bed**		CT-FBD	☐ Paddle	☐ Spray
	☐	Rotary	☐	Combination	☐
Capacity :	Dry Product :	197.2 Kg/hr.		tonnes/day	
	Wet Product :	125.7 Kg/hr.		Tonnes/day	
Feed Moisture	**95%**			Product Moisture	**5%**
Bulk Density	*		Kg/m^{3}		
Particle Size	1-2mm				
Heat sensitive	YES				
Typical Product Characteristics :		Hazardous	NO	Toxic	NO
Material of construction :			SS-304 ✓	SS-316	
Dust Collection System :			Bag Filter	Cyclone	YES
			Max. dust loading in exhaust		
Heat Source :	YES				
☐ **Steam :**	*	Pressure	*	$kg/cm^{2}(g)$	Temp *

☐ Thermic Fluid :	*	Pressure	*	kg /cm^2(g)	Temp	*	
	Other Details	**					
Instruments & Controls :	*	Central DCS			Local C.P.		
Site Data :	Ambient temp. Max			°C	Min.		
	Humidity		**less**		Elevation		
Space Available in m2							
Is pilot plant test required :		**Yes**	No				
Special Features Reqd. :							
Offer Required :	Firm						
Project Schedule :	Project Completion by			Equipment supplied by		KILBURN	
	Firm Enquiry by						

CHAPTER -11 COSTING AND PAYBACK PERIOD

COST ESTIMATION

11.1. COSTING OF FERMENTOR

Shell thickness = 4mm

Dish end thickness =5mm

Density of stainless steel, SS = 8000 kg/m^3

Steel Cost = Steel weight in Kg x [Material + Labour]

Material Cost for stainless steel, SS per Kg (INR) = 250

Labour cost for stainless steel, SS per kg (INR) = 60

Density of Mild Steel, MS = 7750 kg/m^3

Material Cost for mild steel, MS per Kg (INR) = 80

Labour cost for mild steel, MS per kg (INR) = 15

1. **Shell Cost**

Shell cost = Surface Area x Thickness

$= \pi dLT \; x \; Density \; of \; Steel \; x \; Steel \; cost$

= 3.14 x 2.3 x 2.7 x 8000 x 0.004 x 310

= ₹193434

2. **Dish end cost**

Blank diameter of dish end =1.2 x Shell diameter

= 1.2 x 2.3

= 2.76m

=2 x ($\pi d^2/4$) x thickness x Steel density x labour cost

= 2x ($3.14x2.3^2/4$) x 0.005 x 8000 x 310

= ₹148299

3. Miscellaneous cost

= 0.15 (Shell cost + Dish end cost)
= ₹51260

4. Total cost = Shell cost + dish end cost + miscellaneous costs
= 193434+148299+51260
= ₹3, 92,993/-

MOTOR LIST

S.NO.	DESCRIPTION	OPERATIONAL (KW)	QUANTITY	
			OPR	STD. BY
1	MPC-01	3.3	1	1
2	MPC-02	3.2	1	1
3	MPC-03	3.2	1	1
4	MPC-04	3.2	1	1
5	MPC-05	3.2	1	1
6	F-01	8.7	1	1
7	F-02	8.7	1	1
8	PF-01	6.5	1	1
9	CV-01	4.3	1	1
10	CF-01	25	1	1
11	CF-02	25	1	1
12	RVF-01	50	1	1
13	FBD-01	100	1	1

TABLE NO. 11.1.

11.2. IN- HOUSE ITEMS

11.2.1. MOLASSES PRE-TREATMENT SECTION

SNO	EQUIPMENT	TECH SPEC.	QTY.	UNIT COST	PURCHASE COST	PACKING at 3%	GST 18%	TOTAL PURCHASE COST	FINAL COST
1	Broth Mixer	Std, SS	1	50,000	50,000	1500	9270	60,770	51,500
2	Dilute Molasses tank	5m3 ,SS	1	2,14,962	214962	6448.86	39853.9548	261264.8148	221410.86
3	Sludge collection tank	0.5m3, SS	1	38,364	38364	1150.92	13811.04	53325.96	39514.92
4	Clarified molasses tank	5m3 , SS	1	2,14,962	214962	6448.86	39853.9548	261264.8148	221410.86
5	Sweet water tank	1m3,SS	1	75,224	75224	2256.72	13946.5296	91427.2496	77480.72
6	H2SO4, Bulk storage tank	5m3, MS	1	65,964	65964	1978.92	12229.7256	80172.6456	67942.92
7	Molasses storage tank	149m3, MS	2	847857.7	1695715.4	50871.462	314385.6352	2060972.497	1746586.862
		TOTAL		**15,07,334**	**23,55,191**	**70655.742**	**443350.84**	**28,69,198**	**24,25,847**

11.2.2. FERMENTATION SECTION

SNO.	EQUIPMENT	TECH. SPEC.	QTY.	UNIT COST	PURCHASE COST	PACKING at 3%	GST 18%	TOTAL PURCHASE COST	FINAL COST
1	Culture Vessel	0.47M3, SS	1	46424	46424	1392.72	8607.0096	56423.7296	47816.72
2	Pre-fermentor	2.35M3, SS	2	1,43,427	286854	8605.62	53182.7316	348642.3516	295459.62
3	Fermentor	13M3,SS	4	3,92,993	1571972	47159.16	291443.6088	1910574.769	1619131.16
4	Holding tank	13M3,SS	1	3,92,993	392993	11789.79	72860.9022	477643.6922	404782.79
		TOTAL		**975837**	**2298243**	**68947.29**	**426094.2522**	**2793284.542**	**2367190.3**

11.2.3. CENTRIFUGATION

SNO.	EQUIPMENT	TECH. SPEC.	QTY	UNIT COST	PURCHASE COST	PACKING at 3%	GST 18%	TOTAL PURCHASE COST	FINAL COST
1	Holding tank	5M3, SS	1	2,14,962	214962	6448.86	39853.9548	**261264.8148**	**221410.86**

11.2.4. CIP

SNO.	EQUIPMENT	TECH SPEC.	QTY	UNIT COST	PURCHASE COST	PACKING at 3%	GST 18%	TOTAL PURCHASE COST	FINAL COST
1	Hot water tank	6.87m^3 ,SS	1	3,53,052	353052	10591.56	65455.8408	429099.4008	363643.56
2	caustic tank	6.87m^3, SS	1	3,53,052	353052	10591.56	65455.8408	429099.4008	363643.56
3	water tank	6.87m^3, SS	1	3,53,052	353052	10591.56	65455.8408	429099.4008	363643.56
		TOTAL		**10,59,156**	**1059156**	**31774.68**	**196367.5224**	**1287298.202**	**1090930.7**

11.3. VENDOR ITEMS

SECTION – MOLASSES PRE-TREATMENT

SNO.	EQUIPMENT	TECH SPEC	QTY.	UNIT COST	PURCHASE COST	PACKING 3%	GST 18%	TOTAL PURCHASE COST	FINAL COST
1	Process water heater	PHE	1	1,50,000	150000	4500	27810	182310	154500
2	Clarified molasses cooler	PHE	1	1,50,000	150000	4500	27810	182310	154500
3	Centrifugal pumps	2.5m^3 /h	10	50,000	500000	15000	92700	607700	515000
		TOTAL		**3,50,000**	**800000**	**24000**	**148320**	**972320**	**824000**

TABLE 11.3.1.

SECTION – FERMENTATION

SNO.	EQUIPMENT	TECH. SPEC.	QTY.	UNIT COST	PURCHASE COST	PACKING 3%	GST 18%	TOTAL PURCHASE COST	FINAL COST
1	Centrifugal pumps (Fermentor)		8	1,00,000	800000	24000	148320	972320	824000
2	Pumps for pre-fermentor		4	50,000	200000	6000	37080	243080	206000
3	Pump for Culture vessel		2	25,000	50000	1500	9270	60770	51500
4	PHE- Pre fermentor	STD	2	1,50,000	300000	9000	55620	364620	309000
5	PHE- fermentor	STD	4	3,00,000	1200000	36000	222480	1458480	1236000
6	Agitator	STD	6	2,50,000	1500000	45000	278100	1823100	1545000
		TOTAL		**8,75,000**	**4050000**	**121500**	**750870**	**4922370**	**4171500**

TABLE 11.3.2.

SECTION- CENTRIFUGATION

SNO.	EQUIPMENT	TECH. SPEC.	QTY.	UNIT COST	PURCHASE COST	PACKING 3%	GST 18%	TOTAL PURCHASE COST	FINAL COST
1	Disc Stack Centrifuge	3.9m^3/h	2	11,90,000	2380000	71400	441252	**2892652**	**2451400**

TABLE 11.3.3.

SECTION- FILTER PRESS

SNO.	EQUIPMENT	TECH. SPEC	QTY.	UNIT COST	PURCHASE COST	PACKING 3%	GST 18%	TOTAL PURCHASE COST	FINAL COST
1	RVF	STD	1	26,75,000	2675000	80250	495945	**3251195**	**2755250**
2	Extruder	STD	2	1,50,000	300000	9000	55620	364620	309000
3	Packaging machine		1	3,50,000	350000	10500	64890	425390	360500
		TOTAL		31,75,000	3325000	99750	616455	4041205	**3424750**

TABLE 11.3.4.

SECTION- FLUID BED DRYER

SNO.	EQUIPMENT	TECH SPEC.	QTY.	UNIT COST	PURCHASE COST	PACKING 3%	GST 18%	TOTAL PURCHASE COST	FINAL COST
1	Fluid bed dryer	STD	1	90,00,000	9000000	270000	1668600	10938600	**9270000**
2	Packaging machine	STD	1	6,00,000	600000	18000	111240	729240	618000

TABLE 11.3.5.

11.4. PIPING, VALVES AND INSTRUMENTATION

SNO.	EQUIPMENT	TECH SPEC	QTY	UNIT COST	PURCHASE COST	PACKING AT 3%	GST AT 18%	TOTAL COST	FINAL COST
1	Piping and valves	lots	1	4029754.346	4029754.346	120892.6304	747116.46	4897763	4150646.98
2	Instrumentation	STD	1	2686502.897	2686502.897	80595.08692	498077.64	3265176	2767097.98
3	Electrical	STD	1	1343251.449	1343251.449	40297.54346	249038.82	1632588	1383548.99
		TOTAL			**8059508.69**	**241785.2607**	**1494233**	**9795527**	**8301294**

TABLE 11.4.

11.5. UTILITES

S.NO.	EQUIPMENT	TECH SPEC	QTY	UNIT COST	PURCHASE COST	PACKING 3%	GST 18%	TOTAL COST	FINAL COST
1	Boiler	0.5MTH at 3.5bar (g)	1	10,00,000	1000000	30000	185400	1215400	1030000
2	Cooling tower	STD	1	35,00,000	3500000	105000	648900	4253900	3605000
3	Refrigeration	STD	1	15,00,000	1500000	45000	278100	1823100	1545000

TABLE 11.5

11.6. SUMMARY

SUMMARY	
Technology offered :	**BAKER'S YEAST PLANT**
Material rates: **SS 304/INR per Kg** **MS/INR per Kg** **SS 316/INR per Kg**	 250+60 (Mtl + Labour) 65+32 (Mtl + Labour) 340+60 (Mtl + Labour)
	PRICE IN LAC
In house Fabricated Items	61.05378972
Bought out Items	207.5965
Piping & Valves	41.50646976
Utilities	61.8
Instrumentation	27.67097984
ETP	187
Electricals	13.83548992
TOTAL	600.4632292
Man-hour Cost @Rs.400/ man-hr.	5
Contingency@ 3%	18.16389688
FINAL COST (INR)	623.6271261
Price @ 30 % Contribution	890.8958945
Erection @12 % of Price	106.9075073
Project Related Expenses @ 5% of Price	44.54479472
Civil , Structural & Shed @ 20% of Price	178.1791789
Transportation @ 5% of Price	44.54479472
Gross Total	1265.07217
GST	62.25396481
GRAND TOTAL	**1327.326135**

11.7. FEATURES OF PROJECT IDENTIFICATION

Following are the important features of project identification:

1. Market and sales – justification of project
2. Methods of Production
   (a) Process flow diagrams
   (b) Chemical reactions
3. Chemical Engineering problems
   (a) Manufacturing
   (b) Economics
4. Land requirement and Land Development
5. Raw material storage and handling system
6. Utility sources etc.

The most important aspect of any project is the identification of the business need not necessarily anything related to engineering or construction. This is the conclusion of studies by various organizations. This documented business need is commonly called the business case, the project charter or the business statement. The business case must relate to the end result and be based on the business expectations. The overall Return on Investment (ROD, a key decision parameter, is defined by determining the capital cost, and the time-to-market. A well-developed business case should also identify the risk posture of the. Business, the required economic return and other business-oriented parameters; the longer the construction time, the lower is the rate of return.

11.8. PAYBACK PERIOD

Payback period is a widely utilized financial metric to evaluate the financial viability of an investment. It signifies the duration required for an investment to generate adequate cash flow to recover its initial cost. This metric is straightforward and extensively used in the investment community to assess the potential risks and returns of an investment. To calculate the payback period, the initial cost of the investment is divided by the annual cash inflow generated by the investment; resulting in the number of years it will take for the investment to recuperate its initial cost. A shorter payback period is generally perceived as more attractive, indicating lower risk and faster recovery of the initial investment. However, the payback period has limitations and may not consider certain factors such as inflation and the opportunity cost of investing the money elsewhere. Despite its limitations, payback period remains a valuable tool to provide valuable insights into the financial performance of an investment.

11.8.1. ESTIMATED PROJECT INVESTMENT

S.NO.	**PARAMETER**	**PRICE IN LACS(INR)**
1	Land and land development	100
2	Civil and structure	122.5
3	transportation and project related expenses	62
4	Cost of Equipment	889.9
5	Contingencies	12.5
6	Erection	73.7
7	ETP	187
8	Laboratory set up	25
9	Misc.	70
	TOTAL	**1542.6**

TABLE 11.8.1.

11.8.2. SALES REVENUE

SNO.	TYPE OF PRODUCT	QTY MT/ANNUM	RATE Rs./KG	RATE Rs./MT	SALES/ANNUM (INR IN LACS)
1.	Active dried yeast	300	350	3,50,000	1050
	Compressed yeast cake	600	120	1,20,000	360
		TOTAL			**1410**

TABLE 11.8.2.

11.8.3. VARIABLE EXPENSES (IN LACS PER ANNUM)

S NO	TYPE	QUANTITY	PRICE	PRICE IN LACS (INR)
1	Molasses 1410MT at Rs.10,000 per MT	1410	15,000	211.5
2	Steam	1524	4000	60.96
3	Electricity	14,95,116	8	119.60928
4	Chemicals			10
5	Packing bags (500g ADY , 1KG CY)	12,00,000	8	96
	TOTAL			**498.06928**

TABLE 11.8.3.

FIXED EXPENSES	PRICE IN LACS (INR)
Total Investment	1542.6
Equity (40%)	617.04
Term Loan (60%)	925.56

Working capital:

Molasses: 5 days stock

211.5/300 x 5 = 3.5 lac

Packing material: 5 days stock

96/300 x 5 = 1.6 lac

Misc. = 5 lac

Total = 10.1 lac

FIXED EXPENSES	IN LACS
Interest on term loan	138.834
Interest on working capital	1.51875
Administrative expenses	20
Sales expense(3% of sales)	42.3
Salary and wages	20
Total	222.65275
TOTAL EXPENSES (FIXED + VARIABLE)	**720.72203**

Contribution: Sales revenue – expenses

=689.2lac

Depreciation: 20% of interest

=308.5lac

Gross Profit: Contribution – Depreciation

=380.7lac

TAX: 22% on gross profit

=83.7lac

Profit after Tax: Gross Profit –Tax

=296.9lac

Money Generated: Profit after tax + Depreciation

=605.5lac

Payback period:

= Investment/ Money generated

= 1542.6/605.5

=2.54

= 2.5 years

Or **2 years 6months**

CHAPTER -12

UTILITY SUMMARY

PROJECT TITLE	**:**	**BAKER'S YEAST PLANT**
PLANT CAPACITY	**:**	**1MT/DAY – ACTIVE DRIED YEAST** **2 MT/DAY – COMPRESSED YEAST CAKE**
LOCATION	**:**	**PUNE**
SCOPE	**:**	**UTILITY SUMMARY**

CONTENTS

S. No.	DESCRIPTION
12.1	PROCESS WATER (RO QUALITY)
12.2	STEAM
12.3	INSTRUMENT AIR
12.4	ELECTRICAL POWER
12.5	COOLING TOWER
12.6	EFFLUENT TREATMENT PLANT

12. UTILITY CONSUMPTION:

12. 1. PROCESS WATER - (REVERSE OSMOSIS i.e. RO WATER QUALITY)

Process Water is required for the baker's yeast plant purpose in Baker's yeast flame proof and non-flame proof section during reaction process, Plant upset condition, Chemical and enzyme Preparation, Pump Sealing, Centrifuge Sealing, Centrifuge cleaning, Hot water tank make up

The Quality and Quantity of process water required are as below:

12.1.1. QUANTITY OF PROCESS WATER REQUIRED:

PROCESS WATER FOR PROCESS CONSUMPTION (Specification –A)		
Description	**Unit**	**Value**
Continuous Water Requirement	m^3/day	33.84
Pressure of Process Water	Bar (g)	4
Temperature of the Process Water	Deg.C	28 to 30

12.1.1.1. Specification A – Process Water (RO Water) Quality

Parameter	**Unit**	**Value**
Total germs	Nos./ml	60 CFU
Coliform Bacteria	Nos./ml	Nil
E. Coli	Nos./ml	Nil
Residual free chlorine	PPM	< 1
H_2S	PPM	Nil
Chlorides (Cl^-)	PPM	NIL
TDS	PPM	200
pH	–	6 – 8
Suspended Solids	PPM	Nil
Hardness as CaCO3	PPM	<11
Silica (SIO2)	PPM	< 30
Dissolved O2	PPM	0.1 Max
Free CO2	PPM	Nil
Bound CO2	PPM	<5
Turbidity	NTU	Nil

12.1.1.2. Specification B – Cooling Tower makeup water (RO water) Quality

Parameter	**Unit**	**Value**
Total germs	Nos./ml	60 CFU
Coliform Bacteria	Nos./ml	Nil
E. Coli	Nos./ml	Nil
Residual free chlorine	PPM	< 1
H_2S	PPM	Nil
Chlorides (Cl^-)	PPM	NIL
TDS	PPM	200
pH	–	6 – 8
Suspended Solids	PPM	Nil
Hardness as CaCO3	PPM	<10
Silica (SIO2)	PPM	< 30
Dissolved O2	PPM	0.1 Max
Free CO2	PPM	Nil
Bound CO2	PPM	<5
Turbidity	NTU	Nil

12.2. STEAM:

Quality of Steam Required:

Steam should be dry (dryness fraction =1.0), saturated at 3.5 bar (g) constant pressure, provided at the inlet of Header provided in the bio diesel process plant for flameproof and non-flameproof sections.

Quantity of Steam Required:

The steam consumption at steady state of operation is:

DRY SATURATED STEAM FOR PROCESS PLANT		
Description	**Units**	**Value**
Normal Load	MT/hr.	2
Peak Load	MT/hr.	3 (F&A 100 Capacity)
Steam Pressure at the Inlet of Steam Header	Bar (g)	3.5
Steam Temperature	^{o}C	148

Note:

1. Steam consumption is at steady state conditions and at uninterrupted utility supply.
2. The maximum variation in the steam pressure shall not be more than $\pm$ 0.05 kg/cm2.
3. Steam consumption mentioned above is net consumption excluding heat Losses.
4. At turn down capacity of plant steam consumption is not linear & will be higher.
5. Maximum Steam consumption is based on the upset operation in the plant. Steam system shall be designed for the Maximum Load.

12.3. INSTRUMENT AIR:

Sr. No.	Description	Unit	Value
1.	Normal Load	Nm^3/hr	6.3
2.	Peak Load	Nm^3/hr	6.5
3.	Pressure at inlet of the Instrument air Header	Bar (g)	6

Note:

1. Instrument air should be Clean, dry and Oil free with dew point of (-) 40^oC.

12.4. ELECTRICITY (POWER SUPPLY):

Sr. No.	Description	Unit	Normal Load
1.	Electrical Power –Connected	KW	340
2	Voltage	V	415 VAC +/- 10 %
3	Frequency	Hz	50 Hz +/- 5 %
4	Phase	-	3 Phase
5	Supply	-	4 Wire Supply

12.5. COOLING WATER CAPACITY & COOLING WATER PUMP:

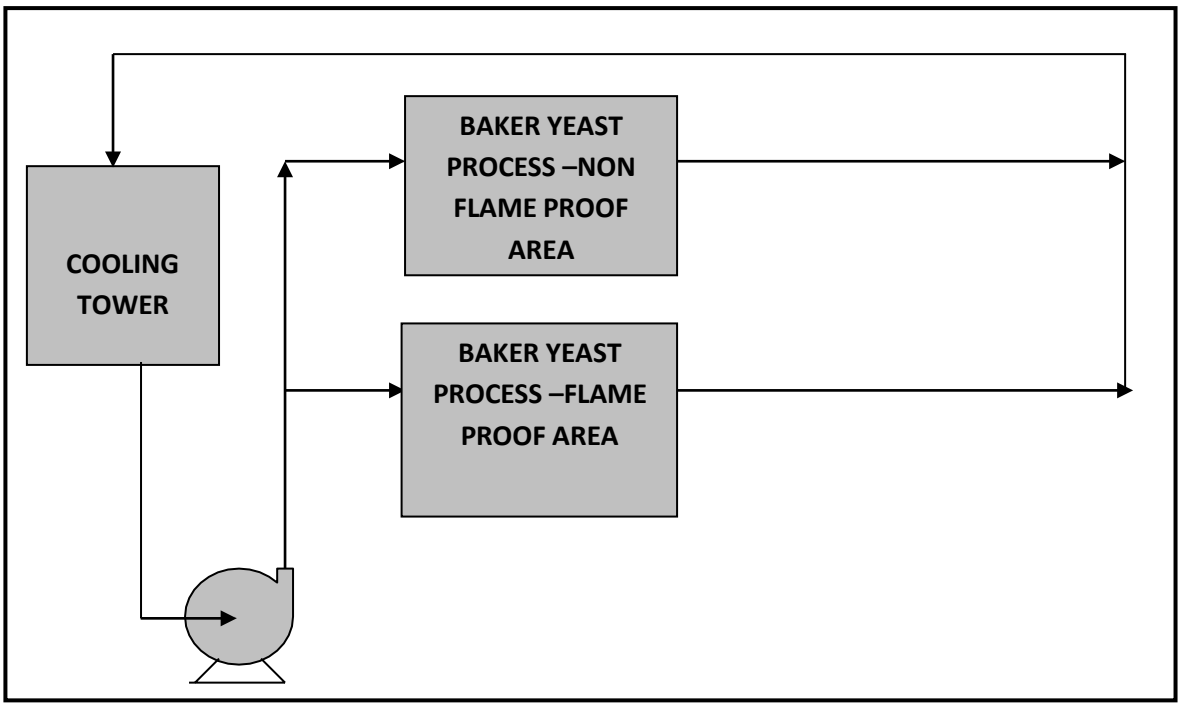
11.5.1 Cooling Water Recirculation Rate:

Sr. No.	Section	Inlet Temp ^{0}C	Outlet Temp ^{0}C	Recirculation Rate (design) m^3/hr. (**)
1.	Baker's yeast Process	28 to 30	33 to 35	180-200

12.5.2. Cooling Water Recirculation Pump:

Section	Quantity (Op+ std.by)	Flow rate/Each (m3/hr)	Head (m)
Cooling Water Recirculation Pump	2+1	100	20

12.5.3. Schematic Cooling Water Circuit:



Note:

1. Mentioned quantities are based on maximum cooling water supply temperature of 28-30^{O}C.
2. Cooling water Recirculation Pump (2 Operating + 1 Standby) is considered for design.
3. (**) All above Cooling water Requirement are with 10 % Margin.

Specification C – Cooling Water recirculation

Parameter	**Unit**	**Permissible Limits**
pH	-	7-9
H_2S	mg/l	Nil
Residual Free Chlorine	mg/l	< 1
Total Hardness(Expressed as $CaCO_3$)	mg/l	<300
Total Dissolved Solids	mg/l	<3500
Silica (SiO_2)	mg/l	<100
Chloride	mg/l	<300
Sulphate	mg/l	<600
Turbidity	NTU	<10
Total Suspended Solids	Mg / Lit	< 20

Note:

mg/lit – Parts per Million (PPM).

1. Complete draining of the cooling water from the equipment needs to be ensured during Shut-down**.**

2. Cooling Water Recirculation quality should be filtered, potable, and free from algae and Suspended solid- like sand, sludge etc.

12.6.ETP – EFFLUENT TREATMENT PLANT

Basis: 2MT Compressed yeast per day

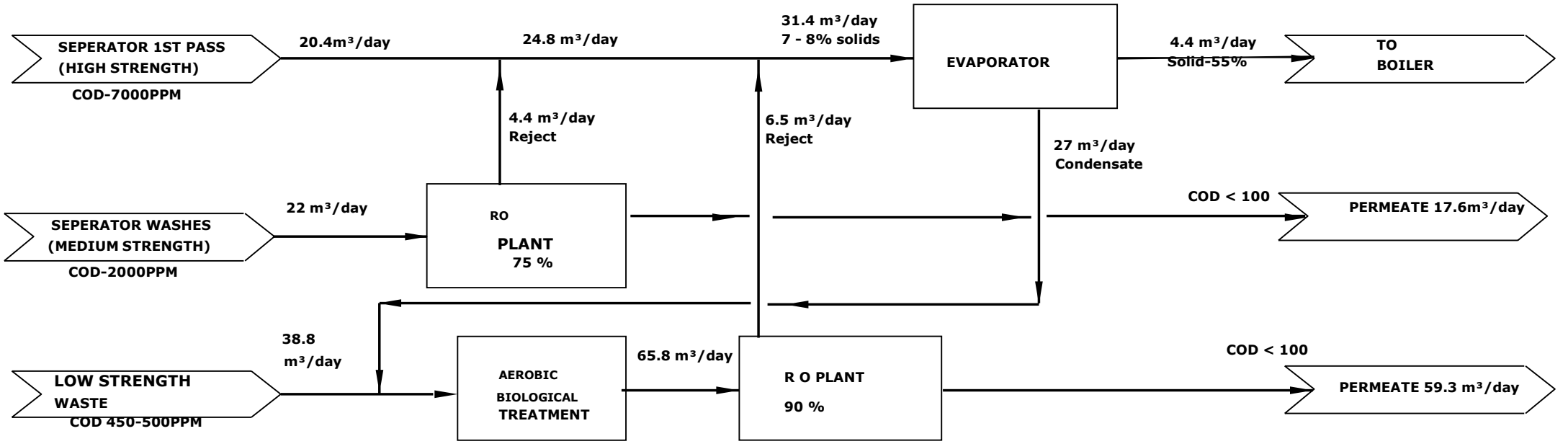
1 MT Active dried yeast per day

Considering compressed yeast as a basis for yeast generation per day = 4.7MT
No. of working days = 300
So, total yeast production per annum = 300 x 4.7 =1410
=1410 TPA BAKER'S YEAST

Effluent generation is a common by-product of the production of baker's yeast. The effluent from a baker's yeast plant is typically classified as organic wastewater, characterized by high concentrations of organic matter, such as carbohydrates, proteins, and lipids. The effluent also contains nutrients such as nitrogen and phosphorus, as well as residual yeast cells, cleaning agents, and disinfectants used in plant sanitation.

The high organic load of baker's yeast plant effluent can make it challenging to treat and dispose of. However, there are several treatment options available, including aerobic and anaerobic biological treatment, physical-chemical treatment, and membrane filtration. The choice of treatment method will depend on factors such as the volume and composition of the effluent, as well as local regulations and environmental considerations. Effective treatment of baker's yeast plant effluent is crucial for ensuring compliance with environmental regulations and minimizing the plant's impact on the surrounding ecosystem. Proper treatment and management of effluent can also help to minimize the plant's operating costs and improve its overall sustainability performance.

EFFLUENT GENERATION FOR 1410 TPA BAKER'S YEAST



CONCLUSION

Saccharomyces cerevisiae is a versatile microorganism with numerous applications in different industrial sectors, including food, beverage, pharmaceutical, and environmental industries. Its wide range of metabolic capabilities and its ability to tolerate harsh conditions make it an attractive microorganism for various biotechnological applications. Through years of research and development, the use of S. cerevisiae has grown tremendously, and its industrial significance cannot be overstated.

In the food and beverage industry, S. cerevisiae plays a crucial role in the production of fermented foods and beverages such as bread, beer, wine, and cheese. The unique aroma, flavour, and texture of these products are attributed to the metabolic activities of S. cerevisiae during fermentation. In the pharmaceutical industry, S. cerevisiae has been used as a model organism for studying the genetic and metabolic pathways of eukaryotic cells. It has also been employed in the production of recombinant proteins, vaccines, and therapeutic agents.

The design of a baker's yeast production plant from cane molasses involves various parameters, such as reactor type, fermentation conditions, and downstream processing methods. The use of a fed-batch reactor with optimal fermentation parameters, such as pH, temperature, and aeration rate, is crucial in achieving maximum yeast growth and productivity. The implementation of downstream processing methods, including centrifugation, fluid bed drying, and packaging, also plays a vital role in ensuring the quality and shelf-life of the final product.

The project economics of the proposed baker's yeast production plant also highlights the importance of a thorough feasibility study, including capital and operating costs, revenue streams, and profitability analysis. The payback period of 2.5 years for the proposed plant is promising and indicates that the project is financially viable. The sensitivity analysis also highlights the impact of varying input costs on the production of baker's yeast and suggests strategies to mitigate these risks.

Overall, the design of a sustainable and profitable baker's yeast production plant from cane molasses is feasible and can contribute to the food industry's growth and development. The implementation of novel technologies and techniques, such as genetic engineering and continuous fermentation, can further enhance the process efficiency and product quality. Further research and development are needed to explore the full potential of S. cerevisiae in various industries, including pharmaceutical, bio-research, and environmental technologies

S. cerevisiae has also found applications in environmental biotechnology, such as in the treatment of wastewater and the production of biofuels. Its ability to tolerate various environmental stresses, including high salinity, temperature, and pH, makes it an ideal candidate for these applications.

Despite the numerous applications of S. cerevisiae, there is still room for further research and development. The understanding of its genetic and metabolic pathways continues to evolve, opening up new possibilities for its use in various biotechnological applications. Moreover, the development of advanced bioprocess engineering techniques such as metabolic engineering and systems biology has the potential to improve the yield and efficiency of S. cerevisiae-based bioprocesses.

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