



Use of Artificial Intelligence in Sugar Factory : A New Tool

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ABSTRACT

Indian sugar industry is the second highest agro based industry in our country. About 532 sugar factories are in running operation in crushing season 2023-24, producing plantation white sugar and raw-refined sugar. Some of the factory are diverting partially sugarcane syrup or B-heavy molasses to the distilleries for boosting of ethanol production. Indian government is very keen for ethanol blending programme (EBD) and achieved 11.60 % target up to March 2024 and has pledged to meet a 20% ethanol blending target by sugar season 2025-26. India is the second largest sugar producer in the world and maintained its position from several years by upgrading its manufacturing techniques from time to time. The developing future is of Artificial Intelligence (AI) is expected to improve direction and functioning of industries like food, health, manufacturing and customer service, leading to higher quality experiences for both employee and employer. The major problem areas addressed in AI can be summarized as perception, manipulation, reasoning, communication and learning. The manufacturing industries are undergoing a significant transition owing to the widespread adoption of AI and robotics. Using sophisticated machine learning algorithms in sugar production increases accuracy and efficiency. Using AI to automate repetitive processes, such as processing, maintenance of process equipment, packing, sorting and smart farming helps sugar manufacturing business enhance efficiency, quantity and quality of product and reduce sugar losses with minimum cost of production.

Keywords : Robotics, process technology, standard operating parameters (SOP's), sugar quality, plantation white sugar, refined sugar, multiple effect evaporator (MEE).

INTRODUCTION

Indian sugar factories are producing about 85% plantation white sugar (PWS) by double sulphitation process (DS Process) and rest raw-refined sugar by Defco-Melt phosphofloatation followed by Ion Exchange Resin (IER) process. In present scenario, sugar factories are converting their manufacturing process from plantation white sugar to refined sugar, year by year, to meet out globally product quality with less processing cost. AI is new tool which will change the landscape of sugar industry in the field of

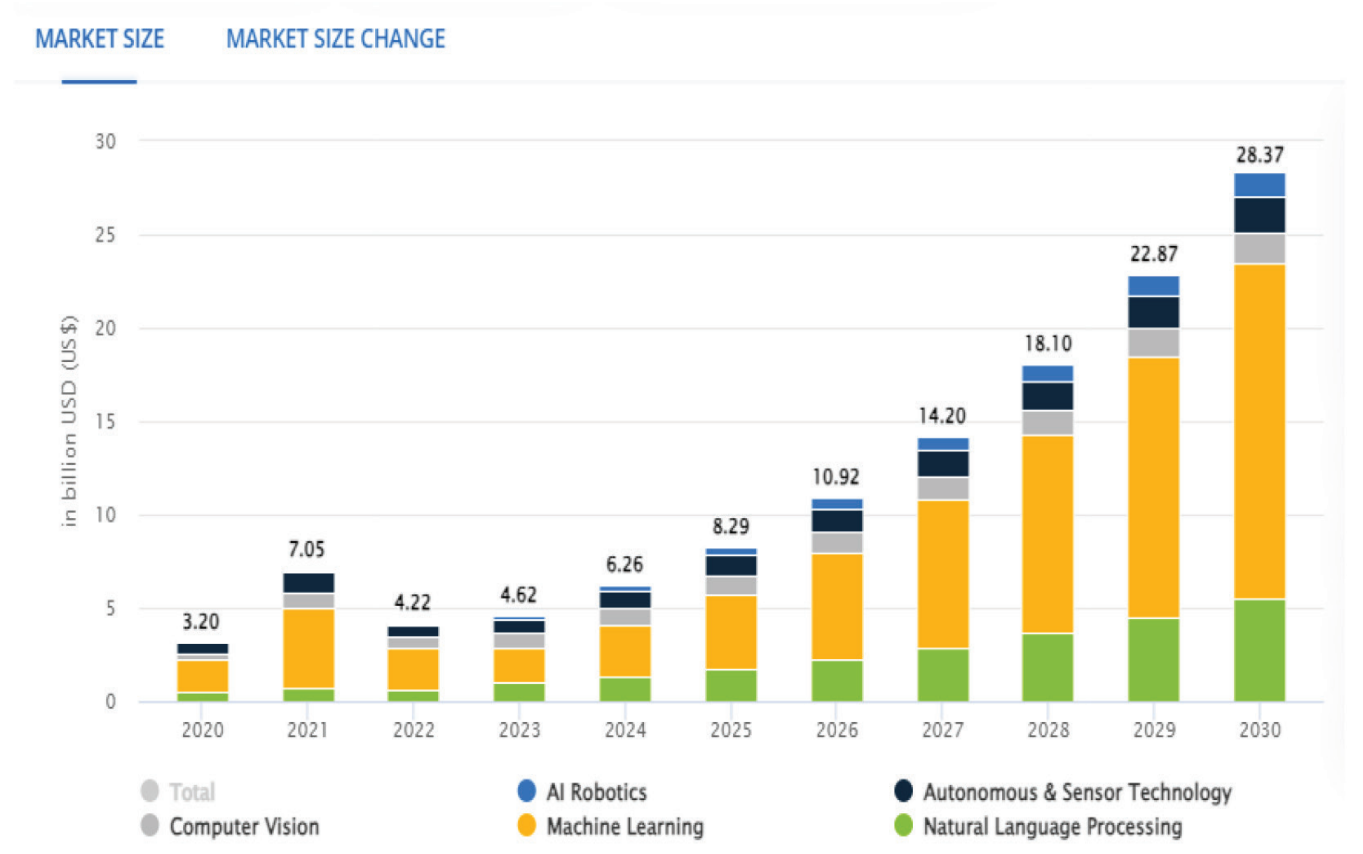
smart sugarcane farming, manufacturing process, safety, quality, preventive maintenance service (PMS), food safety compliance, packaging etc. AI is currently one of the hottest buzzwords in technology and worked on the simulation of human intelligence in machines that are programmed to think and act like humans. Learning, reasoning, problem-solving, perception and language comprehension are all examples of cognitive abilities which remove the human errors.

We discussed the utility of artificial intelligence in the field of sugar manufacturing through the data

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collection, sorting and draw the best possible result that make the standard operating parameters (SOP's) which improve the efficiency of unit operations in the processing. With the help of AI in sugar industry may conquer the future as others food process industry in the world.

The AI market in India is projected to reach \$8.29 billion by 2025 and \$28.37 billion, growing at a CAGR of over 40% from 2025 to 2030. With its vast talent pool, growing digital infrastructure, and government initiatives like Digital India, India presents significant opportunities to leverage the AI technologies.



Graph 1 : Market size of artificial intelligence in India

MATERIALS AND METHOD

AI in the sugar industry involves the use of artificial intelligence technologies like data analytics, machine learning, robotics use and logic based automation.

Main measurable data available in sugar processing during like milling operation, FFE operation, VCP operation, batch operation, etc. are:

Mass measurement	pH measurement	Power consumption
Flow measurement	Time measurement	Light (lux) measurement
Temperature measurement	Brix, Pol & Purity analysis	Humidity measurement
Pressure measurement	Moisture analysis	Soil nutrients
Level measurement	GPS tracking	Vibration of motor

From above data, artificial intelligence helps to improve the efficiencies and gives the best results in the different fields :

Smart Sugarcane Farming

Agriculture is being transformed by AI and robotics, which have improved production, sustainability, and efficiency. Precision agriculture led by AI-powered drones and robots with cutting-edge sensors can monitor crops, soil conditions and water use. Machine learning algorithms examine data to determine the best times to plant, forecast yields and identify diseases early, improving agricultural management and decreasing waste.

AI-driven automated farm equipment performs duties like sugarcane planting, harvesting and weeding with accuracy and little assistance from humans (Figure 1).

1. Soil testing to optimize the dose of fertilizer/manure.
2. Automatic sugarcane planting gives high yield.
3. Use of drones for spraying of fertilizer, pesticide, insecticides, etc.
4. Treatment of pests, insect by use of laser treatment.
5. According to moisture in soil, controlled irrigation system to save the water.
6. Sugarcane crop area and yield mapping by satellite.
7. Mechanical harvesting to save time.
8. GPS tracking of transport vehicle for reducing the cut to crush time.
9. Sugarcane Information System (SIS), direct connect to farmers.
10. Automation in cane weighment by magnetic card reading machine.
11. Forthcoming weather information system.



Figure 1 : Use of AI in different fields

Milling Section

The objective of milling section is to extract the maximum sucrose content from sugarcane by minimum use of imbibition water and minimum pol loss in bagasse with optimum energy use.

Modern mill section comprises 4 to 5 mill tandem and rotation of roller is about 4-5 rpm which connect with AC/DC VFD motor. AI may help in the following points:

1. Speed of cane carrier can regulate by consisting in crushing rate.
2. Automatic sanitization of mill house to avoid sugar losses.
3. Juice flow establishing system control on AI based.
4. Chemical dosing according crush rate.
5. Hydraulic load application controlling through AI.
6. Temperature monitoring of bearings/motors
7. Online moisture controlling of bagasse.

Clarification Section:

For cane juice clarification, two process viz. sulphitation process and defecation process are being used in Indian sugar factories to produce the plantation white sugar and refined sugar, respectively. In the sulphitation process main clarifying agent lime and sulphur di-oxide (SO_2) gas are used, while in defecation process only lime is used for cane juice clarification.

The objective of juice clarification is to remove the maximum quantity of non-sugars with optimum chemical consumption and obtained the brilliant quality of clear juice without change in reducing sugar quantity from mix juice to clear juice. Three parameters viz. pH, time and temperature are key factor in cane juice clarification process however consistency in mix juice flow have quite a role too.

AI is introduced into the multi-layer extreme learning machine to construct the deep kernel extreme learning machine for the purpose of predicting production indicators which are difficult to be measured online in sugarcane juice clarification, realizing online prediction of gravity, purity difference and color

value of sugarcane juice. Following points are based on artificial intelligence may help to increase the clarification efficiency as:

1. Mix juice flow establishment system linked with consistence in crushing rate.
2. Optimum final heating of raw, sulphited and clear juice to achieve the object of clarification.
3. pH based automation in juice sulphiter/defecator.
4. Automation for P_2O_5 , flocculant and other chemicals dosing according to juice flow.

Evaporation Section

The sulphited and defecated juice after removal of its impurities is termed as clear juice. The original cane juice is having brix around 120-140 and clear juice is concentrated in multi-effect evaporator (MEE) to form thick liquor called syrup (brix 600-700). Even in the case of raw sugar factories, the process of clarification differs but the concentration of clear juice is carried out in similar way in MEE. The evaporators in the sugar factories are basically multi effect evaporators used as quadruple, quintuple, DEVC plus quad set, etc. This is the most widely used unit operation to concentrate the clear juice to make the concentrated liquor means syrup by use of steam as heating media.

The object of evaporation is to evaporate the water quantity from clear juice up to desired level with minimum steam consumption and minimum sugar loss across the MEE operation. Some new concepts like use of MVR technology, clear juice concentration through RO membrane technology and freeze concentration System (FCS) is in pipeline. AI can enhance the operations in following manner:

1. Automatic feed control system in each effect of MEE.
2. AI helps in proper dosing of scale inhibitor in each effect of MEE.
3. Vacuum control through AI based on evaporation rate.
4. Robotic tube cleaning of heat exchangers (time saving in tube cleaning).

Crystallization section

After concentration of clear juice it's turned to syrup (brix 600-750), syrup looks like brown colour and hazy and required clarification again. Syrup clarification is done by application of sulphur di-oxide (SO₂) gas in double sulphitation process however in refined sugar process, syrup is clarified by syrup clarification process (SCS) by used of lime, phosphoric acid, flocculant and other colour precipitant, etc.

The object of pan boiling is to extract the maximum quantity of good quality sugar through crystallization process under the vacuum boiling with minimum use of steam/vapour and minimum sugar losses in final molasses. Following are the point related to AI technologies may be used during crystallization process:

1. Unsulphured syrup flow establishment system helps in better syrup sulphitation.
2. AI based graining of A massecuite.
3. Controlling in conditioning of intermediate molasses (grains free).
4. Auto feed control system in batch pans and continuous pans.
5. Entrainment alarming devices in pans/evaporators.
6. Hot water temperature control system at centrifugal machine.
7. Fully controlled vapour condensing system.
8. High resolution camera used in pans to observe the crystal growth and quality.

Drying and bagging section

Fluidized bed dryer (FBD) are common solution for cooling of ungraded sugar coming from batch type centrifugal machine. In this process, the crystalized sugar is moved in a current of whirling air from the intake feeder to the discharge end. Large volumes of air from powerful fans are used to fluidize the material, enabling it to flow from one end to the other. FBD require hot and cold air, an important air treatment system controlled by logic control.

Rotary drums are also most reliable method for drying of sugar, as they are suitable for a variety of sugars

and variable feed conditions. Rotary drums are reliable, long term solution for drying sugar that helps to keep the product safe from caking. During operation counter current air flow moves along the long, cylindrical drum to dry the sugar. Heated air can be fed into the dryer through a centralized pipe to further control the drying effect by use of AI technology based on moisture content in sugar.

Generally, in Indian sugar factory, for sugar packaging semi automatic machine are being used. While now robotic machine may be advance version of packaging which can reduce the manpower from the bagging house. This robotic machine can work continuously without wasting of time in shift changeover and better controlled manner and remove the errors. Also, according to hygiene point of view it is the best.

Some of AI based technologies may change the traditional practices are:

1. Automation in drying of sugar on the basis of moisture content.
2. Pallet packaging machine, maintained food safety norms.
3. AI technology can help in shorting of bags and storing without use of manpower.
4. Robotic loading of sugar bags.
5. Coding/tagging of each bag.

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CONCLUSION

Modernization and up gradation is key factor of every industry to make economic benefits. In this connection artificial intelligence is going to be a new efficient tool which enhance the profitability with the measurable efficiency and product quality. Many developed countries already started using the

AI tool and achieving the unbeatable results in the food processing industries like sugar factory. AI is transforming process operations in many ways, from automating routine tasks to improving decision making and reducing costs. Indian sugar industry may also improve their quality product by use of artificial intelligence and robotic operating functions in the field of farm to target product objectives.

REFERENCES

- Anil Kumar, Hari Chand and DN Kamat (2019). Artificial intelligence applications in sugarcane *Central Agriculture University, Pusa Bihar*, 69(8): 2019.
- Hugo Gaspar Hernandez-Palma, Andrea Lilian Moreno Rios (2023). Technological tools based on artificial intelligence in the sugar industry: A bibliometric analysis and future perspectives for energy efficiency. *Developments in Energy Engg.*, 4(2):49-64
- Meng, Y. (2021). Modeling and optimization of sugarcane juice clarification process. *Journal of Food Engineering* 291(3):110223.
- Pathak, H., Mishra, J.P., Mahapatra, T. (2022). Indian agriculture after independence, Indian Council of Agricultural Research, New Delhi, p. 278-340.
- Srujan Kotagiri Raju (2022). Artificial intelligence: A new hope in agriculture, CMR Technical Campus, 261-271.