

# Possibilities of Artificial Intelligence in Ethanol Industries

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## ABSTRACT

India is the largest sugar producing country in the world and ethanol blending with petrol the latest trends in sugar industries. Robust growth in the sugar and ethanol industry paved way for green energy solution for restricting environmental deterioration. More than 750 sugar industries and 1000 distilleries are involved in sugar and ethanol production to meet E20 ethanol program in India to be successful in 2025. In latest trend, possibilities of Artificial intelligence in ethanol industry is very essential to improve the fermentation and distillation efficiencies and supply chain management. In this article details study have been made to introduce Artificial intelligence in all possible ways to explore the industry growth to international standards. Artificial intelligence has already been food and beverage industries to provide good recipes to attract the consumers. Especially in ethanol industry, Artificial intelligence definitely improve the fermentation process optimization, quality control, environmental management, energy management, supply chain management, data analysis, and reporting etc. Various factors have been studied to introduce Artificial intelligence in ethanol industry in near future.

## INTRODUCTION

Indian ethanol industry is currently playing crucial role in protecting environmental degradation by introducing green energy with petrol which avoids global warming. In India, National biofuel Policy 2018 introduced 10 % ethanol blending target in 2022 and 20% target in 2030. Government of India has introduced Interest subvention scheme to support the sugar industries for new ethanol industry would encash 6% interest for 5 years. More than 200- 300 new sugar industries are upcoming with new ethanol plant and ethanol production have been improved. Ethanol blending rate in 2013 was in 1.3% increased to 10% in 2022. Further National Biofuel policy 2018 have been amended and ethanol blending target has been advanced to 20% by 2025. For this government has relaxed the sugar diversion for ethanol production by permitting B -heavy, sugarcane juice, sugar syrup and raw sugar can be used as feedstock for ethanol production. Since the sugarcane cultivation is facing shortage of sugarcane cultivation, grain alcohol has been introduced and more than 450 new grain ethanol units are upcoming to meet the ethanol requirement for ethanol blending program. To meet 20% ethanol blending more than 1000 crore liters of ethanol to be supplied for ethanol programme. In 2023, more than 650 crore liters of ethanol has been produced and supplied it to Oil Marketing companies and 10% target have been achieved in November 2022. Later 20% ethanol blending has been introduced by government of India and the program under operation at national level. To meet this requirement more than 450 ethanol plants are upcoming and commercial production has been started one by one.

### Artificial Intelligence approach in Ethanol industries:

Ethanol fuel production from biomass is a complex process known challenges in the area of handling, optimizing and future forecasting. The existence of modelling techniques like artificial intelligence is therefore, necessary in the design, handling and optimization of bio-ethanol production.

### How is AI used in fermentation?

AI can be used to monitor and control the temperature and humidity levels during fermentation, ensuring that the process is an energy-efficient as possible. Additionally, AI can be used to predict the optimal use of raw materials, reducing waste and ensuring that resources are used efficiently

**Current trends and future prospects:**

One of the primary applications of Artificial intelligence (AI) in fermentation science is the optimization of fermentation processes. Traditionally, the fermentation process has been monitored and controlled by skilled technicians who rely on their experience and intuition to make adjustments. However, AI can now be used to analyze vast amounts of data generated during the fermentation process. Such as temperature, pH and nutrient levels to identify patterns and correlations that can be used to optimize the process. By using machine learning algorithms. AI can predict the optimal conditions for fermentation, allowing for better control of the process and resulting in higher quality products. Artificial Intelligence (AI) is making an impact in fermentation for the development of new strains of yeast. Yeast plays a vital role in the fermentation by synthesizing alcohol and the selection of the right strain can significantly affect the final products taste, texture and nutritional value. AI used to analyze the genetic information of yeast cells and predict their behavior during fermentation. AI can help to minimize the resources requirements by optimizing the fermentation process. AI can also predict the optimal use of raw materials reducing unfermentable sugars etc. The potential benefit of AI in fermentation are not limited to the production of ethanol. The application of artificial intelligence in ethanol fermentation is an existing and rapidly evolving field with the potential to revolutionary in the bio-ethanol industry.

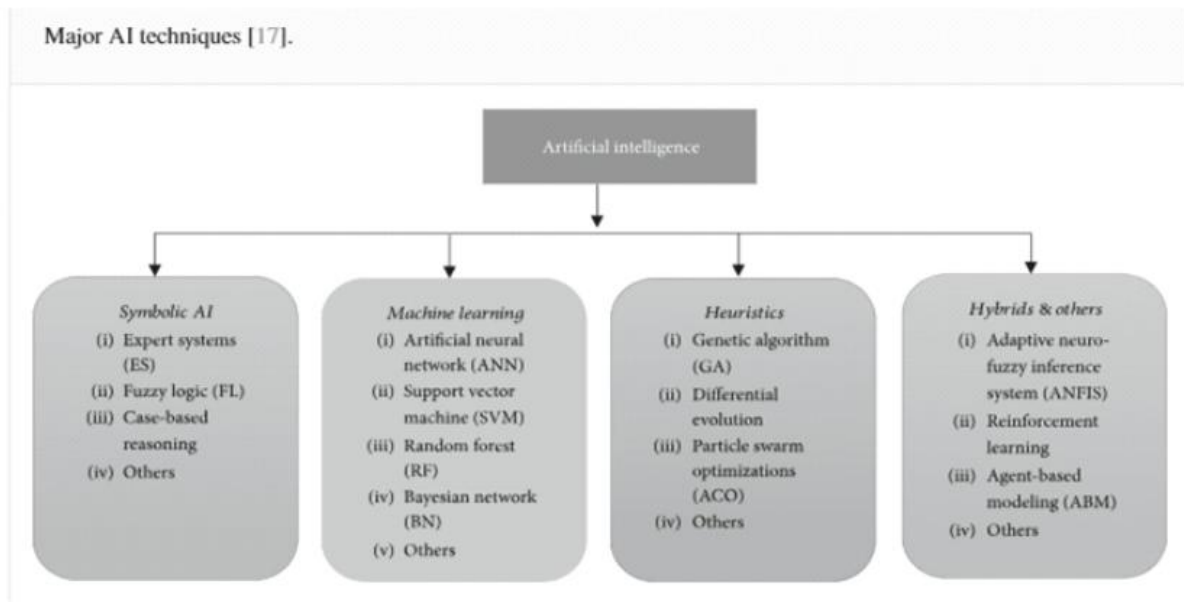
**Artificial Intelligence (AI) in Molasses and Grain based ethanol industry:**

The introduction of AI in the molasses and grain-based ethanol industry has brought about significant advancements in various areas. There are some key applications.

1. **Process optimization:** Artificial intelligence algorithms can analyze process data to optimize fermentation and distillation processes, improving ethanol yield and quality
2. **Predictive maintenance:** AI can predict equipment failures and schedule maintenance, reducing downtime and increasing efficiency.
3. **Quality control:** AI powered sensors and cameras can monitor the quality of molasses and grain feedstocks and ethanol in real time, ensuing consistent product quality.
4. **Supply Chain Management:** AI can optimize the supply chain, from raw material procurement to product distribution, enhancing overall operational efficiency.
5. **Energy Management:** AI systems can monitor and manage energy usage, optimizing energy consumption and reducing costs.
6. **Environmental monitoring:** AI tools can monitor and manage environmental impact, aiding in compliance with regulations and sustainable practices.
7. **Data Analysis and Reporting:** AI systems can analyze large volumes of data to provide insights for better decision making and compliance reporting.

These applications highlight how AI is revolutionizing the molasses and grain based ethanol industry by increasing efficiency, reducing costs, and enhancing product quality (Fig 1).

Fig -1 Major AI techniques adopted in Process control



### Designing on Artificial Intelligence (AI) systems for Data Analysis in distillery industry:

1. **Define Objectives:** Clearly define what you want the Artificial intelligence (AI) to achieve. This could include improving plant efficiency, maximizing ethanol yield, reducing energy consumption or enhancing product quality.
2. **Data collection and integration:**
  - Gather data from various sources within the plant, such as fermentation parameters, distillation parameters, energy usage and quality control metrics.
  - Ensure integration of data from different systems (e.g. Sensors, control systems, ERPO systems)
3. **Data Preparation:**
  - Cleanse and preprocess the data remove inconsistencies or outliers.
  - Normalize the data to ensure uniformity in measurement units and scales.
4. **Choose AI models**
  - Select appropriate machine learning algorithms based on the objective common choices include regression models for prediction, for process optimization and neural networks for complex pattern recognition.
  - Consider advanced techniques like deep learning for more complex analysis if the data volume and complexity justify it.
5. **Training the AI models:**
  - Use historical plant data to train the model.
  - Ensure a diverse dataset that covers different operational conditions and scenarios.
6. **Model validation and testing**
  - Validate the model using a separate dataset to test its accuracy and reliability.
  - Perform continuous testing to ensure the model remains accurate overtime.
7. **Deployment:**
  - Integrate the AI model with the plant's control systems for real time analysis and decision making.
  - Ensure that the AI systems can integrate with existing hardware and software Infrastructure.
8. **Monitoring and Maintenance**
  - Continuously monitor the systems performance and make adjustments as necessary.
  - Update the AI model regularly with new data and insights.

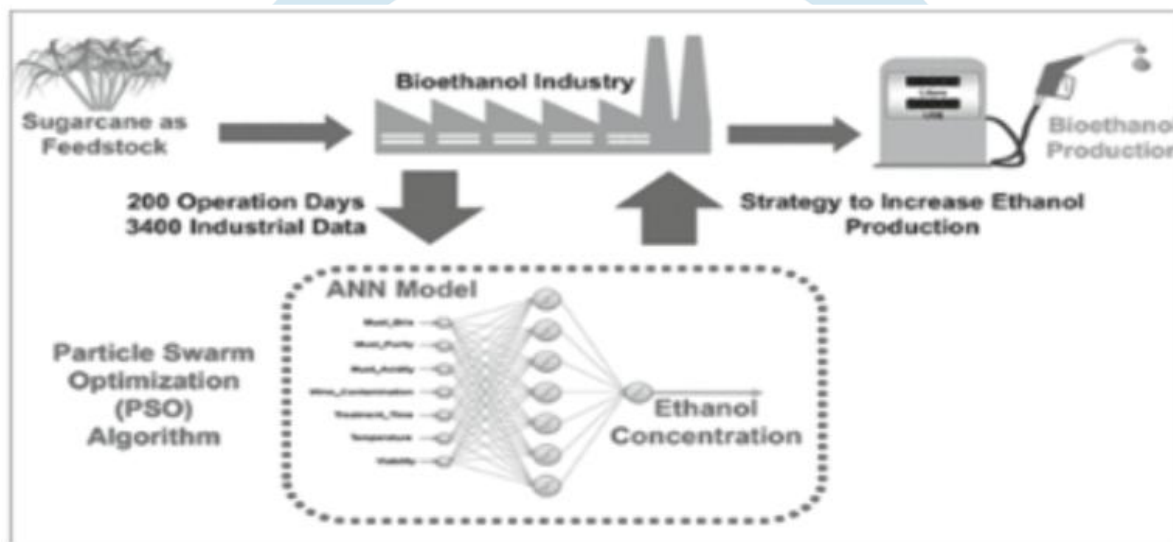
## 9. Feedback loop:

- Establish a feedback mechanism to learn from the AI's performance and make iterative improvements.
- Involve plant operators and engineers in the process for practical insights.

## 10. Compliance and Security:

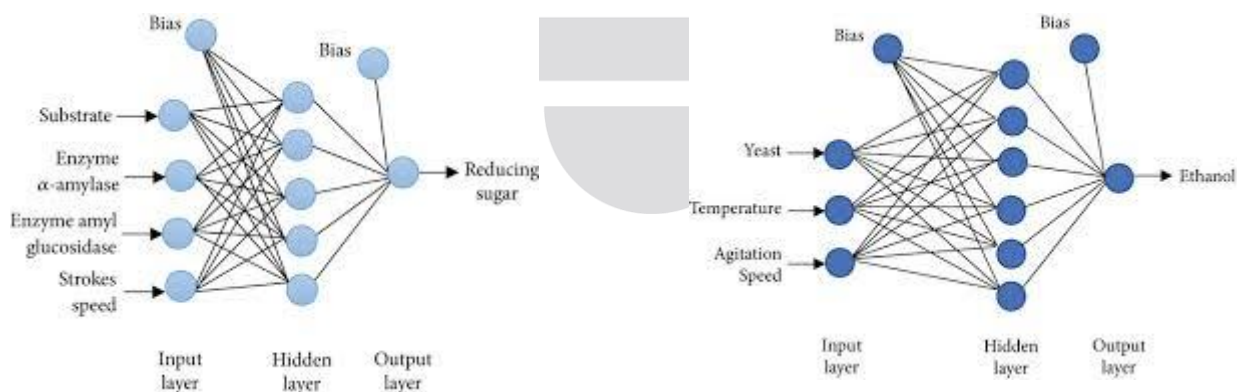
- Ensure that the AI systems complies with industry regulations and standards.
- Implement robust data security measures to protect sensitive information.

By following the above said steps we can design an AI system that enhances plant performance in a ethanol plant leading to increase efficiency, reduced costs and improved product quality (Fig 2).



## How Artificial Intelligence plays a significant role in distillery processes:

Artificial intelligence in the ethanol industry especially in advanced plants using a latest technology plays a significant role in optimizing the fermentation processes through data mining (Fig 3).

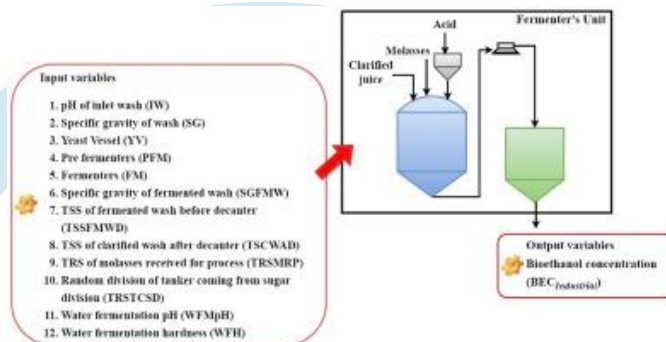


## 1. Fermentation Process optimization:

- a) Monitoring Fermentation Parameters: AI algorithms can continuously monitor parameters like temperature, pH, sugar concentration and yeast activity.
- b) Predictive Analysis: By Analyzing historical and real time data. AI can predict the outcome of the fermentation process, such as the expected ethanol yield and quality.
- c) Process control: AI can adjust fermentation conditions in real time to optimize the process like controlling temperature or adding nutrients.

## 2. Distillation Process Efficiency:

- Energy consumption optimization: AI can optimize the energy usage in the distillation process, reducing operational costs.
- Quality control: Through real time monitoring of the distillation process, AI
- ensures the consistent quality of ethanol produced.



## 3. Yield Maximization:

- AI algorithms can predict and adjust the process parameters to maximize ethanol yield from the available feedstock.

## 4. Predictive Maintenance

- Equipment Health Monitoring: AI systems can predict when equipment might fail or require maintenance, reducing downtime and improving overall efficiency
- Anomaly detection: AI can detect anomalies in the fermentation and distillation processes signaling potential issues before they became critical.

## 5. Integration with IoT and advanced Sensors:

- Real time data collection: IoT devices and advanced sensors collect vast amounts of data from the entire process.
- Data Analysis and insights: AI analyze this data to provide achievable insights for process improvements.

## 6. Supply Chain Optimization:

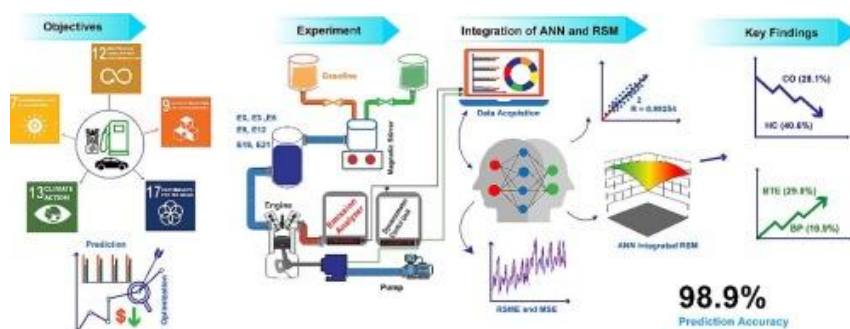
- Raw material usage: AI can optimize the use of molasses or grains and other raw materials considering variables like cost availability and quality.
- Logistics: AI also plays a role in optimizing the logistics of the supply chain from raw material procurement to product distribution.

## 7. Compliance and Reporting:

- Regulatory compliance: AI systems can ensure that the plant operates within environmental and safety regulations.
- Automated Reporting: AI can automate the generation of reports for compliance and performance monitoring.

## 8. Implementation of Latest Technologies:

- Advanced Analytics: Techniques like machine learning and deep learning offer more sophisticated analysis of complex dataset (Fig 4).



2. Clouds computing and Edge Computing: These technologies allow for scalable data processing and real time analytics.

**Conclusion:**

In this article, Artificial Intelligence, an effective modern technology requires to be implemented in the distillery or ethanol industry to minimize the waste generation, downtime and environmental complication and maximization of ethanol product yield to the required level. Various ways have been analyzed and guidelines have been issued to design artificial intelligence promoted models in distillery plant designing to supply chain management.

