INDIAN ALCOHOL INDUSTRY - FUTURE CHALLENGES

Dr. S. Kumar & N Mohan
NATIONAL SUGAR INSTITUTE
KANPUR
India is one of the largest producer of alcohol in Asia & annual installed capacity of 375 molasses based distilleries is 400 million litres.

The capacity utilization of distilleries is in the range of 60-65% only, due to the non availability of main raw material molasses and chances of its being available in large quantities in future are also remote.

Since ethanol is fuel of future, its production assumes great significance and the presentation discusses some challenges which are likely to be faced by the distilleries in the years to come.
INTRODUCTION

Fast depleting fossil fuels and continuous increase in the demand of petro products is a matter of concern throughout the world.

In our country the situation is more serious since we are importing more than 70% of our requirement and spending huge amounts of foreign currency for the import of crude.
Thus we must produce maximum alcohol by distilleries to meet the future requirements.

By doing so, the value addition created by converting molasses into alcohol shall also improve the financial health of the sugar industry.
Raw Materials for Alcohol Production

These include sucrose containing plants (sugar cane, sugar beet, sweet sorghum, fruits etc.)

• Starch containing plants (corn, wheat, potato, cassava, sweet potato, millets etc).

• Cellulosic materials (sugar cane bagasse, wood, crop residues, switch grass, waste paper etc).
RAW MATERIALS FOR ALCOHOL PRODUCTION

Simple
Sucrose
Single Stage Hydrolysis

Moderate
Starch

Complex
Starch
Two Stage Hydrolysis

Most Complex
Cellulose
Treatment Followed by Liquefaction

Cane juice; Beet juice
Molasses

Cassava; wheat; rice, sorghum; millets

Bagasse; wheat & straw; grass
Out of these, the most widely used raw material is molasses in our country while sugar cane juice is commonly used in Brazil.

Starchy raw materials are mainly utilized for the production of grain spirit (in USA corn is used for the fermentative production of fuel ethanol).

In India, utilization of grains for fermentative production of alcohol is restricted to some states mainly for the production of grain spirit for IMFL (till recently when rates of ethanol were comparatively less).
Fermentation Technologies

The conventional and oldest of the technologies is **batch fermentation**.

• Here each fermenter is pitched separately with yeast culture.

• After completion of fermentation and allowing sufficient time for yeast settling, the fermented wash is sent for distillation.
• This is the time tested technology and is still prevalent in large no. of distilleries giving yield of 225-230 l/ton of molasses having TRS content of about 47-48 %.

• Continuous fermentation technologies developed in foreign countries have also been adopted by Indian distilleries, the most common are cascade and biostil.
• The **cascade system** uses three to five fermenters and **Biostil** uses single large fermenter and uses *Schizosaccharomyces pombe* which is osmotolerant yeast.

• It also involves weak wash recycle and generates less effluent.

• Both the technologies have been adopted by Indian distilleries but both of them are giving problems especially in Northern Indian distilleries.
Distillation Technologies

• Though batch fermentation is still common in India but distillation is continuous.

• Atmospheric distillation using analyzer and rectifier columns is being replaced by modern, efficient and less energy consuming distillation systems.
• These include those using partial vacuum columns, Multi Pressure Redistillation (MPR) columns, Total Vacuum System (TVS) etc.

• The fermented wash in these columns can directly produce ENA from wash and also consumes less steam with little formation of scales.
Power Alcohol

• The need of fuels other than petro fuels was first felt during second world war.

• Thus plants producing absolute alcohol were established throughout the world including India (first plant was at Mandya near Mysore).
• These plants prepared rectified spirit from molasses in our country and this was redistilled after mixing with benzene etc.

• These plants are now replaced by MSDH plants since these are more efficient at the same time free from toxic (carcinogenic) entrainers.
By products of Alcohol Fermentation

The distillation industry is able to exploit the potential of utilization of its by products in order to improve the financial health of distilleries and to make up for any downward trend in alcohol. These by products are:
Carbon dioxide

• It is major by product of distillery which is produced during anaerobic fermentation of molasses.

• Quantitatively the extent of generation of carbon dioxide is 95% of ethanol.

  Yeast

  Glucose $\rightarrow$ ethyl alcohol + Carbon dioxide

  $180 \rightarrow 92 \rightarrow 88$
Biogas

• Spent wash obtained after recovery of alcohol from fermented wash by distillation, is a highly polluting liquid and has COD in the range of 1,00,000 – 1,30,000 mg/l and a BOD of about 50,000 – 65,000 mg/l with a pH value of about 3.5.

• This polluting liquid needs to be treated in the factory premises to bring pollution loads to permissible limits.
• The most useful treatment is anaerobic digestion of spent wash with the recovery of methane rich biogas (1 kg decrease in COD gives 0.53 cubic meter).

• This biogas produced can meet up to 75% of steam requirement of distillery by spent wash treatment in biodigester.
Future Challenges

• The competition in domestic as well as global market and the awareness with regard to environment protection has seen this industry to be modernized and eco friendly.

• It is likely to face some challenges in the time to come with regard to following:
Raw Materials

• The main raw material used by distilleries is molasses, the byproduct of sugar factories.

• The availability of molasses to distilleries is dependent on the quantity of cane crushed by sugar factories.

• In past few years, molasses availability has remained quite insufficient to the distilleries.
• In future, availability will be scarcer since the production of molasses is expected to be constant though new distilleries are being installed especially attached to sugar factories.

• Thus distilleries can not depend solely on molasses as feedstock in coming years.

• To overcome the probable acute shortage of molasses in near future, we must look in for using other raw materials for alcohol production.

• Sugarcane juice is one such alternate.
• However, considering the present cost of sugarcane and the yield of alcohol from it, it may not be viable alternative.

• But in future years it is most probable that sugarcane juice is utilized for alcohol production on a mass scale provided Government provides incentives on its procurement as is the case in U.S. where corn is utilized for manufacture of power alcohol.
Sweet sorghum is another crop, the cultivation of which should be encouraged to make it a future raw material for distilleries.

Starchy materials like wheat, rice, corn, sorghum, millets, cassava, potato, sweet potato etc. are also the raw materials of future for alcohol production.

Since out of above many are also consumed as food, here shall always be a debate whether food is important or fuel since both are essential.
However, surplus and partially spoiled grains may be allowed for alcohol production to meet future demands of energy.

• The most abundant carbohydrates present on earth are in the form of lignocellulosics and are represented by grass, trees, wood, grain stalks etc.

• Due to presence of lignin, these have so far not been successfully employed for fermentative production of ethanol.
Need is to concentrate our research in the direction of removal of lignin by simple procedures and for converting cellulose to fermentable sugar.

Attempts should also be made to produce and cultivate those plants on large scale which contain little lignin.

Canada is the land richest in lignocellulosic forests and they are planning to screen less lignin containing plants and to grow them on massive scale to meet future demands of alcohol.
• The quality of molasses available to distilleries is deteriorating due to extraction of more and more sugar by the sugar factories by using better equipment, better technology and use of a variety of chemicals.

• At present only B, C and below grade molasses is available to distilleries. Sludge content in molasses is also increasing and so is the case with regard to content of volatile fatty acids (VFA).
• Cases of molasses deterioration on storage are also being reported in large nos.

• Molasses with high sludge and more VFA affect fermentation process causing drop in recovery, excessive foaming, drop in yeast cell count etc.

• Thus, fermentation process needs to be continuously monitored / modified and suitably adjusted to have minimum effect of presence of sludge, VFA & microorganisms.
Fermentation

The fermentation of diluted molasses is carried out using distillers yeast *S. cerevisiae*. The desirable characteristics of distiller’s yeast are:

- Broad range of substrate utilization
- Fast rate of fermentation
- High ethanol tolerance
- High osmotolerance
• High temperature tolerance
• Genetic stability
• Flocculating nature
• High acid tolerance
• Low generation of byproducts
• Since yeast is a living organism and is susceptible to effects of temperature, pH, osmolarity, concentration of substrate etc., it is likely to change its behavior by repeated use for long periods. Attempts should be made so that it does not change its characteristics.

• Yeast also suffers from the drawback of high sludge formation and less specific growth rate as compared to bacteria.

• In coming years, distilleries may be using genetically modified bacterial strains like Zymomonas which have faster specific growth rate, high osmotolerance and tolerance to low pH.
Technology Adoption By Distilleries

• The available technologies are batch fermentation (which is conventional fermentation process) and continuous fermentation process.

• Continuous fermentation may be one step process employing one reactor with constant alcohol content with slop and yeast recycling (biostil) or cascade system using three to four fermenters in a series or cascade with yeast recycling.
• In batch fermentation process normally installation costs are low and manpower requirement is more, easy contamination control but productivity is low and fermentation efficiency values up to 90% (maximum) are achievable.

• On the other hand, installation costs are high in continuous system, manpower requirement is less, system is largely automated and productivities high but contamination control is difficult.

• A large number of distilleries have adopted continuous fermentation systems both cascade and biostil.
Out of these biostill process did not prove successful especially in Northern India.

Cascade process has so far been partially successful.

Increased content of sludge as well as VFA in molasses affects fermentation in cascade system as a result of this, some factories operate continuous as batch or fed batch. Use of immobilized yeast may be in use later on.
• In addition to above, newer problems may be added in molasses fermentation for which we must be ready including prohibition which is likely to be extended to many more states, at the same time prices of ethanol may also be slashed. Rs 3/ w.e.f. 13.10.16.

• Since new raw materials are likely to be utilized in coming years, problems associated with them also need to be visualized.
Distillation

• Atmospheric distillation is continuously being replaced by MPR (Multi Pressure Redistillation) and Total Vacuum System at low temperature.

• MPR is quite common wherein at low steam consumption directly ENA can be produced from fermented wash.

• It is expected that newer distillation technologies may be developed which will produce rectified spirit and ENA of good quality at the expense of less consumption of energy.
Effluent Treatment Systems

• Keeping in view the recent guidelines from CPCB to reduce generation of spent wash per litre of alcohol produced and to achieve ZLD for distilleries, MEE. RO, incineration system etc. are in use.

• Biocomposting is a very noble method of spent wash bio treatment using press mud and spent wash/concentrated spent wash.
• The major problem with biocompost is its storage and disposal.

• Another problem which is likely to be faced shall be packing/sale of incompletely composted fertilizer. If it so happens, the process itself will come to strict scrutiny.

• Some foolproof arrangement needs to be developed to discourage incompletely composted fertilizer.
• As regards use of incineration boilers, besides capital cost, its useful life and emission through flue gases shall require an exhaustive study.

• It is felt that collaborative studies may be carried out to develop alternate techno-economic technologies for handling spent wash to achieve ZLD and also to get some useful byproduct.
Some alternate technologies may be:

- Drying of spent wash and to convert the powder obtained into potash rich fertilizers.

- One time land application of biomethanated spent wash under controlled condition.
Power Alcohol

• The major use of alcohol in future shall be in the energy sector especially as ethanol blended petrol (EBP).

• The first committee was formed in 1979 to examine the use of alcohol as fuel in admixture with gasoline followed by trials by IIT Delhi on vehicle using 5-10 % blends of ethanol in gasoline.
• With Govt. making it mandatory to use 10% blend in petrol from October 2015 and intending on further raising the blending levels, the requirement of ethanol is to rise further.

• It is probable that sufficient quantity of ethanol may not available for EBP.

• To overcome this, need shall be to increase the land for sugarcane crop which is only 7%.
• An increase of 1 million hectare will produce 75 million ton of sugarcane that can give additional 5.0 billion liters of ethanol.

• Due to increasing demographic pressures, such increase area may not be possible. Thus, this can also be achieved by raising the yield to 100 T/ha. Biomass to ethanol conversion needs to be commercialized which can be a limitless source of biofuels.
• At present for the targeted EBP 10 programme, the requirement of power alcohol or Ethanol is estimated to be approximately 2680 million litres, which is equal to the total alcohol production potential in the country through molasses route.

• Thus, after meeting the requirement of potable and chemical industries, only 5% blending target seems to be achievable through molasses route and to meet the desired blending levels potential of alternate feed stocks has to be harnessed.
Thank you