Sustainable Power Generation using Thermal Renewable Fuel in Sugar Industry

In a conventional captive power plant, fossil fuels are burned in a boiler to produce high-pressure (HP) steam. This steam is used to drive a turbine, which then powers a generator to produce electricity. In contrast, a combined heat and power (CHP) or cogeneration power plant has the capability to utilize sustainable thermal sources such as bagasse, a residue from sugarcane processing. This enables the CHP plant to produce steam for generating electricity. Notably,the CHP plant optimizes efficiency by harnessing the surplus steam from the turbine for various sugar manufacturing processes.

Through the utilization of bagasse as its energy source, the CHP plant can generate sufficient electricity to sustain the sugar mill's operations during the season. It can even sell surplus power to the grid during the off-season,resulting in additional income. Further, the cost associated with electricity generation through the CHP plant is about 14-15% less compared to the cost incurred by Independent Power Producers (IPPs).

With the growing emphasis on sustainability across industries, the sugar sector is actively seeking methods to decrease its dependence on fossil fuels. Among the primary hurdles encountered by this industry is the enhancement of energy efficiency and the reduction of capital expenses (CAPEX) across a broader spectrum of operational scenarios than what conventional steam turbines can provide. In response to this obstacle, an innovative hybrid axial exhaust steam turbine solution has been conceived by Triveni Turbines (depicted in Figure 1).

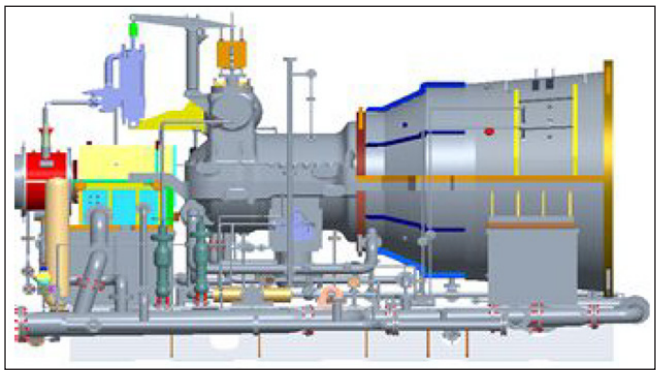


Figure 1. Axial exhaust turbine with controlled extraction for sugar factory cogeneration

Within the sugar sector, steam turbines must be adaptable to diverse flow conditions during both the season and off-season periods of the year. Throughout the season period, the HP section of the turbine operates at full load conditions, while the low-pressure (LP) section functions under partial load conditions. Conversely, during the off-season period, both HP and LP sections are engaged at full load conditions.

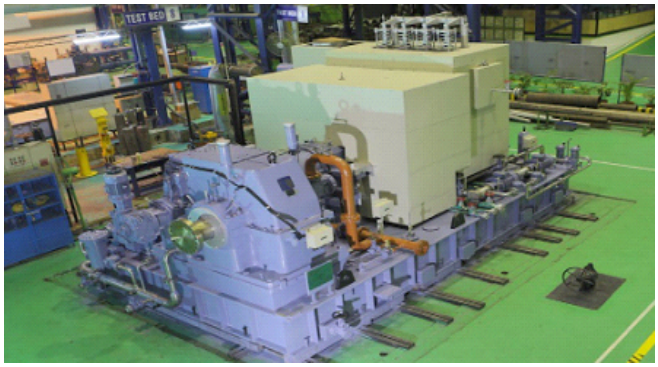
Triveni Turbines has devised a distinctive blade configuration that maintains a relatively consistent conversion efficiency across a wide array of flow conditions. This axial exhaust turbine solution serves to curtail both operational expenses (OPEX) and CAPEX, positioning it as an appealing choice for the sugar industry.

Case Studies

Bagasse-based cogeneration plant installed overseas, driven by Triveni Turbines 30 MWe back-pressure steam turbine with an inlet steam of 65 Bar and inlet temperature of 500 Deg C with 2.5 Bar exhaust

The plant's main goal is to generate electricity while also utilizing the extracted steam for various processes in sugar manufacturing. This cogeneration approach enables the plant to operate more efficiently, reducing the overall energy costs and carbon footprint. The use of bagasse as a renewable fuel source also contributes to the plant's sustainability objectives.

The Triveni 30 MWe steam turbine's high-performance capabilities allow for efficient power generation, making it a reliable and cost-effective choice for cogeneration plants worldwide.



Challenge: A customer had a requirement for a steam turbine with higher efficiency and expected delivery within 7 months.

Solution: To meet the customer's needs, a steam turbine with reaction technology was installed. The turbine's steam path was designed to handle a significantly large

volumetric steam flow, while the rotor with reaction blading ensured higher efficiency.

Benefits: The exterior casing of the turbine was single-cast, which included guide blade carriers, allowing for faster start-ups. The turbine's reaction stages also provided better efficiency, leading to increased energy output.

Overall, the installation of this steam turbine offered improved performance and energy savings for the customer.

Bagasse-based cogeneration plant installed overseas, driven by Triveni Turbines 2*16.5 MWe back-pressure steam turbine with an inlet steam of 42 Bar and inlet temperature of 400 Deg C

The Triveni steam turbines are designed with back-pressure technology, allowing for efficient steam utilization and energy generation. The turbines also feature a robust construction with high-quality materials, ensuring long-term reliability and performance. The turbines' high-performance capabilities and efficient design enable the plant to meet its energy demands while reducing its carbon footprint.

Challenge: A customer had a requirement for a steam turbine that could operate at maximum efficiency with two different inlet steam parameters: 42 Bar (a) for a new boiler and 21 Bar (a) for an existing one.

Solution: To meet the customer's needs, the steam path of the turbine was meticulously designed to handle extremely high volumetric steam flow, ensuring maximum efficiency at both inlet steam parameters.

Benefits: The blade and nozzle of the turbine were constructed using high-quality materials, specifically American Society for Testing and Materials (ASTM) grades. This ensures longer blade life and reduced operational expenditures. The plant utilized the generated power to produce sugar, with the remaining power sold to the local electricity grid, contributing to sustainable energy generation.

Overall, the installation of this steam turbine demonstrates the effectiveness of precise steam path design and high-quality material construction in maximizing energy efficiency and sustainability. The project serves as an example of the importance of meeting customer requirements and utilizing renewable energy sources in power generation.

O&M Services

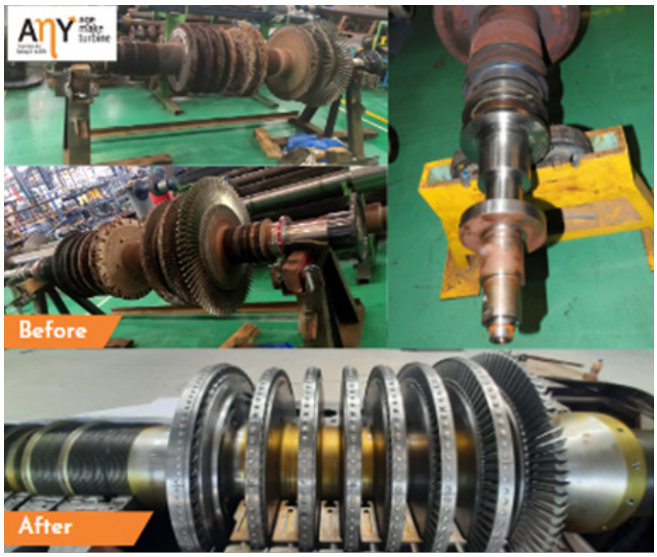
The company also extends a range of aftermarket services through its refurbishment arm known as **"Triveni REFURB".** This division delivers refurbishment solutions not only for its proprietary turbine fleet but also for turbines of various other brands, with capacities reaching up to 940 MW and of any age.

Triveni REFURB is today a multi-brand repair division, offering various benefits of efficiency enhancement services on steam turbines including renovation and modernization, re-engineering/reverse engineering, health survey and condition assessment, Residual Life Assessment (RLA), overhauling, operation & maintenance (O&M) and Long-Term Service Agreements (LTSA), and Remote Monitoring (Triveni Touch).

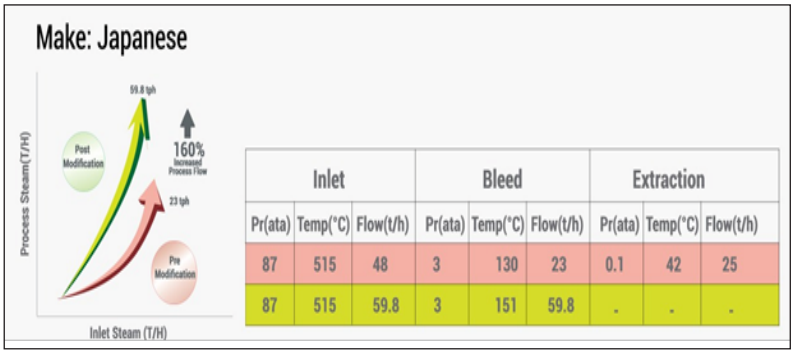
Due to rising energy costs, changes in requirement of the process, or the age of the turbine, the equipment becomes inefficient and increases cost. To operate turbines efficiently and save costs, they may need to be restored to meet new parameters. In the case of sugar industry, where part of the revenue comes from exporting power, the increase in the cost of power will reduce the company's profitability.

Case studies show how Triveni REFURB converted double extraction-condensing and single extraction condensing turbines to back-pressure turbines to improve efficiency and meet changing process needs. The re-designing process retains the existing system and only modifies the turbine internals to suit the new parameters.

Over a period of time, the existing turbines degrade thereby reducing the efficiency of the turbines by consuming more steam. The Triveni REFURB team



provides solutions to enhance the efficiency of turbines by only replacing the critical components of the turbine, i.e., rotor, guide blade carriers and bearings, which ensures the efficiency is restored, thereby reducing the carbon footprint.



Inlet			Bleed			Extraction		
Pr(ata)	Temp(°C)	Flow(t/h)	Pr(ata)	Temp(°C)	Flow(t/h)	Pr(ata)	Temp(°C)	Flow(t/h)
87	515	48	3	130	23	0.1	42	25
87	515	59.8	3	151	59.8	.	.	.

The **re-engineering** will be done to ensure the old rotor and stator can be reused within the existing casing once the price of power improves, thereby giving the customer flexibility of choosing any option based on the fluctuation of power pricing and enhancing the efficiency in either case.

Case studies show how Triveni REFURB provided a re-engineered solution to convert their existing 10 MW single-extraction condensing turbine to a back-pressure turbine by reducing the number of stages and changing the exhaust pressure from 0.1 ata to 3.0 ata.

Conclusion

There is a growing demand for renewable thermal energy sources, and the steam turbine industry is progressively moving towards energy conservation by adopting such sources. Governments are promoting solutions like cogeneration based on bagasse, biomass, and recovery of waste heat, and power generation from municipal solid waste to attain sustainability objectives. The transition from coal-fired power facilities to cleaner fuel-based power generation will additionally propel the requirement for renewable and thermal renewable-based power production in the coming years.

Courtesy:
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About Triveni Turbines Limited

With more than fifty years of expertise, Triveni Turbine Ltd. (TTL) specializes in tailoring steam turbine solutions for industrial customers and power producers across the world to meet their requirement for power and heat. Within the sub-30 MW capacity, TTL stands as a largest producer of industrial steam turbine generators (STGs), globally. The company designs and manufactures steam turbines up to 100 MW through its state-of-the-art facilities located in Bengaluru, India. The company has installed over 6,000 steam turbines, collectively generating more than 16 GW of power across the globe. With a presence in 80 countries, TTL's STGs find applications in 20+ segments.

TTL has a long-standing association with the sugar industry and has supplied tailor-made steam turbine solutions since 1968. Over 2,500 steam turbines (approximately 5,000 MWe of power generation capacity) are in operation in sugar plants across 36 countries. The company offers steam turbines for process heating and power generation applications, which are designed for higher efficiency and are capable of performing under varying process steam requirements and operating conditions. The governing and actuating system of these turbines provides speedy response and stable control to accommodate grid fluctuations and frequent load throw-off conditions.

Triveni's Product Offerings for Sugar Industry

Type	Sub-Types
Back-Pressure Turbine Generator	1. Straight Back-Pressure 2. Controlled Extraction Back-Pressure 3. Uncontrolled Extraction Back-Pressure
Condensing Turbine Generator (withwater-orair-cooled condenser)	1. Controlled Extraction Condensing 2. Uncontrolled Extraction Condensing
Power Output: Upto 100 MW	
Parameters: Inlet Steam Pressure–Upto 140 Bar; Inlet Steam Temperature–Upto 545 DegC	