CSTR PROCESS DESCRIPTION

In ‘CSTR’ process, which is a high rate process, anaerobic digestion takes place in the mesophillic range of temperature, i.e. 36° - 40°C. The pH inside the reactor is usually kept around 7.2 while proper ratio of volatile acid and alkalinity is maintained.

The following three stages are involved in the process of anaerobic digestion.

a. **Hydrolysis:** In the process of hydrolysis the complex molecular compounds i.e. polymers are converted into the simple molecular form i.e. monomers.

b. **Acidogenesis:** The monomers so formed at the end of hydrolysis process are converted into volatile fatty acids. Acetic acid forms the major portion of volatile fatty acids. The process of conversion of monomers into acids is carried out by a group of anaerobic bacteria known acid formers.

c. **Methanogenesis:** Acids produced at the end of Acidogenesis process are converted into carbon dioxide and methane gases. The process of conversion of acid into gases is carried out by group of anaerobic bacteria known as methane formers.

In CSTR process all the three stages are carried out in a single reactor. The bacteria responsible for digestion process are present in reactor and are maintained in suspension with the help of agitators. The adequate population of microorganisms is maintained in reactor by recirculating the settled solids from treated spent wash.

2.0 DESCRIPTION OF THE CSTR SYSTEM

2.1 **Wastewater Transport**

The effluent from the collection sump shall be fed to the reactor with the help of feed pumps.
2.2 CSTR Reactor

The CSTR Reactor will be erected and fabricated at site using mild steel plates of designed thickness conforming to I.S. 2062. The roof of the reactor will be fixed type supported on Grid of ISMB.

The Reactor will be painted from inside using chlorinated rubber paint, whereas the outside surface will be painted by synthetic enamel or aluminum paint as per client preference.

The CSTR Reactor has four/six agitators. One located at center and others located equidistant along the circumference of reactor. The agitators are designed in such a way that the entire contents of reactor are in completely mixed condition. This constant agitation helps to maintain active bacteria in suspension. These bacteria utilize organic matter present in wastewater and produce biogas.

The solids are separated from the outlet of reactor in Lamella Clarifier and returned to the system by recirculation pumps. This recirculation of settled solids helps to maintain adequate population of active bacteria inside reactor.

2.3 Treated effluent discharge

In CSTR reactor the raw spent wash is introduced from top of reactor. The recycled sludge is also introduced from the top of the reactor. This mixed liquor travels downward through the central shaft. In this central shaft agitator provides adequate mixing of RSW and recycled sludge. From central shaft well mixed liquor enters reactor near bottom of tank. Inside reactor, the content is kept in suspension by means of agitators. The treated effluent leaves the system from top of reactor. This ensures utilisation of head in carrying effluent to further treatment units.
2.4 Biogas Recovery

The biogas produced by anaerobic digestion inside the reactor is collected from the top of reactor and is conveyed to gas holder. This gas holder is located near reactor and is equipped with floating roof. This floating roof is very effective tool in routine operation. The Gas Dome is placed at Reactor roof and is fitted with all essential safety equipment such as breather valve, flame arrestor etc., The biogas is then conveyed to blower for further utilization in boiler or biogas engines.

3.0 CSTR REACTOR – SALIENT FEATURES

The reactor consists of a cylindrical Mild Steel Tank having central mixer and lateral agitators to ensure complete mixing of the contents inside the reactor. The reactor is rested on a suitable foundation. The reactor tank base plate is 6-mm thick plate with 16-mm thick annular plate. The shell thickness varies from 6 mm to 22 mm, height wise. The roof plate shall be of 8-mm thickness. The corrosion allowance considered is 1.5 mm. Reactor tank inside is painted with zinc phosphate primer and chlorinated rubber paint.

Steel plates used confirm IS 226. Fabrication of reactor tank is as per IS 803.

4.0 CHIEF DESIGN AND PERFORMANCE PROJECTIONS

DESIGN DATA

Each CSTR reactor is designed to treat yeast free raw spent wash having following characteristics.

1. Flow - 450 m$^3$/day
2. pH - 4.0 – 4.5 S.U.
3. COD - 120000 mg/L
4. BOD - 45000 mg/L
PERFORMANCE PROJECTIONS

Upon reaching the steady state each CSTR reactor would produce the following results, when operated under optimum design conditions:

1. COD Removal : 65 ± 5 %
2. pH : 7.0 - 7.5
3. Biogas Production : 0.53 ± 5 % m³ /Kg COD Removed

Average Gas Composition
1. Methane content : 55 % - 60 %
2. Hydrogen Sulfide : 1.5 % - 2.5 %
3. Carbon Dioxide : 33 % - 43 %.

5.0 UTILITY REQUIREMENTS (CLEINT’S SCOPE)

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>POWER (FOR EACH REACTOR)</strong></td>
</tr>
<tr>
<td></td>
<td>Operating HP</td>
</tr>
<tr>
<td></td>
<td>77.5</td>
</tr>
<tr>
<td></td>
<td>Connected HP</td>
</tr>
<tr>
<td></td>
<td>117.5</td>
</tr>
<tr>
<td>2</td>
<td><strong>MANPOWER</strong></td>
</tr>
<tr>
<td></td>
<td>1 Chemist in general Shift. One operator in each shift.</td>
</tr>
<tr>
<td>3</td>
<td><strong>AREA REQUIREMENT</strong></td>
</tr>
<tr>
<td></td>
<td>2500 m².</td>
</tr>
<tr>
<td>4</td>
<td><strong>CHEMICALS &amp; CONSUMABLES</strong></td>
</tr>
<tr>
<td></td>
<td>During Start up.</td>
</tr>
<tr>
<td></td>
<td>➢ Soda ash</td>
</tr>
<tr>
<td></td>
<td>➢ Seed sludge</td>
</tr>
<tr>
<td></td>
<td>During operation.</td>
</tr>
<tr>
<td></td>
<td><strong>Micronutrients like</strong></td>
</tr>
<tr>
<td></td>
<td>➢ Ferric chloride</td>
</tr>
<tr>
<td></td>
<td>➢ NiCl₂</td>
</tr>
<tr>
<td></td>
<td>➢ COCl₂</td>
</tr>
<tr>
<td></td>
<td>➢ ZnCl₂</td>
</tr>
</tbody>
</table>
SMART PROCESS DESCRIPTION

Influent Homogenisation
Raw effluent i.e. raw spent wash from the distillery shall be carried to treatment site through suitably designed channel or a closed pipe depending upon the topography of the site. Raw spent wash shall then be passed through heat exchanger to bring down the temperature to 38–40°C. Yeast free raw spent wash is then mixed with part of reactor content [recirculated back] for pH adjustment in the Reactor feed tank or Homogenisation Tank. This homogenized Raw spent wash is then pumped to reactor.

SMART Reactor
The SMART [Structured Media Anaerobic Reactor Treatment] Reactor shall be tailor made as per your requirement and shall be designed as per guidelines of IS 803 [Bureau of Indian Standard] or as per your design standard. The reactor tank shall be rested on floating type civil foundation [this will be confirmed on receipt of Site Soil Investigation report]. The reactor tank will be erected and fabricated at site using mild steel plates of designed thickness. The roof of the reactor will be fixed type supported on Grid of medium grade “I” sections.

The Reactor shall be painted from inside using chlorinated rubber paint, whereas the outside surface will be painted by synthetic enamel or aluminum paint as per your preference. The surface preparation as per painting requirement shall be carried out prior to painting.

The SMART Reactor is partially packed with structured media made out of PVC. The entire media remains submerged in the reactor content. The bacteria grow and reside on large surface area provided by media. The bacteria developed on media surface takes upon organic content of wastewater to metabolize it and
produce biogas and resultant biomass. The suitable media supporting arrangement is provided at the bottom of reactor for media stacking. The reactor content is kept under constant re-circulation using recirculation pumps. Each recirculation pump is connected to the suction network, placed next to the bottom of the reactor. This suction network is designed in such a way that it sucks reactor content from entire bottom cross sectional area. Thus the possibility of formation of dead zone is eliminated and the entire reactor is kept active. All recirculation pumps pour their discharge into Roof Feed Tank.

The distribution Network provided at the top of SMART Reactor will then distribute feed tank contents over inside top area of reactor. The distribution pipes kept submerged in reactor content.

**Overflow from SMART Reactor**

As SMART reactor is down flow, the treated effluent is collected from the bottom of reactor. To utilize head available, the overflow arrangement is so designed that the treated effluent is discharged at reactor liquid level. The suitable number of overflow weirs are provided as per process requirement.

**Biogas Recovery**

The biogas produced by SMART reactor shall be recovered at the Gas Dome provided at the roof of the tank. All necessary safety arrangements such as pressure & vacuum relief tanks are provided on the roof tank. The biogas collected at Gas Dome is then taken to blower for further utilization in boiler or biogas engines.
BASIC ASSUMPTIONS FOR CONVERTING EXISTING ANAEROBIC REACTORS INTO SMART REACTORS

1) The dimensions of existing anaerobic reactors are 25.00 m diameter & 11.00 m height.

2) The existing reactor foundations can withstand a liquid height of 10.5 m.

3) The Reactor shell plates can sustain liquid height of 10.5 m.

4) The Existing reactors are suitable for carrying out the revamping & rectification works. Any strengthening/repairs if required for base plate, shell plates, roof plate, etc. will be carried out by M/s CSL under our supervision.

5) M/s CSL will provide Yeast free Raw Spent Wash at 38 ± 2°C and collect biogas from gas dome.

DETAILS OF EXISTING REACTORS

No. of units: 2 nos.

1) Diameter – 25.00 meter

2) Height up to rim – 11.00 meter

3) Liquid level in existing reactor: 10.5 m (assumed)

REACTORS AFTER CONVERSION INTO SMART SHALL TREAT

RSW flow (to be treated in each reactor) : 400 M³/Day

RSW flow (to be treated in both reactors) : 800 M³/Day

RSW COD to be handled in the SMART reactors : 150000 mg/L. (max.)

TSS in the RSW shall be : 4000 mg/L
PERFORMANCE PROJECTIONS

FLOW (in each reactor) - 400 M³/Day
BOD - 80+ 5 % Reduction
COD - 60 ± 5 % Reduction
BIOGAS - 0.53 ± 5 % m³/Kg COD Destroyed

BATTERY LIMITS FOR COST ESTIMATION

Effluent (Yeast free) at 38°C - At inlet of existing feed tank
Power - At the respective drives
Biogas - At Gas Dome outlet
Treated Effluent/Sludge/Foam - One meter away from SMART tank

SALIENT FEATURES OF SMART REACTOR

- It is Fixed Film, Fixed Bed reactor.
- It is mesophilic reactor i.e. it operates best in temp range of 38 – 40°C.
- It is provided with specially designed Structured Rigid PVC Plastic Media to maintain high microbial population.
- It provides maximum substrate to microorganism contact by appropriate recirculation ratio.
- The reactor is provided with following features to ensure efficient performance and safety of the reactor:
  - Built in gas collection system, hence no additional gasholder is required.
  - Suitable number of overflow-weirs designed to serve as pressure breakers in case of emergency.
  - Pressure cum Vacuum breaker tanks, in case pressure goes out of operating range in case of emergency.
  - Flare stack to flare the biogas generated in case it is not used.
  - Instrumentation for online measurement of Feed and Gas flow
- If required the higher instrumentation can also be incorporated as per your requirement.
SALIENT FEATURES OF STRUCTURED MEDIA

- Specially designed made out of polyvinyl chloride- the most chemically resistant thermoplastic material.
- Provides large surface area (95-105 m$^2$/m$^3$ of media) and 95% voids for immobilization of bacteria and their subsequent growth.
- Media fills are self-supporting and can be stacked up to 20 feet without intermediate support.
- Plastic material is manufactured under strict quality control and tested thoroughly for uniformity of color, smooth edges, thermoforming properties, and contamination.
- Media sheets are rigorously tested before use and strict control is exercised on its quality.

ADVANTAGES OF SMART SYSTEM

a. **Dilution Water:**

   SMART Reactor can handle raw spent wash having COD up to 1,50,000 mg/L without any dilution.

b. **Higher Organic Loading Rate:**

   SMART reactor has the highest loading rate in terms of COD per m$^3$ of reactor volume and thus requires smaller tank.

c. **Special Media:**

   SMART reactor employs honeycomb type, specially designed geometrically structured rigid PVC media to immobilize the bacteria inside the reactor. This immobilization of the bacteria on the specially designed performed media measures that
I) The bacteria are neither washed away nor settled at the bottom of the reactor tank.

ii) All through the 24 hours of the day and 365 days of the year, there is an optimum (designed) contact between the bacteria and the organic impurities contained in raw spent wash, ensuring continuous generation of biogas at the optimum designed level.

d. **Reliability**
Due to structured media biomass attachment, promised performance in term of BOD/COD reduction and Biogas generation is available every day of the year.

e. **Sludge recycling**
SMART reactor does not need any recycling of anaerobic sludge, which is even otherwise, difficult to settle.

f. **Faster Restart**
Even after long factory shutdown of ONE week, system restarts in 72 hours. (No loss of biogas. No worry of what to do with wastewater while the system struggles to come back to stream).

g. **Most Rugged system**
Can withstand variation in flow, pH, COD concentration etc. without system going sour.

h. **Lower operating Cost**
The system has low power consumption i.e. power is required for only feed and reticulation pumps.

i. **Higher digestion**
SMART reactor reduces the initial COD by 60 – 70 %, consistently and produces biogas up to 0.50 - 0.56 m³/kg of COD digested.
j. **Easy Maintenance**
   As there are no moving parts inside the digester, no pulsating flows, no backwash, no sludge recycle, simple pump operators even High school level education can run the system.

k. **pH Neutralization**
   SMART reactor does not need any alkali/acid for pH neutralization for day to day operation.

l. **Chemicals and Nutrients**
   No chemicals and nutrients are required for day-to-day operation.

m. **Toxicity**
   As only TOP of bacterial film is exposed in SMART reactor against the entire bacterial population in other anaerobic systems like UASB, SMART reactor can withstand higher toxic shock load.

n. **Smell nuisance**
   There is no smell nuisance in the vicinity of SMART reactor.

o. **Appearance**
   A system is aesthetically pleasing and extremely neat and clean (people visiting our installation feel that it does not look like an ETP).

p. **Life cycle cost**
   Life cycle cost of SMART system is the lowest in spite of its higher capital cost because of:
   a. Lowest operation and maintenance cost and
   b. Higher and consistent biogas generation compared to other Non Media anaerobic systems available in India.
1.0 BIPHASIC SEQUENCING UASB PROCESS BASICS

The Up Flow Anaerobic Sludge Blanket (UASB) process is a high rate anaerobic treatment process where the bacteria responsible for anaerobic digestion are present in the form of sludge blanket. The bacteria grow and reside as bacterial flocs suspended in the up-flow effluent stream. The bacteria take upon organic content of wastewater to metabolize it and produce biogas and biomass.

The distribution network provided from the top of the UASB Reactor, which distributes the feed effluent uniformly inside reactor.

In “SEQUENCING UASB” process, the effluent feed into the reactor is based on the concept of intermittent induction of effluent at different sludge blanket zones in time sequence by a PLC controlled feeding system. The process of conversion of organic matter into biogas occurs through a group of anaerobic bacteria residing in the sludge blanket.

In this present treatment scheme, ‘BIPHASIC’ treatment process is adopted where acetogenesis and methanogenesis is bio-engineered into two separate tanks – the Acidogenic Reaction Tank (ART) and the Methanogenic Reaction Tank (MRT). Here the MRT is operated in SEQUENCING UASB mode.

The pH inside the ART is usually in acidic range and the pH of the MRT is kept around 7.2 while proper ratio of volatile acid and alkalinity is maintained.

The bacteria responsible for digestion process are present in ART and S-UASBR and are maintained in suspension. The adequate population of microorganisms is maintained in reactors by recirculating the active biomass.
2.0 BIPHASIC S-UASB PROCESS DESCRIPTION

2.1 Process description
The effluent shall be passed through serpentine sedimentation chamber to removesettlatable yeasts from the raw spent wash (RSW) and the yeast free RSW is collected in a collection sump. The RSW from the collection sump shall be pumped into the Acidogenic Reaction Tank (ART).

In the ART, the complex organics in the wastewater is subjected to hydrolysis and acidification. In the process of hydrolysis the complex molecular compounds i.e. polymers are converted into the simple molecular form i.e. monomers. The monomers so formed at the end of hydrolysis process are converted into volatile fatty acids. Acetic acid forms the major portion of volatile fatty acids. The process of conversion of monomers into acids is carried out by a group of anaerobic bacteria known acid formers.

The process parameters specific to hydrolysis and acidification are precisely controlled in the ART to achieve the maximum efficiency. The pH correction of the highly acidic spent wash is achieved in this reactor. During the start-up of the plant, pH shall be controlled by adding alkaline buffer. Later, pH correction and control is achieved using alkalinity generated in the methanogenesis stage, by recycling a part of the MRT overflow in the ART. The ART helps in handling the shock loading to the MRT and faster recovery from any process upset.

The acidified effluent from ART shall be transferred to the Methanogenic Reaction Tank (MRT), ie the S-UASB Reactor. In the S-UASB Reactor, acids produced at the end of acidogenesis process are converted into carbon dioxide and methane gases. The process of conversion of volatile organic acids into biogas is carried out by group of anaerobic bacteria known as methane formers.
2.2 The S-UASB Reactor

The S-UASB Reactor and the ART shall be tailor made as per your requirement and shall be designed as per guidelines of IS 803 [Bureau of Indian Standard]. The reactor tanks will be erected and fabricated at site using mild steel plates of designed thickness. The roof of the S-UASB Reactor will be fixed type supported on Grid of medium grade “I” sections.

The reactor tanks shall be painted from inside using epoxy paint, whereas the outside surface will be painted by synthetic enamel or aluminum paint as per your preference. The surface preparation as per painting requirement shall be carried out prior to painting.

The S-UASB Reactor is a covered tank with feed distribution pipelines entering the reactor from top. The feed lines are provided PLC controlled actuated valves with auto ON/ OFF level switches. At every preset time interval, each auto valve shall open to allow the feed effluent to enter into the specific zone of the reactor. The bacteria responsible for digestion process are present in the form of sludge blanket. The bacteria grow and reside as bacterial flocs suspended in the up-flow effluent stream. These bacteria utilize the volatile organic acids present in wastewater to produce biogas.

The solids are separated at the inbuilt clarification system at the top of the S-UASB Reactor and returned to the system by gravity. Thus the sludge blanket of active bacteria inside reactor is maintained.

2.3 Treated effluent discharge

In SEQUENCING UASB system, the raw spent wash is introduced into the MRT. The treated effluent leaves the system after clarification in tube settling zone. This ensures utilization of head in carrying effluent to further treatment units.
2.4 Biogas Recovery

The biogas produced by anaerobic digestion inside the ART is released to the atmosphere since it contains mainly carbon-di-oxide. The biogas generated inside the MRT is rich in methane and is collected from the top of reactor. It is conveyed to gasholder. The gasholder is located near the MRT and is equipped with floating roof. This floating roof is very effective tool in routine operation. The Gas Dome is fitted with all essential safety equipment such as pressure valve, flame arrestor etc., The biogas is conveyed to blower for further utilization in boiler or biogas engines.

6.0 CHIEF DESIGN AND PERFORMANCE PROJECTIONS

DESIGN DATA
The SEQUENCING UASB system is designed to treat yeast free raw wastewater having following characteristics:

5. Flow - 250 m3/day
6. pH - 4.5 S.U.
7. COD - 75000 mg/L
8. BOD - 35000 mg/L
9. Total Solids - 4000 - 5000 mg/l

PERFORMANCE PROJECTIONS
Upon reaching the steady state the system would produce the following results, when operated under optimum design conditions:

4. BOD Removal : 85 ± 5 %
5. COD Removal : 65 ± 5 %
6. Biogas Production : 0.53 ± 5 % m^3 /Kg COD Removed

Average Gas Composition
1. Methane content : 55 % - 65 %
2. Hydrogen Sulfide : 2.5 % - 3.5 %
3. Carbon Dioxide : 32 % - 42 %.
### 7.0 UTILITY REQUIREMENTS (CLIENT’S SCOPE)

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Items</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Power</td>
<td>Operating HP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Connected HP</td>
</tr>
<tr>
<td>2</td>
<td>Manpower</td>
<td>1 Chemist in general Shift. One operator in each shift.</td>
</tr>
<tr>
<td>3</td>
<td>Area</td>
<td>700 m² (approx.)</td>
</tr>
<tr>
<td>4</td>
<td>Chemicals &amp; consumables</td>
<td>During Start up. Soda ash, seed sludge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>During operation. Micronutrients.</td>
</tr>
</tbody>
</table>
Programme logic:

1. All 4 feeding pipe is connected to feed pumps. There will be two pumps 1 w +1 s (any one of the pump shall operate at a time).

2. Pump shall operate 24 hrs for inducing feed in the reactor.

3. Feed to the reactor is pulsating through each valve. V1 will open first to feed in the reactor. This will remain open for ONE minute, then close.

4. Once V1 close, V3 will open for 1 min.

5. After V3, V2 will open for 1 min and then V4 and then V1 again.

NOTE:

This one minute opening time is just indicative, and we shall communicate the actual time of opening at later stage of design. But please note that this time is preset and shall be equal for all valves. Provision shall be there to set the timing for optimisation of the feed process.

No. of valves are at present 4. It may be 6 or 8 at later stage of design. 8 is the maximum no. and shall not go beyond that.
TECHNICAL PROPOSAL

1.0 PROCESS BASICS

The Thermophillic Anaerobic Reactor process being offered by ‘LARS ENVIRO’ is based on the concept of anaerobic conversion of organic matter into biogas. The process of conversion of organic matter into biogas occurs through a group of anaerobic bacteria.

In “Thermophillic Anaerobic Reactor process”, which is a high rate process, anaerobic digestion takes place in the thermophillic range of temperature, i.e. 50° - 57°C, conditions suitable for thermophillic bacteria. The pH inside the reactor is usually kept around 7.2 while proper ratio of volatile acid and alkalinity is maintained. Because biochemical reaction rates increase with temperature, doubling with every 10°C rise in temperature until a limiting temperature is reached, thermophillic process is much faster than mesophillic process (where reaction takes place at temperatures between 35°C – 45°C).

The bacteria responsible for thermophillic digestion process are present in reactor and are maintained in suspension with the help of biogas re-circulation within the reactor. The adequate population of microorganisms is maintained in reactor by recirculating the settled solids from central clarification zone and lamella clarifier.

The Thermophillic Anaerobic Reactor is basically an Anaerobic Baffled Reactor operated in Staged Sludge Bed mode where a high process stability and high organic removal efficiency is obtained under extreme loading conditions during thermophillic digestion process. This reactor consisted of 5 compartments along the reactor circumference. From each separate compartment of this reactor the produced biogas is withdrawn.
The major advantage of staging the thermophilic process is a very low concentration of intermediate products, such as hydrogen and acetate, in the last compartments of the system. A low concentration of these products enhances the anaerobic thermophilic degradation of all fatty acids. The properties of the sludge grown in the various compartments of the staged reactor depend on the environmental conditions prevailing in each compartment.

2.0 DESCRIPTION OF THE THERMOPHILLIC SYSTEM

2.1 Wastewater Transport
The effluent from the collection sump shall be fed to the reactor with the help of feed pumps.

2.2 THERMOPHILLIC Reactor
The THERMOPHILLIC Reactor will be erected and fabricated at site using mild steel plates of designed thickness. The roof of the reactor will be fixed type supported on Grid of ISMB.

The THERMOPHILLIC Reactor has no mechanical moving parts. The tank is compartmentalized into five compartments with a centralized clarifier. Biogas is purged intermittently inside the reactor compartments to keep the sludge in the form of sludge blanket. The feed is introduced in the initial compartments, which passes to the subsequent compartments one after the other. Acetogenesis occurs in the initial compartments while the later comprises of rich methanogens. This process stability is maximum since susceptible methanogens are segregated from acetogens. The acetogenic bacteria utilize organic matter present in wastewater to produce volatile fatty acids and the methanogens produce methane rich biogas by digesting the acids.

The solids are separated in the inbuilt clarifier and returned to the system by recirculation pumps. This recirculation solids helps to maintain adequate population of active bacteria inside reactor.
2.3 Treated effluent discharge
In **THERMOPHILLIC** reactor the raw spent wash is introduced from top of reactor. The recycled sludge is also introduced from the top of the reactor. The mixed liquor enters the reactor near the tank bottom. The treated effluent leaves the system from the peripheral launder around the inbuilt clarifier top. This ensures utilisation of head in carrying effluent to further treatment units.

2.4 Biogas Recovery
The biogas produced by anaerobic digestion inside the reactor is collected at the Gas Dome. The Gas Dome is placed at Reactor roof and is fitted with all essential safety equipment such as breather valve, flame arrestor etc., The biogas is then conveyed to blower for further utilization in boiler or biogas engines.
8.0 CHIEF DESIGN AND PERFORMANCE PROJECTIONS

DESIGN DATA

The characteristics of the RSW from distillery shall be as follows:

10. Actual RSW Flow - 250 m3/day [w/o dilution]
11. pH - 4.2 – 4.4 S.U.
12. COD - 150000 mg/L
13. BOD - 60000 mg/l
14. TSS - 4000 - 5000 mg/l
15. Temperature* - 90 - 105 °C

To treat the above effluent in THERMOPHILLIC reactor, the effluent needs to be diluted to reduce the organic toxicity. Also the RSW shall be freed from yeast sludge in suitable tank and cooled in a cooling pond. The yeast free RSW shall be fed to the THERMOPHILLIC at the temperature range of 55 – 57°C. Suitable PHE/Steam injection system shall be installed to maintain the influent temperature.

The THERMOPHILLIC is designed to treat yeast free RSW having following characteristics:

1. Diluted flow - 300 m3/day [with dilution]
2. pH - 4.4 – 5.0 S.U.
3. COD - 125000 mg/L
4. BOD - 50000 mg/l
5. TSS - 2500 - 3000 mg/l
6. Temperature* - 55 - 3 °C
PERFORMANCE PROJECTIONS

Upon reaching the steady state the system would produce the following results, when operated under optimum design conditions:

7. BOD Removal : 80 ± 5%
8. COD Removal : 60 ± 3%
9. pH : 7.0 - 7.5
10. Biogas Production : 0.53 ± 5 % m³/Kg COD Removed

Average Gas Composition
1. Methane content : 50 % - 60 %
2. Hydrogen Sulfide : 1.5 % - 2.0 %
3. Carbon Dioxide : 38 % - 48 %.
4. Calorific value : 4800 Kcal/ m³

9.0 UTILITY REQUIREMENTS

A] Electrical Load List [Approx.]

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Items</th>
<th>Connected HP</th>
<th>Operating HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Digester Feed Pump</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Gasseration blowers</td>
<td>37.5</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Sludge Recycle pumps</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Blowers</td>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>Caustic recirculation pump for gas washing</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>75.5</strong></td>
<td><strong>44.5</strong></td>
</tr>
</tbody>
</table>

B] Manpower
1 Chemist in general Shift. One operator in each shift.

C] Area
1200 m². (APPROX)

D] Chemicals & consumables
During Start up.
Soda ash, seed sludge

During operation.
Micronutrients:
Ferric chloride.
NiCl₂, COCl₂, ZnCl₂, etc.,
Zero Discharge Solution for Distillery Effluent [write up of ROCHEM]

**Salient Features**
- 50 % of effluent becomes colorless.
- This colorless effluent can be recycled back into process.
- 50 % appears as reject in the form of dark brown concentrate.
- Capital investment for 45 KLPD distillery is approx. Rs. 270 Lacs.
- Operation and Maintenance cost of system is Rs 30 / m³ of effluent. We are ready to take O & M contract at this rate.

**Problems & Challenges**
The post-anaerobic distillery spent wash is still a dark brown colored effluent with high pollution load. The treatment options available for this waste are very limited and the operation and maintenance cost of such plants is enormous. This problem of treatment and disposal of distillery effluent has even threatened very existence of distillery at numerous places.

Earlier attempts to remove color of effluent have met with limited success because of very high cost of chemicals and sludge handling. The application of membrane technology for removing color has also failed because of spiral wound membranes, which have inherent tendency to clog.

Innovations & intelligent use of available resources has been providing the tailor made & situation specific solutions to our customers. In order to provide REAL RELIEF to distillers for their problem of disposal of treated spent wash, we in association with Rochem Separation Systems have come up with the state of the art system based on membrane technology. The system utilizes PATENTED Disc and Tube type membrane, which makes it different from other membrane technologies available in market.
The distillery effluent after cooling is first treated in an Anaerobic reactor where the biogas is extracted. The post anaerobic distillery effluent is pre-filtered in a multi-layer reversible flow filter system and downstream multiple cartridge filters. This prefiltered spent wash is then pumped at an inlet pressure of 30 to 60 bar in DT Module system. In DT module, it flows over the “series connected” membrane cushions in which cross-flow filtration occurs. Up to 50% of the feed supplied permeates through the membrane and appears as clean water. This clean water is absolutely colourless and can be reused as process water. The remaining concentrate effluent appearing as reject is taken to bio-composting.

The plant operation is automated and is controlled by a Storable Program Microprocessor system (SPS). The control cabinet is designed to provide the operating and monitoring data on the front.

**Advantages of Rochem DT System.**

1. Simplified pretreatment.
2. Direct applications to high COD/BOD, SDI, Turbidity streams.
3. No suspended solid fouling.
4. Consistent high quality pure water.
5. Single treatment & reuse solution.
6. Lower cost as compared to Other alternatives.
8. High recovery rates possible.
9. Technologically advanced systems.

The System exhibit very low specific energy consumption at steady state fluxes. Unique is the possibility of an optimal adaption of the feed path space (distance between membrane cushions) for the individual case. This feature allows for applications in a wide range of solid concentration.
Process Performance Parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Inlet</th>
<th>Permeate</th>
<th>Reject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Blackish Brown</td>
<td><strong>Colorless</strong></td>
<td>Dark Brown</td>
</tr>
<tr>
<td>Flow</td>
<td>585</td>
<td>293</td>
<td>292</td>
</tr>
<tr>
<td>COD</td>
<td>45000 – 50000</td>
<td>&lt; 1000</td>
<td>80000 – 90000</td>
</tr>
<tr>
<td>TDS [Inorganic]</td>
<td>As incoming</td>
<td>&lt; 1250</td>
<td>Remaining</td>
</tr>
<tr>
<td>Recovery</td>
<td></td>
<td>50%</td>
<td></td>
</tr>
</tbody>
</table>

Budgetary Costs and Utility requirement:

<table>
<thead>
<tr>
<th>Capital Investment</th>
<th>270.00</th>
<th>Rs. Lacs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation Land Area</td>
<td>275</td>
<td>Sq. m</td>
</tr>
<tr>
<td>Connected Load</td>
<td>112</td>
<td>kW</td>
</tr>
<tr>
<td>Operating Power Required</td>
<td>3</td>
<td>kW-hr/m3 of Feed</td>
</tr>
<tr>
<td>Preventive Maintenance cost</td>
<td>0.12</td>
<td>Rs/Lit of alcohol</td>
</tr>
<tr>
<td>Operating Power cost [approx]</td>
<td>0.16</td>
<td>Rs/Lit of alcohol</td>
</tr>
<tr>
<td>Manpower Cost</td>
<td>0.01</td>
<td>Rs/Lit of alcohol</td>
</tr>
<tr>
<td>TOTAL Operating Cost</td>
<td>0.29</td>
<td>Rs/Lit of alcohol</td>
</tr>
</tbody>
</table>

Advantages of Installing Lars Rochem System.

- The assured annual savings after installation of system shall be approx. **Rs 50.0 Lacs**.
- System offers Practical Zero Discharge Solution and it is workable even in long run.
- 50 % of effluent becomes colorless.
- This colourless effluent can be recycled back into process.
- 50 % appears as reject in the form of dark brown concentrate, which can be composted.
- This system not only ensures the return of useful ingredients of spentwash to soil but at the same time minimizes the quantity of water required for the same.
- Area required for biocomposting are reduced by almost 50 %.
- Press mud and other input required for biocomposting are also reduced by 50%.
- The dependency on press mud for achieving zero discharge is reduced. Hence biocomposting can be operated even during non-crushing season of sugar factory.
- The storage capacity required for press mud and treated effluent is reduced.
- Handling of treated effluent is reduced.

### COST BENEFIT ANALYSIS OF COLOUR REMOVAL SYSTEM

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost (Rs. [Lacs])</th>
</tr>
</thead>
<tbody>
<tr>
<td>The total approx. capital investment required for the system.</td>
<td>250.00</td>
</tr>
<tr>
<td>Annual approx. Operating Cost</td>
<td>38.00</td>
</tr>
</tbody>
</table>

### SAVINGS

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost (Rs. [Lacs])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings due to water recovery</td>
<td>12.50</td>
</tr>
<tr>
<td>Savings due to less loss in biocomposting @ Rs 150 per MT</td>
<td>28.55</td>
</tr>
<tr>
<td>Savings due to handling of reduced quantity of waste</td>
<td>5.00</td>
</tr>
<tr>
<td>Savings due to reduction in laggon capacity requirement</td>
<td>10.00</td>
</tr>
<tr>
<td>Savings because of avoiding of shutdown for shortage of water, say 10 days in a year @ Rs 3.0 Lacs per day</td>
<td>30.00</td>
</tr>
<tr>
<td><strong>Gross Annual Savings</strong></td>
<td><strong>86.05</strong></td>
</tr>
<tr>
<td><strong>Yearly Net Savings</strong></td>
<td><strong>48.05</strong></td>
</tr>
</tbody>
</table>