

Bio-refinery application of shell and tube heat exchanger

The modern world is moving its focus towards the green energy transition as well as complete decarbonization. As an important intermediate step in achieving that goal, biofuels provide an economical alternative. In developing countries like India, the demand for energy is rapidly growing and dependence on fossil fuel has become a great challenge.

By Vijayaraghavan Chakravarthy, President (Sales & Marketing) Americas and Ganesh Prasad, Technical Sales - Precision Equipments

To overcome this challenge and to contribute towards the national objective of the energy transition, the Government of India is encouraging production of biofuels targeting self-sufficiency in energy and reducing conventional fossil fuel consumption.

Ethanol is the most common biofuel that can be used as a fuel directly or blended with fossil fuels which will reduce emissions as well as the dependency on fossil fuels. Ethanol has a higher octane number compared to that of gasoline/petrol and burns completely inside the engine cylinder contributing towards lower emissions.

What are biofuels?

Biofuel is derived from biomass such as plant or algae material or animal waste. It is produced through contemporary processes rather than by the very slow geological processes involved in the formation of fossil fuels, such as oil or natural gas. Since such feedstock material can be replenished readily, biofuel is considered to be a source of renewable energy, unlike fossil fuels such as petroleum, coal, and natural gas.

(Reference: <https://www.britannica.com/technology/biofuel>)

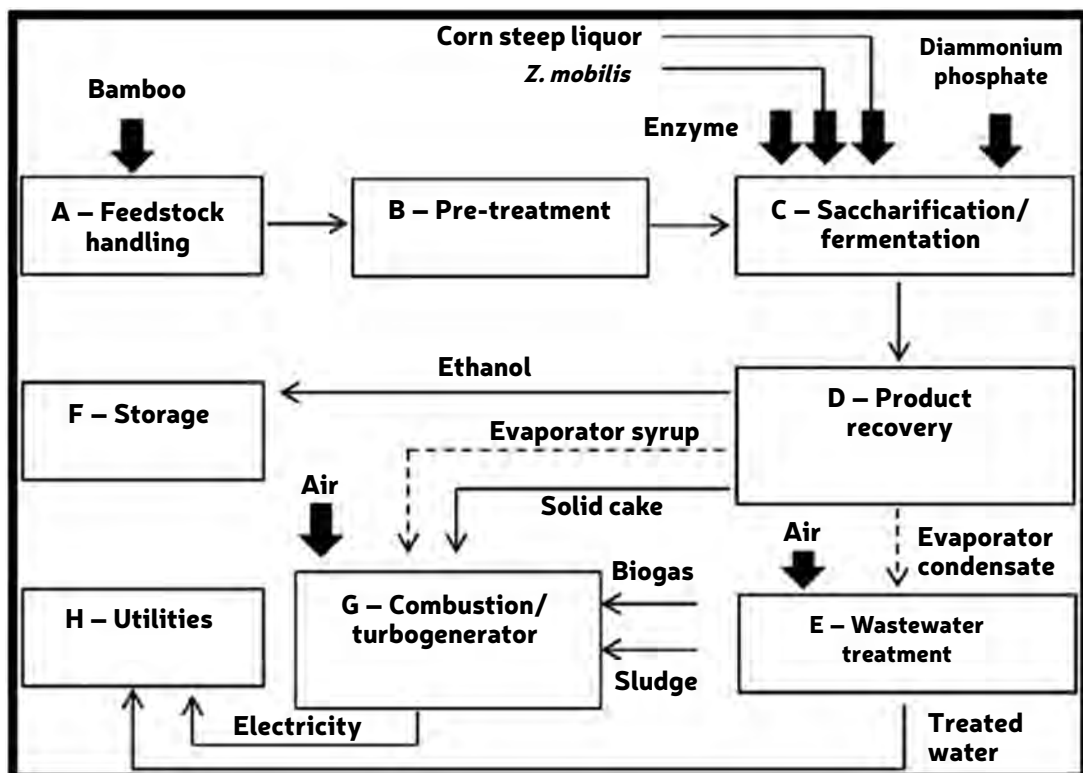
According to the expert committee on the road map of ethanol blending in India, the target is to achieve 20% ethanol blending by 2025. By this objective the country can save approximately 4 billion USD of foreign exchange per year with contribution to energy security, lower carbon emissions, better air quality, self-reliance, use of damaged food grains and increasing farmer's incomeⁱ.

Bamboo for biofuel

Bamboo as a feed stock for bio-ethanol production is interesting due to the relatively high growth rate, the resource abundance in India, and sustainable availability for a continuous production process. The process of ethanol production from bamboo feedstock is explained in the chart below. This technology depends on the utilization of a novel sulfur-free bio-solvent which is a closed loop cycle of bio-solvent and water, preventing the wastage. As the bio-solvent is totally recoverable and the cycle requires a low degree of chemical input, this process is excellent in terms of cost savings with higher sustainability.

The major benefits of bio-ethanol derived from Bamboo as a feedstock are listed below:

- Reduces CO₂ emissions, thus contributing towards global decarbonization goals.
- Byproducts of ethanol production are bio-chemicals which will reduce environmental impact.
- In comparison with fossil fuels, bio-ethanol production involves fewer chemical processes and generates more energy.
- This process is not food-based and will therefore not have an impact on human habitation.



» Figure 1. - Process flow chart of bio-ethanol productionⁱⁱ

About Precision Equipments

Precision Equipments is a pioneer in the field of manufacturing & supply of shell and tube heat exchangers since 1981 was established with a clear vision to provide end to end solutions to their customers in the process industry such as oil & gas, petrochemicals, fertilizers, and chemical industries. Recently the company has completed supply of shell & tube heat exchangers to one of the world's first bio refinery plants which will use bamboo as feedstock. With in-house thermal design capabilities and early adaptation of energy-saving heat transfer technologies, the company is looking forward to supporting the new era of bio refineries and supporting the nation to achieve its goal for net carbon neutral by 2070. Typical heat exchangers supplied by Precision Equipments for the bio-ethanol project are shown in the following pictures.

- e. Apart from fuel, sustainable textile fiber can also be produced which can support the rising demand for textile raw materials.

The role of heat exchangers

Heat exchangers play a vital role in bio-ethanol production in the areas of pretreatment, fermentation, distillation and dehydration to stillage dewatering and evaporation. Proper design of heat exchangers with associated process parameters helps to maintain high process efficiency along with high plant operation efficiency. Shell & tube is the most preferred configuration for the aforementioned reasons due to the nature of the fluids handled. They also place critical requirements such as:

- Highly skilled design team for the proper selection of the TEMA type and designs that address all operational requirements arising from – temperature, pressure, corrosion intensity, cyclic nature of variations in operational parameters, flow induced vibration etc.
- Selection of exotic tube metallurgy such as duplex, super duplex stainless steels, titanium and non-ferrous alloys.
- Fabrication shops with highly skilled welders.
- Ability to develop WPS and PQRs for exotic materials.
- Machine shops that can handle large dimension components.
- An excellent NDT capability.
- A strong experience base for handling such requirements

Apart from the metallurgy, the heat transfer efficiency can also be optimized by using our PHP HX (precision high performance heat exchanger), which uses proven technology to improve the heat transfer efficiency by reducing the surface area. Any reduction in the temperature approach of the heat exchanger helps in the reduction of the power consumption which directly translates into savings in the operating cost of the refinery. It's important to work very closely with



Figure 2. Kettle type heat exchanger with fixed tube bundle.



Figure 3. Removable tube bundle heat exchanger.

the bio refinery process licensors, engineering contractors and the owner's right from the FEED stage to ensure the selection of right type of the heat exchanger taking into consideration the efficiency and metallurgy requirement.

Through this experience Precision Equipments is confident to continuously provide heat exchangers of high quality and performance for such globally important projects.

i <https://www.niti.gov.in/expert-committee-roadmap-ethanol-blending-india-2025>

ii Littlewood, Jade & Wang, Lei & Turnbull, Colin & Murphy, R.J. (2013). Techno-economic potential of bioethanol from bamboo in China. Biotechnology for biofuels.

References

1. Claudia Daza Montaño; Jan E.G. van Dam (2021). Potential of Bamboo for Renewable Energy: Main Issues and Technology Options.
2. https://en.wikipedia.org/wiki/Ethanol_fuel
3. "Biofuels: What are they?" – Biofuel.org.uk



Figure 4. Tube bundle assembly sequence.



Figure 5. Floating head type heat exchanger.

About the Authors

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