Waste heat recovery: Converting heat to power

Waste heat generated from the steel production process is extracted to produce power through waste heat recovery. The optimal design of a steam turbine enables customers to operate integrated steel plant efficiently, leading to sustainable manufacturing.

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Efficient recycling of waste heat energy resources is the future for the global iron and steel industry, but conversion of heat to power remains a challenge in a steel plant. The potential for saving energy through the application of advanced technologies to the utilization of waste heat, is higher in developed economies compared with China and India. Future growth in global crude steel production will rely on two major technological trends: a shift from ore-based to scrap-based steel and from BF-BOF (Blast Furnace-Basic Oxygen Furnace) to Electric Arc Furnace (EAF) production. It is estimated by worldsteel that global crude steel production will grow from 1,864Mt in 2020 to 2,118Mt in 2024, a compound annual growth rate of 3.2%. It is worth noting though, that global finished steel production contracted to 1,772Mt in 2020.

The iron and steel sector is the backbone of the Indian economy. Rapid urbanization and growth in key sectors, such as building construction, infrastructure development, railways, machinery and automobiles, has driven growth of the Indian iron and steel industry in recent decades. The sector contributes nearly 2% to the country's GDP. Crude steel production in India touched 99.6Mt in 2020, a contraction of 10.6% as compared with the 2019 output of 111.4Mt. This makes India the world's second largest producer of crude steel and, at 88.5Mt in 2020, the second largest producer of finished steel. India is also the third largest consumer of finished steel globally, behind China and the USA.

Being an energy intensive sector, the demand trajectory for steel will considerably impact Greenhouse Gas (GHG) emissions. With a heavy dependence on coal as fuel and Direct Reduced Iron (DRI) furnaces, the Indian iron and steel industry is considered to be one of the most energy intensive sectors in the world. Therefore, strategic interventions through policy, technology and investment support, is imperative to curb GHG emissions while simultaneously meeting the growing steel demand in the country.

Waste heat that is recovered from other industrial processes is commonly used to generate steam and electricity in iron and steel processing. According to a report published by the Ministry of New and Renewable Energy (MNRE), the potential total energy generation from waste heat in India across various industrial sectors, such as cement, iron and steel, petroleum refining and chemical processing, is estimated at between 5.0 and 7.5GW. The Waste Heat Recovery (WHR) based power plant installed in the iron and steel industry uses heat generated through coke dry quenching (CDQ), sintering and exhaust hot gases for power generation.

TRIVENI TURBINE'S CONTRIBUTION TO THE STEEL INDUSTRY

The steel industry is characterized by high load variations, due to many 'on/off' conditions arising from batch processing and load fluctuations in furnaces and kilns. This affects the stability of the grid and the quality of power supply. For the steel and metallurgical industries, it is extremely critical to have a constant and reliable source of power. Power has been one of the major cost components for the steel and metallurgical industries. Hence, the availability of captive power becomes critical for the continuous operation of a steel plant. Industry estimates give the electricity requirement for a 0.5Mtpa rod plant to be 50MW, though many plants are smaller than this. The average integrated steel plant production size is 100,000t of thermo-mechanically treated rods per annum. In the case of a captive power plant, an integrated steel plant would need 10,000kW for a 350t per day DRI sponge iron plant, 15t induction furnace and 100,000tpa rolling mill. This gives thermo-mechanically treated steel rods as the finished product. Waste heat from the 350t per day DRI plant can generate 10,000kW of electric power. This meets the captive power requirement of an integrated steel plant.

CASE STUDY 1: WASTE HEAT RECOVERY BASED POWER PLANT INSTALLED IN EUROPE

Zarmen Group, based in Poland, is a significant producer of blast furnace and industrial-heating coke for the European market. The company produces forged products on hydraulic presses, classified according to the PKD 'Polish Classification of Activities' in section 28.40, as forging and pressing of metals. Production includes bars, forged rings, discs, metallurgical rolls, flanged shafts and other shaped forgings.

The company produces various forged products to satisfy the demand for the European and American markets. The steel production volumes and capacities vary, amplifying the need to design and operate a steam turbine from as low as 3MW to 30MW, due to the varied load requirements and the availability of steam. Another challenge is to meet the specification of the European Standards & Polish Grid Code requirement.

Triveni Turbines successfully designed a 30MW extraction condensing steam turbine, with an inlet steam pressure of 65 bar and inlet temperature of 490oC and associated control system, to meet the varying power and steam demand and conforming to Polish Grid Codes. The Alternator & Electrical systems were designed to be suitable for Polish grid conditions and SIL Rated PLC & SCADA systems were used with redundancy for safe operation and to cater to steam demand. The customer is now able to operate with lower power output to full load.

Increasingly, customers prefer to refurbish turbines to accommodate increases in the scale of operations, changes in process parameters, or simply due to the age of the turbines. Such support is provided by Triveni REFURB, Triveni's refurbishment arm. Triveni REFURB acts to improve the efficiency of operations of their existing turbines without the need to replace the entire turbine, thereby negating the impact of increases in specific steam consumption that can occur from operational changes.

With rising costs, operating turbines efficiently is a necessity for cost saving and reducing the carbon footprint. With age, turbines become inefficient and increase the cost of producing power. By redesigning the turbine, efficiency can be improved. Our engineers study the process change requirements of the customer and redesign the existing turbine by modifying the steam flow path to the new parameters. This re-engineering process is carefully done to ensure the existing system ie, the casing, civil foundations, lubrication oil system etc, is retained. The only modifications made are to the turbine internals, such as a new rotor, diaphragms and bearings, to suit the upgraded blade path.

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

Fig 1 **30MW Extraction condensing steam turbine**

Fig 2 **Upgrading an 8MW turbine**

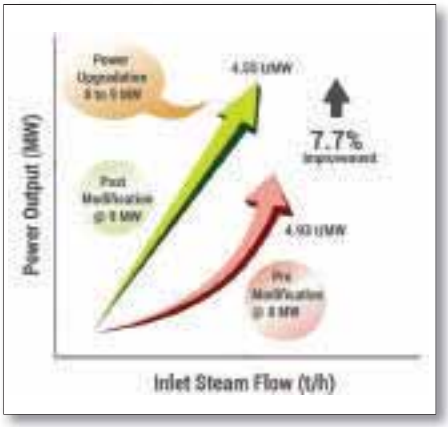

Fig 3 **Schematic of turbine performance improvement following upgrading**

CASE STUDY 2: TRIVENI AFTERMARKET REFURBISHMENT

A major process industry customer had been operating an 8MW turbine for more than 15 years. Due to changes in power requirements they were operating the turbine inefficiently. We reviewed the turbine and confirmed to the customer that we would modify the parameters to the current requirements and also ensure availability of 1MW of extra power. Triveni REFURB provided a solution to route the additional steam to the existing turbine with an upgraded steam flow path design.

By only modifying the turbine internals, consisting of a rotor with high efficient blades, diaphragms, bearings and gear internals, the customer could achieve a power enhancement to 9MW with the new design and achieve a lower specific steam consumption than for normal running conditions.

The overall project cost was significantly reduced as no modifications were required to the foundations, and the turbine housing was retained. The pay back for the refurbishment was under one year.

Triveni Turbines has been offering captive and Waste Heat Recovery (WHR) power generation solutions to the steel industry for over three decades. More than 150 steam turbines have been installed, enabling customer in the sponge iron and steel industry to operate efficiently, both in terms of CAPEX and OPEX. With flexibility in operation, availability and proven design capabilities, the company's turbines can generate maximum power with minimal waste in the range from 3 to 50MW. Triveni Turbines provides its customer a complete power plant solution and optimal design efficiency. Each steam turbine offered by us is engineered to order and customized based on the customer's requirement to match the plant load, boiler load and future power to steam ratio requirements. The company offers complete turnkey solutions for turbo-generation operations, including: supply of steam turbines, steam piping, fire fighting systems and cabling.

During these challenging times, Triveni Turbines is striving hard to serve its customers in the steel and metallurgical industries with its on-site and off-site support. MS

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