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Fermenter Design for Production of Ethanol from Napier Grass

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Abstract: *1000 ml of 0.1M sodium acetate buffer solution poured into 1000 ml (Erlenmeyer) conical flask, 20 g of Aspergillus Niger (crude enzyme), 5 g of brewer's yeast (Saccharomyces cerevisiae), 20 g of treated elephant grass added and 1 g of MgSO4, 2 g of (NH4) H2PO4 added as nutrient. The flask corked properly, sealed with aluminum foil paper and incubated at 30 OC for 48-72 hrs. in an incubator. We can increase the fermentation time 4-6 days for analysis of yield of ethanol from biomass. As per literature study optimum time of fermentation is 72 hrs. i. e. 3 days. As per analysis 1000 ml (1 L) of ferment yield of 110 ml of ethanol. 11 % of yield of ethanol from Napier grass with substrate concentration 140-160 gm/L. With help of yield we design fermenter (Reaction Vessel) for both continuous and batch operation. For batch operation, for fermentation of elephant grass required time is 72 hrs. i.e. is 3 days So, in case of batch operation we need to install 2 No. of fermenter. 2 fermenter for 4 days operation including one day cleaning and feeding. According to fermentation time we feed material in 1st and 2nd feed 1st and 2nd day will get output as 4th, and 5th with twice volume as continuous operation. For this system we design fermenter for 27.79 m3 volume get internal and outer diameter as 5and 5.06 m resp., Thickness and length 4 mm and 7.5 m resp. We need two fermenter of volume 27.79 cubic meter each.*

Keywords: Napiergrass, Ethanol, Batch operation, Fermenter Design

I. INTRODUCTION

Napier grass or others of lignocellulose biomass has to hydrolyze cellulose into fermentable sugars by enzyme and then these sugars are converted into products by microorganism. It is showing a low utilization of enzymatic hydrolysis when the lignocellulose biomass is used directly because the cellulose fiber is covered with the lignin. Pretreatment step is needed to render it more accessible for hydrolytic enzyme. Numerous physical, physicochemical, chemical, and biological methods have been tested for the pretreatment of Napier grass. These pretreatments afford the recovery of cellulosic content from grass biomass, the removal of structural components such as lignin, pectin, or hemicellulose and the breakdown of the crystal region in the cellulose bunch to render it digestible for cellulolytic enzymes. Chemical methods for Napier grass biomass pretreatment involve the use of sodium hydroxide, liquid ammonia, dilute sulfuric acid, dilute acetic acid and hydrogen peroxide. [4]

Two-stage by diluted sulfuric acid and sodium hydroxide successively on non-cellulosic components removal. The yield cellulosic materials were used to produce ethanol by simultaneous saccharification and fermentation (SSF) that is an effective process for bioethanol production from lignocellulosic feedstock after pretreatment. The ethanol production using SSF was influenced by the removal efficiency of non-cellulosic fractions via different pretreatment methods.

1. Wet Milling

Wet milling is used to produce many products besides fuel ethanol. Large-scale, capital-intensive, corn processing wet mills produce such varied products as high fructose corn syrup (HFCS), biodegradable plastics, food additives such as citric acid and xanthan gum, corn oil and livestock feed.

2. Dry-Grind

In dry mill process the entire grain kernel is ground into flour. The starch in the flour is converted to ethanol during the fermentation process, creating carbon dioxide and distillers' grain. Fermentation is one of the oldest process known to man.

Ethanol is mainly produced by dry-grinding process (approximately 67%) and its percentage is increasing rapidly. Dry-grind ethanol process whole grain is processed and the residual components are separated at the end of the process. There are five major steps in the dry-grind method of ethanol production.

Dry-Grind Ethanol Processing [1]

The liquid portion of the slurry has 8-12% ethanol by weight. The whole process requires 48-72 hours. Batch fermentation systems use and is more popular. For continuous operation need 4 numbers of fermenter for fermentation time.

1. Milling
2. Physical and Chemical Pre-treatment
3. Liquefaction
4. Saccharification and Fermentation
5. Filtration
6. Distillation and Recovery

1. Milling

Milling through a hammer mill (with screens between 3.2 to 4.0 mm) to reduce size of biomass. This whole is slurries with water and heat-stable enzyme (a-amylase) is added.

2. Liquefaction

Slurry is cooked (liquefaction) is accomplished using jet-cookers that inject steam into corn flour slurry to cook it at temperatures above 100 °C. The heat and mechanical shear of the cooking process break apart the starch granules present in the kernel endosperm and the enzymes break down the starch polymer into small fragments. The cooked corn mash is then allowed to cool to 80-90 °C additional enzyme is added and slurry is allowed to continue liquefying for at least 30 minutes.

3. Saccharification

After liquefaction slurry (corn mash) is cooled to approximately 30 ^{O}C second enzyme (glucoamylase) is added. Glucoamylase completes the breakdown of the starch into simple sugar (glucose) called saccharification often occurs while the mash is filling fermenter in preparation for fermentation.

4. Fermentation

In fermentation step yeast grown in seed tanks are added to corn mash to begin process of converting simple sugars to ethanol. Other components of corn kernel remain largely unchanged during the fermentation process. In most dry-grind ethanol plants fermentation process occurs in batches. A fermentation tank is filled and the batch ferments completely before the tank is drained and refilled with a new batch. The up-stream processes (grinding, liquefaction and saccharification) and downstream processes (distillation and recovery) occur continuously. Dry-grind facilities of this design usually have three fermenters where at any given time one is filling one is fermenting (usually for 48 hours) and one is emptying and resetting for the next batch. Carbon dioxide is also produced during fermentation. Carbon dioxide can be compressed and sold for carbonation of soft drinks or frozen into dry ice for cold product storage and transportation.

After the fermentation is complete and the fermented corn mash (beer) is emptied from the fermenter into a beer well. The beer well stores the fermented beer between batches and supplies a continuous stream of material to the ethanol recovery steps including distillation. The whole process requires 48-72 hours and can concentrate up to 10-12 % of ethanol. CO_2 formed during this process lowers down the pH below 4 in order to enhance the activity of glucoamylase and to check the surrounding infection. The Batch and Continuous fermentation systems can be used and out of both batch process is more popular. CO_2 released can be captured and sold for the use in carbonating soft drinks, dry ice and some beverages industries. The anaerobic fermentation reaction is represented by

$C_6H_{12}O_6 = 2C_2H_5OH + 2CO_2$

5. Distillation and Recovery

The liquid portion of slurry has 8-12% ethanol by weight. Ethanol boils at a lower temperature than water so can be separated by a process called distillation. Conventional distillation/rectification systems can produce ethanol at 92-95 % purity. The residual water and biomass solids that remain after distillation process called stillage. This whole stillage is then centrifuged to separate liquid from distillers' grains. Syrup blended with distillers' grains & dried to produce an animal feed called distillers dried grains with soluble (DDGS).

Pre-Treatments

There are two major problems related to the lignocellulosic material these are one it contains lignin which is hard covering offers resistance to the conversion process require to generate fermentable sugar and second major problem is the degree of crystallinity of cellulose.

Physical Pre-Treatment

a) Drying
b) Grinding
c) Granulometric separation

Thermo-Chemical Pre-Treatment

a) Steam Explosion
b) Alkaline Pre-Treatment
c) Acid hydrolysis
d) Fibre Expansion
f) Liquid Hot Water

II. LITERATURE REVIEWS

Three design matrixes were made by Central Composite Designs (CCD) thirteen batches for each matrix were run in a 3 L fermenter. The first matrix designs conducted by CCD include combined effect of variables, temperature and pH while the substrate concentration remained constant at 160 g. Second matrix design conducted by CCD includes combined effect of variables temperature and substrate concentration at constant pH 5.8. [3]

Maximum ethanol production (74.6 g/L) achieved at combination–pH 5.8, temperature 31^{O}C. Minimum ethanol concentration (36 g/L) obtained at pH 7.21 and temperature 31 ^{O}C in first quadratic model. Maximum ethanol production (74.6 g/L) achieved at temperature 31 ^{O}C and substrate concentration 160 g. Minimum ethanol production (47 g/L) found to be at temperature 43.7 ^{O}C and substrate concentration 160 g in the second quadratic model. Maximum ethanol production (74.6 g/L) in this experiment found to be at pH 5.8 and substrate concentration 160 g. [3]

Minimum ethanol production (36 g/L) reported at pH 7.21 and substrate concentration 160 g in the third quadratic model. Microbial culture is highly effective at pH 5.8. At higher pH yeast produces acids rather than alcohol. At acidic pH there is no chances of bacterial contamination.[3]

Yadav et al. found an increase in alcohol concentration productivity as well as efficiency with an increase in pH from 4.0-5.0 and found that the optimum pH range for S. cerevisiae strain HAU-1 to be between pH 4.5-5.0. The temperature also found to be having profound effect on ethanol concentration. The highest ethanol observed at a temperature of 31 ^{O}C. At high temperature there might be the thermal deactivation of enzymes as well as yeast which might be responsible for lesser production of ethanol. At high substrate concentration there is lower heat and mass transfer rate during fermentation process which will inhibit the growth of yeast. At high substrate concentration the growth parameters are inhibited due to high medium osmolality. [3]

The maximum ethanol production observed at substrate concentration 160 g/L, followed by 140 g/L and 180 g/L. Effect of pH is more significant than temperature. In second quadratic model quadratic effects of both the variables more significant than linear effects. Linear effect of temperature slightly more than substrate concentration on ethanol production. Effect of pH found more profound than substrate concentration in third quadratic model. Maximum ethanol production (78 g/L) during first experiment i.e. by changing one variable at a time found to be at conditions-pH 5.5 and temperature 35 ^{O}C. Ethanol concentration effected by pH followed by substrate and temperature. [3]

Napier grass has a great potential to be chosen as raw material for renewable energy production. Napier grass after different pretreatments tested for simultaneous saccharification and fermentation (SSF) with dried yeast (Saccharomyces cerevisiae) and cellulase to produce ethanol. For alkaline pretreatment the grass was incubated with 10% NaOH at a ratio of 1:20 (w/v) at 90°C for 1 hour. For dilute acid pretreatment grass soaked with 1% H_2SO_4 at a ratio of 1:10 (w/v) and incubated at 120 ^{O}C for 1 hour. [4]

For 2 % NaOH at 120 ^{O}C for 1 h with and with 1:20 solid to liquid ratio ethanol yield 0.1415 g/g raw material when SSF by Saccharomyces cerevisiae. For 0.1415 g/g raw material when SSF by Saccharomyces cerevisiae ethanol yield 0.121 g/g, SSF. Two-stage: 1% H_2SO_4 with 1:10 solid to liquid ratio at 120 ^{O}C for 60 min and followed by 2% NaOH with 1:10 solid to liquid ratio at 80 ^{O}C for 6 h ethanol yield 0.116 g/g. [4]

The production of bio-ethanol from Elephant grass (Pennisetum purpureum) stem was carried out using elephant grass stem as a feedstock and a combination of Aspergillus Niger by simultaneous saccharification and fermentation (SSF). The most suitable pre-treatment method from the following pretreatment methods; 1M H_2SO_4, 0.1M H_2SO_4, 1M NaOH, 0.2M NaOH, Boiling, and 3M NH_4OH. IM NaOH pre-treatment gave the highest cellulose and lowest lignin content. Effects of temperature at 25 ^{O}C, 30 ^{O}C, 35 ^{O}C, 40 ^{O}C and 45 ^{O}C, pH values of 3.5, 4.0, 4.5, 5.0, 5.5, 6.0 and 6.5, substrate concentration values of 1, 2, 3, 4 and 5 %. [5]

Substrate concentration of 30 g/l gave highest ethanol concentration of 23.4 g/l and a yield of 78 %. 100 ml of 0.1M sodium acetate buffer solution poured in 250 ml Erlenmeyer flask, 0.2g of Aspergillus Niger, 0.5 g of Saccharomyces cerevisiae (brewer's yeast), 2g of untreated or treated elephant grass added and 0.1g of $MgSO_4$, 0.2 g of $(NH_4)\ H_2PO_4$ added as nutrient. Flask corked properly sealed with aluminum foil paper and incubated at 30 ^{O}C for 5 days in incubator. [5]

The production of bio-ethanol from Elephant grass stem carried out using elephant grass stem as a feedstock combination of Aspergillus Niger and Saccharomyces cerevisiae (brewer's yeast) as cells by simultaneous saccharification and fermentation (SSF). Pretreated and untreated elephant grass considered for ethanol production. Alkaline pretreatment by soaking sample in 1M NaOH for 2-10 hrs. at 1:10 solid/liquid ratio. [6]

Optimum conditions of fermentation obtained at temperature of 35 ^{O}C, pH value of 5.5, substrate concentration of 30 g/l, particle size range of 250-300 μm and Aspergillus Niger to yeast ratio of 0.6/1.5 after 72 hours of fermentation time. Substrate concentration of 30 g/l give highest ethanol concentration of 23.4 g/l and a yield of 78 %. Effect of substrate concentration on ethanol yield from untreated elephant grass. As substrate concentration increases from 10 g/l to 30 g/l, ethanol yield increased to 78 % after 72 hours of fermentation. [6]

Materials and Methods

Raw Materials and Chemicals

1. Elephant Grass
2. Aspergillus Niger (Crude Enzyme)
3. Brewer's Yeast
4. 0.1 N NaOH and 0.1 N H_2SO_4
5. Distilled Water
6. Nutrients for Microorganism - $MgSO_4$ and $(NH_4)H_2PO_4$
7. 5 % NaOH and 5% H_2SO_4 for Biomass Pretreatment

Chemistry of Bio-Ethanol [6]

Simple sugar (Glucose) is synthesized in plant by photosynthesis

$6CO_2 + 6H_2O + \text{light} = C_6H_{12}O_6 + 6O_2$

During ethanol fermentation, glucose decomposed into ethanol and carbon dioxide.

$C_6H_{12}O_6 = 2C_2H_5OH + 2CO_2 + \text{heat}$

During combustion, ethanol reacts with oxygen to produce carbon dioxide water and heat.

$C_2H_5OH + 3O_2 = 2CO_2 + 3H_2O + \text{heat}$

Glucose itself is not the only substrate in plant that is fermentable. Simple sugar fructose undergoes fermentation. Three other compounds in the plant can be fermented often breaking them up by hydrolysis into the glucose or fructose molecules that compose them. Starches and cellulose molecules are strings of glucose molecules and sucrose is molecule of glucose bonded to molecule of fructose. Ethanol also produced industrially from ethene (ethylene). Addition of water to bond converts ethene to ethanol.

$CH_2 = CH_2 + H_2O = CH_3CH_2OH$

This is done in the presence of an acid which catalyzes the reaction.

III. BIO-ETHANOL PRODUCTION PROCESS [6]

Steps of Fermentation of Ethanol

1. Sample Preparation

The elephant grass was first dried to a constant weight in an oven at a temperature of 105 oC for 48 hours and it was then milled. Alkaline/acid pretreatment was done by for 2-10 hrs. at 1:10 solid/liquid ratio. After pretreatment washed repeatedly with distilled water until pH of 7 attain. Elephant grass was then dried in oven at 50 ^{O}C to for 48 hours.

2.Simultaneous Saccharification & Fermentation (SSF) Elephant Grass

100 ml of 0.1M sodium acetate buffer solution poured into 250 ml Erlenmeyer flask, 0.2g of Aspergillus Niger (crude enzyme), 0.5g of brewer's yeast (Saccharomyces cerevisiae), 2g of treated elephant grass added and 0.1g of MgS04, 0.2g of (NH4) H2PO4 were added as nutrient. Flask corked properly, sealed with aluminum foil paper and incubated at 30 oC for 48 - 72 hrs. in an incubator. We can increase fermentation time 4-6 days for analysis of yield of ethanol from biomass.

3. Filtration and Distillation of Fermented biomass

After fermentation of biomass it filter with help of filter cake and then filtrate to be distillate at 78-80 oC for separation of ethanol from it. Finally calculate properties and yield of ethanol.

IV. DESIGN OF FERMENTATION

The liquid portion of the slurry has 8-12% ethanol by weight. The whole process requires 48-72 hours. The Batch and Continuous fermentation systems can be used and out of both batch process is more popular. By using material balance, we get the volume of fermenter for 1 KL ethanol production. With help of volume and design equations we can calculate Length, Height, Thickness, I.D., O.D., Weight of Vessel, Head thickness and cost of Fermenter.

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Stepwise Procedure for Fermenter Design

1. Calculate the volume of ethanol produce from 1 or 2 L of ferment by lab based experimental analysis.
2. Ferment means the medium and biomass mixture which produce the ethanol.
3. Convert that volume for 1 T/Day ethanol production i.e. by calculation we get volume of ferment requires to produce 1 T/day ethanol.
4. By considering volume we can calculate internal diameter and length of fermenter.
5. Then using design equation we can also calculate the outer diameter and thickness of vessel.
6. With help of outer diameter and thickness next we can calculate the weight of heads and vessel.
7. Finally we can calculate the cost of vessel requires. (Total cost for vessel = Material cost and Fabrication Cost)
8. Then add cost of agitator, Motor, supports, gas sparger etc.

Design of Fermenter for Batch Operation

Feed Conditions

Temperature – 35 ^{O}C, Pressure – 101.325 KPa and Fermentation Time – 72 hrs.

Feed –

Elephant grass (20 gm)

Water (1 L or 1 Kg)
Aspergillus Niger (2 gm)
Brewer's Yeast (5 gm)
$MgSO_4$ (1 gm)
$(NH_4)H_2PO_4$ (2 gm)

Output from Fermenter
Fermented Biomass -97-99 gm
Non-fermented Biomass- 931-933 gm
Here, fermented biomass in filtrate is 99 kg but maximum recovery of ethanol will be 98%. Hence, the distillate will be 0.98 * 99 = 98 gm. Volume of ethanol produce can be calculating by using density of ethanol (0.875 gm/ml). As density is the ratio of mass / volume. Volume of Ethanol (ml) = 97/0.875 = 110 ml/L of Ferment.

Volume of Fermenter
Total Feed (Composition) for Fermenter or Reactor = 1030 gm/Day
Total Mass of Ethanol produce = 99 gm (110 ml)
1.030 L (1030 gm) Feed ferment = 110 ml Ethanol
Ethanol contains in slurry or ferment = (110/1030) * 100 = 10.6 %

Design based on 1 Ton per day Production.
Density of Ethanol = 785 kg/m^3 at room temperature.
Using, Density = Mass/ Volume
Volume of Ethanol for 1T (1000 kg) Production
= 1000/785
=1.27m^3 1.27*1000 = 1270 L
Volume of Ethanol per produce batch
= 1.27 m^3 (1270 L)
Volume of ferment can be calculated,
1L Ferment = 0.110 L Ethanol
X liter ferment = 1270 liter
X = 11545.45 L
For batch operation we need to install 2 fermenter that gives 2 T output of ethanol.
So, Volume will be twice = 1270* 2 = 2570 L of Ethanol.

For production of 2 T requires 11545.45*2 L = 23090 L of ferment medium.
Volume of Fermenter (Reactor) (20% Extra) = 27709 liter (27.709 $m^{3)}$
Diameter and Length of Reactor (Fermenter)
Fermenter/Reactor cylindrical vessel can be design from process & mechanical design, Volume =27.709 m^3
V = Area * Length = $\pi/4$ * Di * L
L = 1.5 Di
V = $\pi/4$ * Di * 1.5 * Di
27.709 = $\pi/4$ * Di^2 * 1.5
By solving we get,
Di = 4.30 m = 5 m (take 5 m)
L = 5 * 1.5 = 7.5 m

Di = 5 m and L = 7m And

Thickness and Outer Diameter of Fermenter

Shell Thickness ($t_{s)}$ = P Di / (2 f j – P) + C = 101325 * 5 / (2* 138 *10^6 * 0.85 – 101325) + 1 mm = 0.001727 m + 1 mm = 0.002160*1000 + 1 mm = 2.160mm + 1 mm = 3.160

t_s = 4 mm (Take)

Outer Diameter (Do)

Do = Di + t_s = 5 + 2 * 4 * 10^{-3} = 5.08 m

Here,

f = Permissible stress for SS-316 = 138 MPa = 138 * 10^6 Pa (20000 psi)

J = Joint Efficiency = 0.85 (85%)

C = Corrosion Allowance

t_s = 4 mm and Do = 5.06 m

Weight of Cylindrical Shell and Tori Spherical Head

Weight of Cylindrical Shell = π/4 * (Do^2- Di^2) * L * ρ (Density)

ρ = 7950 kg/ m3 (Density of Stainless Steel-316)

Weight of cylindrical shell = π/4 * (5.06^2 - 5^2) * 7.5 * 7950 = 28266 kg

Weight of Head = π/4 * (Do^2- Di^2) * ρ

= π/4 * (4.06^2 - 4^2) * 7950

Weight of tori spherical head = 3769 kg

Weight of Top and Bottom head = 2 * 3019.5

= 7538 kg

Total Weight of Vessel = Weight of Vessel + Weight of Head = 28266 + 7538 = 35804 kg

Total Weight of Vessel = 35804 kg

Fermenter Costing

As per design total weight of material = 35804 kg.

Material cost = 250 Rs / kg

Total Material cost = 35804*250 = 89,51,000 Rs

Fabrication Cost (45-60 Rs / kg) = 60 * 35804 = 2848240 Rs

Agitator with motor and assembly cost = 2 Lac

Spurger cost = 0.5 Lac

Support cost is 15% of total material cost = 0.15 * 89,51,000 Rs = 1342650 Rs

Jacket cost is 15% of Total Material Cost = = 1342650 Rs

Total Fermenter Cost of fermenter = 1,40,34,540 Rs

For complete fermentation of elephant grass required time is 72 hrs. i.e. is 3 days So, in case of batch operation we need to install 2 No. of fermenter. 2 fermenter for 4 days operation including one day cleaning and feeding. According to fermentation time we feed material in 1st and 2nd feed 1st and 2nd day will get output as 4th, and 5th with twice volume as continuous operation.

Total Fermenter Cost of fermenter = 1,40,34,540 * 2 = 2,80,89,080 Rs.

IV. CONCLUSION

Napier grass or others of lignocellulose biomass has to hydrolyze cellulose into fermentable sugars by enzyme and then these sugars are converted into products by microorganism. Chemical methods for Napier grass biomass pretreatment involve the use of sodium hydroxide, liquid ammonia, dilute sulfuric acid, dilute acetic acid and hydrogen peroxide. Two-stage pretreatment processes have often been used. Biomass of Napier grass presoaked with 5 % H_2SO_4 or 5 % NaOH.

The Batch and Continuous fermentation systems can be used and out of both batch process is more popular. By using material balance, we get the volume of fermenter for 1 KL ethanol production. With help of volume and design equations we can calculate Length, Height, Thickness, I.D., O.D., Weight of Vessel, Head thickness & cost of Fermenter. The sizes of bioreactor vary from microbial cell to shake flask (100-1000 ml) to laboratory scale vessel (1 – 50 L) to pilot level (0.3 – 10 m^3) to industrial scale (2 -500 m^3) for large volume industrial applications. Lab scale fermenter are typically constructed with the glass and the pilot scale and the industrial scale vessel are normally fabricated with stainless steel. The production of bio-ethanol from Elephant grass stem carried out using elephant grass stem as a feedstock combination of Aspergillus Niger and Saccharomyces cerevisiae (brewer's yeast) as cells by simultaneous saccharification and fermentation (SSF). 1000 ml of 0.1M sodium acetate buffer solution poured into 1000 ml (Erlenmeyer) conical flask, 20 g of Aspergillus Niger (crude enzyme), 5 g of brewer's yeast (Saccharomyces cerevisiae), 20 g of treated elephant grass added and 1 g of MgSO4, 2 g of $(NH_4)H_2PO_4$ added as nutrient. The flask corked properly, sealed with aluminum foil paper and incubated at 30 ^{O}C for 48-72 hrs. in an incubator. We can increase the fermentation time 4-6 days for analysis of yield of ethanol from biomass. As per literature study optimum time of fermentation is 72 hrs. i. e. 3 days. As per analysis 1000 ml (1 L) of ferment yield of 110 ml of ethanol. That shows the 11 % of yield of ethanol from Napier grass with substrate concentration 140-160 gm/L. With help of yield we design fermenter (Reaction Vessel) for both continuous and batch operation. With help of design book and design equation calculating L, Di, t, and Do of fermenter. **For batch operation** For complete fermentation of elephant grass required time is 72 hrs. i.e. is 3 days So, in case of batch operation we need to install 2 No. of fermenter. 2 fermenter for 4 days operation including one day cleaning and feeding. According to fermentation time we feed material in 1st and 2nd feed 1st and 2nd day will get output as 4th, and 5th with twice volume as continuous operation. For this system we design fermenter for 27.79 m^3 volume get internal and outer diameter as 5 and 5.06 m resp., Thickness and length 4 mm and 7.5 m resp. We need two fermenter of volume 27.79 cubic meter each and need of total cost for both fermenter will be 3,82,00240 Rs.

According to the cost view the batch operation is economical and requires low maintenance, labor cost and less time consuming and needs two fermenter. For continuous operation need high cost than the batch need four fermenter. In view of continuous is suitable operation than the batch in which regular feeding of fermenter and regular output. Also, one fermenter is in standby operation

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