Title : Industrial fermentation, production of Alcohol

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Name of Faculty: Hemant Balsora

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INTRODUCTION

Industrial fermentation is the intentional use of fermentation by microorganisms such as bacteria and fungi as well as eukaryotic cells like CHO cells and insect cells, to make products useful to humans.

Fermented products have applications as food as well as in general industry.

Common products such as antibiotics, cheese, pickles, Alcohols, wine, beer, biofuels, vitamins, amino acids, solvents, and biological insecticides and pesticides are. produced via industrial fermentation

Industrial alcohol

Industrial alcohol is distilled ethyl **alcohol** (C_2H_5OH), normally of high proof, produced and sold for other than beverage purposes. It is usually distributed in the form of pure ethyl **alcohol**, completely denatured **alcohol**, specially denatured **alcohol** and proprietary solvent blends

Production of Ethyl Alcohol –Ethanol

Method – Ethyl Alcohol by Fermentation

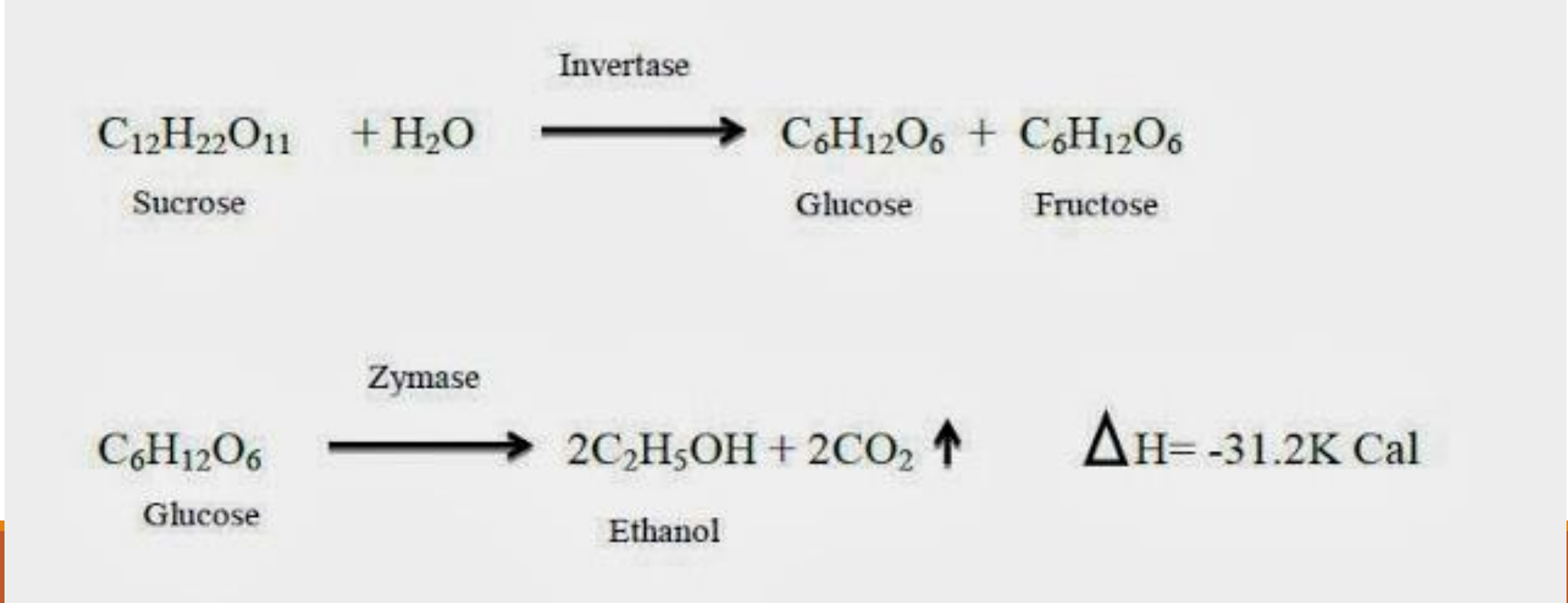
Ethyl Alcohol from Sugar solution (Molasses)

Molasses is a non-crystalline of sugar obtained as mother liquor after crystallization of sugar from sugar solution. This contains about 50% sugar. It is diluted to about 10% solution. The process can be explained in the following two stages:

a) Cultivation of Yeast in the molasses.
b) Recovery of Ethyl alcohol from cultivated solution.

I stage:

The sugar solution is heated up to above **room temperature (40-50ºC)** and then yeast is added proportionality and kept for **cultivation for about 2-3 days**. Yeast supplies the **enzymes invertase and zymase**. The **enzyme invertase hydrolysis** sucrose to glucose and fructose. The enzyme **zymase converts glucose to ethanol** and carbon dioxide.



II Stage:

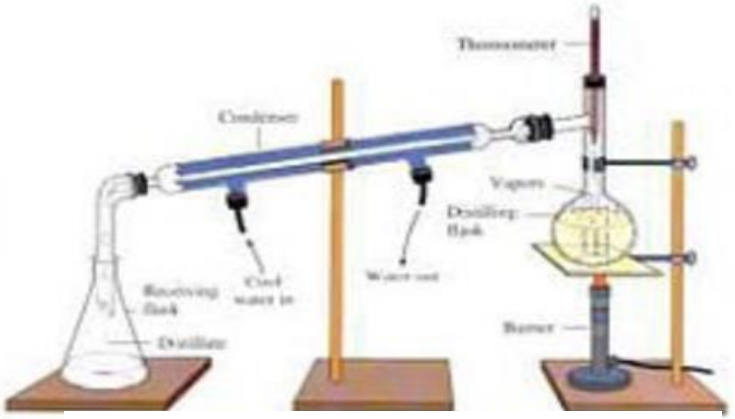
The “mash” is collected and fractionally distilled to recover rectified spirit containing 95.6% alcohol. The final rectified alcohol is stored in cans. Further dehydration with quick lime and distilling with sodium or calcium gives 99.8% ethanol called absolute alcohol.

Laboratory

Adding Sugar
+
Water
+
Yeast

Cultivation of yeast

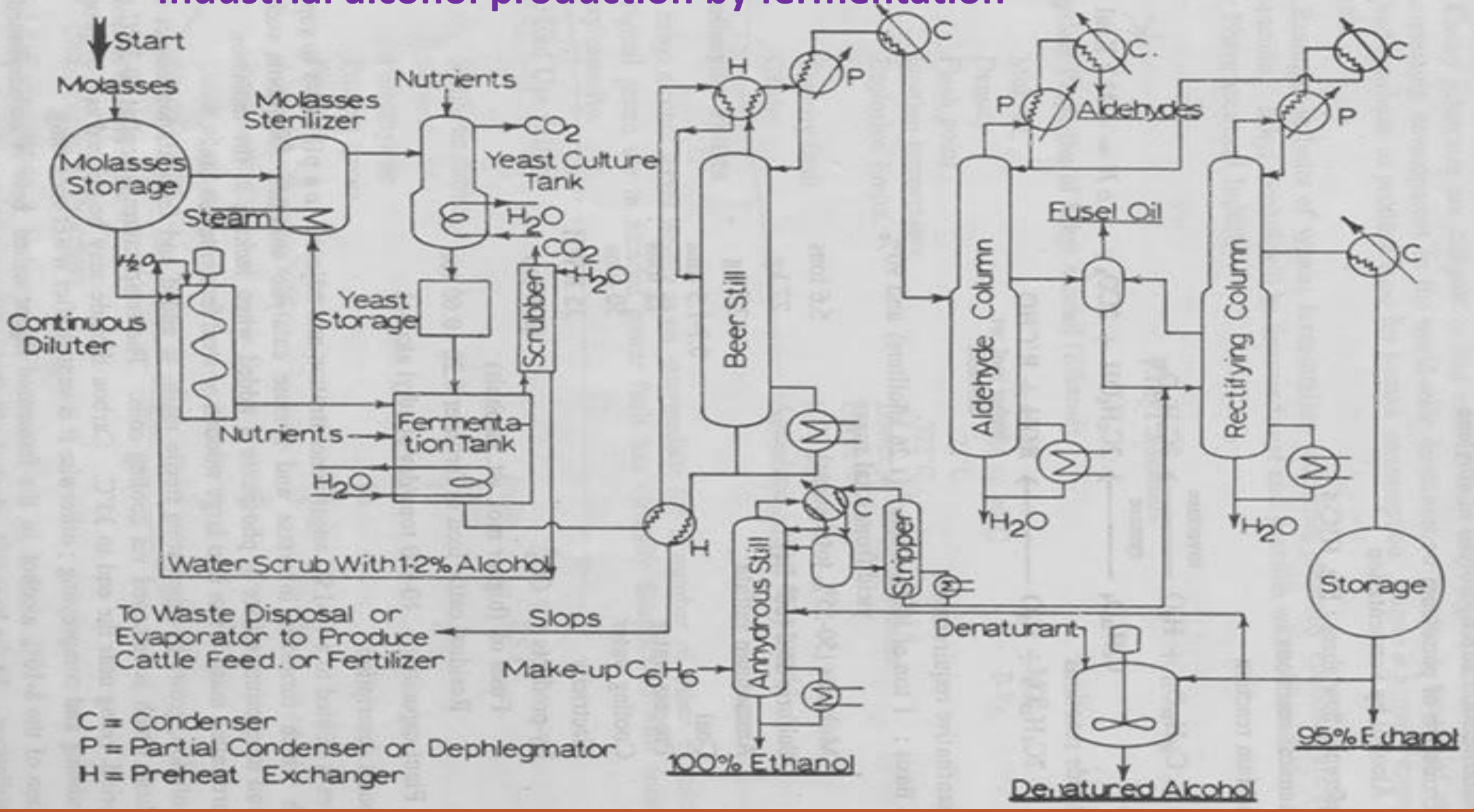
Releasing CO_2 Is observed



Distillation

Storage

Industrial alcohol production by fermentation



Process Description:

- Molasses is diluted to a 10-15% sugar concentration and adjusted to a pH of 4-5 to support yeast growth which furnishes invertase zymase catalytic enzymes.
- Nutrients such as ammonium and magnesium sulfate or phosphate are added when lacking in molasses. This diluted mixture, called mash, is run into large wooden or steel fermentation tanks
- Yeast solution, grown by inoculating sterile mash, is added and fermentation ensues with evolution of heat which is removed via cooling coils. The temperature is kept at 20-30^{o}C over a 30-70 hour period, rising near the end to 35^{o}C.
- Carbon dioxide may be utilized as a by-product by water scrubbing and compressing; otherwise it is vented after scrubbing.
- Separation of the 8-10% of alcohol in the fermented liquor called beer is accomplished by a series of distillations. In the beer still, alcohol (50-60 %conc.) and undesirable volatiles such as aldehydes are taken off the top and fed to the aldehyde still.
- Alcohol is pulled off as a side-stream spilt to the rectifying column.

- In this final column, the azeotropic alcohol-water mixture of 95% ethanol is taken off as a top side-stream, condensed and run to storage where it is spilt into three parts:
  (1) Direct sale as potable, government controlled alcohol.
  (2) Denatured by small additions of mildly toxic ingredients and sold for industrial uses.
  (3) Made anhydrous by ternary azeotropic distillation using benzene or extractive distillation using ethylene glycol.
- When fusel oil recovery is practiced, side-streams are drawn off near the bottom of the aldehyde and rectifying columns and are separated by decantation. These higher molecular weight alcohols are sold directly for solvents or are fractionated to give predominately amyl alcohol.

- The bottoms from the beer still, known as slops, are either discharged as waste or concentrated by evaporation to cattle feed depending on fuel and by-product sales economics.

Major Engineering Problems

- Collection and storage of molasses
- Maintenance of sterile and specific yeast culture conditions
- Batch versus continuous operation: continuous mollasses dilution in the head end of the process and continuous distillation are incorporated to save space, equipment and operating costs.
- Waste disposal problem : if uneconomic to concentrate for cattle feed, must use trickling filters, activated sludge or anaerobic digestion to lower the biological oxygen demand (BOB) before discharging to water run-off
- Fuel economic in the series of distillations: use of preheat exchangers
- Development of methods to produce anhydrous alcohol from 95% alcohol Azeotrope.

Thank you