Molasses Based Process

Generally Molasses as a raw material is obtained from the integrated sugar factory through pipeline. Molasses which is in liquid form has solid content of 88-90 brix and total reducing sugar content of 44-46%. Specific gravity of molasses ranges from 1.47 to 1.48. The molasses is stored in M.S storage tank within the plant premises. The molasses is then pumped to molasses tank before using it for fermentation. The first operation which is carried out on molasses is dilution. For yeast propagation molasses is diluted to get sugar content 8-9% while for fermentation molasses is diluted to keep sugar 16-18 %. Once the fermenters are filled with diluted molasses, yeast is added to it then left for fermentation. The time requires to complete the fermentation process is 15 to 20 hours. Fermentation process, which is fed batch type during which sugar is converted into alcohol and CO₂ with the help of yeast enzyme. The production process of Rectified Spirit can be divided into the following operations:-

1. Dilution
2. Yeast propagation
3. Fermentation
4. Distillation

Dilution:-

The first operation, which is carried out on molasses is dilution. In dilution operation molasses, from the storage tank is diluted with raw water. The diluted molasses is used for subsequent unit operations i.e. yeast propagation & fermentation. The dilution ratios required for yeast propagation and fermentation are different. For requirement of yeast propagation, molasses is diluted to keep the sugar percentage of 8 – 9% while for fermentation molasses is diluted to keep the sugar 16-18%.

Yeast Propagation:-

Saccharomyce cerevisae sp is the yeast used for molasses fermentation. Yeast is unicellular living organism. The growth of yeast takes place by division of one cell into two, two cells into four
and so on, if sugar solution is provided for its growth. Two types of fermentation process are generally observed during fermentation.

**Aerobic Fermentation:**

Aerobic fermentation takes place in presence of excess oxygen and in this process, the yeast growth remains optimum. Ethyl Alcohol production is less, because most of the sugar gets converted into water, carbon dioxide and yeast during fermentation. Aerobic fermentation is suitable for yeast propagation, with the main objective to achieve the growth of yeast cells.

**Anaerobic fermentation**

Anaerobic fermentation occurs in absence of Oxygen. Under anaerobic condition the sugar gets converted into ethyl alcohol and carbon dioxide. Yeast growth is less in the anaerobic process. Hence, this process is suitable for ethyl alcohol production, but not yeast propagation.

Yeast propagation is being done in aerobic condition and it is slated in the laboratory strictly under hygienic conditions. To start with, a few yeast cells are added to the sterilized diluted molasses the entire sugar contain in solution is exhausted. The contents of test tube are then transferred to a volumetric flask and made up to 250 ml with sterilized diluted molasses. The solution is left for further growth of yeast. After yeast growth is achieved in 250 ml solution, it is further made upto 1 liter with sterilized diluted molasses. The process is repeated till 20 liters of solution containing yeast biomass is obtained.

Further, yeast propagation is carried out in the yeast vessel in the fermenter house. The 20 liter of yeast solution obtained from laboratory is propagated to required volume through various stages in yeast vessels of capacities 100 l, 500 l, 2000 l and 2000 l from the yeast vessels the yeast biomass is fed to the pre-fermenters, in which diluted molasses is added in the pre-fermenters, aerobic conditions are maintained by means of submerged aeration to maximize yeast production. The capacity of Pre-fermenter vessels ranges from 15000 L to 18000 L.
Fermentation : (Fed- Batch Fermentation)

The next unit operation is fermentation, which is carried out in the fermentation vessels under controlled conditions of temperature and pH. The propagated yeast biomass is transferred to the main fermenters keeping volume at 10 to 15% of the total fermenter volume. The rest is filled with diluted molasses. After filling the fermenter, it is left for fermentation. This process occurs under anaerobic condition. Under these conditions, the glucose molecule breaks down to produce ethyl alcohol and carbon dioxide. The time required for completion of the fermentation process is 15 – 20 hours. The fermentation process is understood to be completed when the effervescence stops. Other measurement like specific gravity etc., are also taken to assess the completion of fermentation process.

Fermentation is an exothermic reaction. Hence, the temperature rises during the fermentation process. To maintain the temperature at 36 degree C., the fermenter vessels are required to be cooled with fresh water, through plate type heat exchanger.

The yeast sludge along with solids present in molasses is collected at the bottom of the fermenter vessels. These solids need to be removed to make the fermenter vessels ready for another batch of fermentation process. The sludge is washed off by water. The washed sludge called fermenter washing constitutes a waste along with some alcohol.

The fermenter washing is centrifuged in a high speed centrifuge machine, which separates solid and liquid the liquid containing some alcohol is sent for distillation while the solid contained biomass and other solid is sent for bio-composting

DISTILLATION PROCESS DESCRIPTION

WASH TO RS MODE OF OPERATION:

Fermented wash from the Beer well is pumped to PHE (Fermented wash preheater) preheated to about 70 Deg.C. This hot fermented wash is then fed at the top of De-gasifying column.
**De-gasifying Column:**

The de-gasifying column is used principally for removal of non-condensable present in the fermented wash. The De-gasifying column is operated under Vacuum. Fermented wash is fed on the top tray of the Degasifying column. Feed flow to the column is controlled by using a flow control valve. The Wash flows from the top of the column to the bottom by gravity.

The fluid flows over each tray and comes in contact with rising vapours from the bottom, thus getting stripped off non-condensable. From the bottom of the De-gasifying Column, the fermented wash flows to the top of the Analyzer Column through vapour separator where non-condensable present in fermented wash is removed before feeding to Analyzer Column. The vapours from the top of the column are fed on the De-gasifying Condenser-I and De-gasifying Condenser-II and condensed liquid is fed to ED Column.

**Analyzer Column:**

Analyzer Column strips off the alcohol from the fermented wash before discharging the rest of the material as spent wash. Fermented wash is fed to the Analyzer Column from DG Column. Top vapours of Analyzer column containing the wash are sent for heating to De-gasifying Column and Evaporation.

Spent wash from the Analyzer Column bottom is sent to Evaporation Section (Molasses). The level in the Column bottom is controlled by LCV, which is located on the discharge line of the Analyzer bottom Transfer Pump. Analyzer Column is maintained under vacuum.

Water & Higher boiling impurities (spent wash) separated and Analyzer column bottom are sent to analyzer flask tank.

The flashed spent wash vapours from the Flash Tank supply heat to the Analyser Column. Spent wash in Flash tank is heated by the rectifier cum Exhaust column vapors that are condensed on shell side of the Re-boiler.
**Extractive Distillation Column:**

This column serves to remove the impurities based on the principal of Hydro-extraction. Dilution water to the Column is fed in such a way that it selects the higher alcohols and other impurities to move upwards and extracts ethanol down.

The Column operates under pressure the Column is heated using direct steam in ED column.

This feed comes from Analyzer Condensate Tank

Dilution Water i.e.DM water and spent lees are fed in the Mixing Bottle of the Column. At this composition, there is an inversion in relative volatilities of higher alcohols as compared to ethanol and these alcohols get separated in the top distillate.

Vapours from top of the Column are fed to the RC Column Re-boiler where they partially condensed, while the rest of the vapours are condensed Vent condenser for Rectifier Re-boiler. The vapour condensate from Ed column are taken to Recovery feed tank.

Dilute alcohol from Column bottom is fed to Rectifier Column after cooling and pre-heating Rectifier spent lees and DM water controls the level in the Column, which is located on ED Column bottom transfer pump discharge line.

**Rectifier cum Exhaust Column:**

It serves to strip out alcohol from liquid steam flowing down.

Low concentrate Extractive distillation column bottom is fed to Rectifier cum exhaust column for rectification required for product concentration. Exhaust section attached to column as integral will be used to strip out alcohol from spent lees.

Steam is fed to Rectifier re-boiler in a controlled manner.

Flow control valve controls the flow of steam to the re-boiler.

The vapours coming out of the top of the Column are fed to the Analyzer Re-boiler.
On shell side where they are condensed by passing the spent wash on the tube side. Balance alcohol vapours are condensed in the Analyzer Re-boiler. Vent Condenser Cooling water is used for condensing the vapours. The condensate is collected in the Rectifier Reflux Tank.

Rectifier Column operates under pressure and the pressure is controlled by PCV located on the vent line of Analyzer re-boiler vent condenser.

Condensate from PCV condenser is sent to TA Mixing Bottle.

Condensate from the Re-boiler and its vent condenser are fed to Rectifier Reflux Tank. The condensed liquid is pumped back to the Rectifier cum Exhaust column from the Rectifier Reflux Tank as reflux part of it is drawn as I.S draw and taken to the recovery Column and taken to the T.A. Cooler.

Analyzer re-boiler vent condenser and Rectifier PCV condenser are used to meet process. Variable condenser load and pressure control of Rectifier cum exhaust column.

FCV-1 controls the RS draw from trays of the Rectifier cum Exhaust Column. RS is cooled in product RS Cooler.

HFO and LFO drawn from the trays of the Rectifier cum exhaust Column at the required rate; these draws are taken to Recovery Column.

Spent lees coming out of the Rectifier cum Exhaust Column bottom is cooling and heating the Rectifier Feed Pre-heater and DM Water and then sent to further process LCV controls the level in the Rectifier cum Exhaust Column.

**Recovery Column:**

This Column removes the low boiling impurities from Column top in the form of IS cut as well as heavy impurities in the form of fusel oil. Recovery Column is fed through Recovery Feed Tank. This feed consists of extractive distillation Column top condensate. This recovery column operates under atmospheric pressure.
The column is heated using flash stream and some required extra steam is using from medium pressure steam header. Vapours from top of the column are partially condensed in Recovery Condenser-1 and the remaining vapours are condensed in Recovery Condenser-II.

Condensate from Recovery Condenser-I and Recovery Condenser-II is directly fed to the Recovery Column by gravity. A small part from reflux and/or condensate from Condenser-II of this is taken to TA mixing bottle, where it mixes with IS and sent to TA Cooler.

RS draw is collected on the top trays and transferred to fusel oil washing tank.

LFO draws and HFO draws taken from Recovery Column are cooled separately in double pipe coolers with cooling water in the inner tube and fed to Fusel Oil Decanter. Fusel Oil separated in Decanter is taken to storage and Fusel Oil washing is fed back to Recovery Column.

### Comparison of different fermentation systems

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Parameters</th>
<th>Batch Fermentation</th>
<th>Fed-batch fermentation</th>
<th>Cascade continuous Fermentation</th>
<th>Biostil Continuous fermentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fermentation efficiency</td>
<td>87-88</td>
<td>88-90</td>
<td>89-91</td>
<td>90-91</td>
</tr>
<tr>
<td>2</td>
<td>Alcohol % in wash (v/v)</td>
<td>8.0-8.5</td>
<td>9.0-10.0</td>
<td>8.5-9.5</td>
<td>8.0-8.5</td>
</tr>
<tr>
<td>3</td>
<td>Molasses quality</td>
<td>Can work with poor quality of molasses</td>
<td>Can work with poor quality of molasses</td>
<td>Requires good quality molasses</td>
<td>Requires good quality molasses</td>
</tr>
<tr>
<td>4</td>
<td>Retention time, hr</td>
<td>28-30</td>
<td>28-30</td>
<td>22-24</td>
<td>8-9</td>
</tr>
<tr>
<td>5</td>
<td>Spent wash generation, L/L of alcohol</td>
<td>14-15</td>
<td>8-9</td>
<td>9-10</td>
<td>6-7 (with weak beer recycle)</td>
</tr>
<tr>
<td>6</td>
<td>Susceptibility to contamination</td>
<td>Not highly susceptible</td>
<td>Not highly susceptible</td>
<td>Highly susceptible</td>
<td>Not susceptible</td>
</tr>
</tbody>
</table>
### Comparison between atmospheric and MPR distillation systems

<table>
<thead>
<tr>
<th>S. No</th>
<th>Particulars</th>
<th>Atmospheric Distillation</th>
<th>Multi-pressure Distillation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Distillation Efficiency</td>
<td>97-98%</td>
<td>98.50%</td>
</tr>
<tr>
<td>2</td>
<td>Steam Consumption</td>
<td>3.5 Kg/Lit. of R.S. production</td>
<td>2.2 Kg/Lit. of R.S. production</td>
</tr>
<tr>
<td>3</td>
<td>Impure spirit production</td>
<td>10-15%</td>
<td>5-6%</td>
</tr>
<tr>
<td>4</td>
<td>Down Time</td>
<td>Very frequent due to scaling problems in wash boiling column</td>
<td>Rare shutdown are required for very short duration</td>
</tr>
<tr>
<td>5</td>
<td>Plant operation</td>
<td>Manual</td>
<td>PLC/SCADA based control</td>
</tr>
<tr>
<td>6</td>
<td>Spent wash generation</td>
<td>12-15 Lits./Lit. of alcohol production</td>
<td>9-10 Lits./Lit. of alcohol production</td>
</tr>
<tr>
<td>7</td>
<td>Reuse of steam condensate</td>
<td>Nil</td>
<td>80 % condensate can be used as boiler feed water</td>
</tr>
<tr>
<td>8</td>
<td>Finished products</td>
<td>Configured to produce one at a time</td>
<td>Two products can be produced depending on requirement</td>
</tr>
<tr>
<td>9</td>
<td>Quality of R.S./ENA</td>
<td>As per I.S. specifications</td>
<td>Better resolution of impurities. Matches with international specifications</td>
</tr>
<tr>
<td>10</td>
<td>Selling price</td>
<td>Lower than same alcohol produced in MPR distillation plants</td>
<td>Higher than same alcohol produced in atmospheric distillation plants</td>
</tr>
</tbody>
</table>