TURBOEXPANDER SERVICES

EnerTurbo Capability Statement

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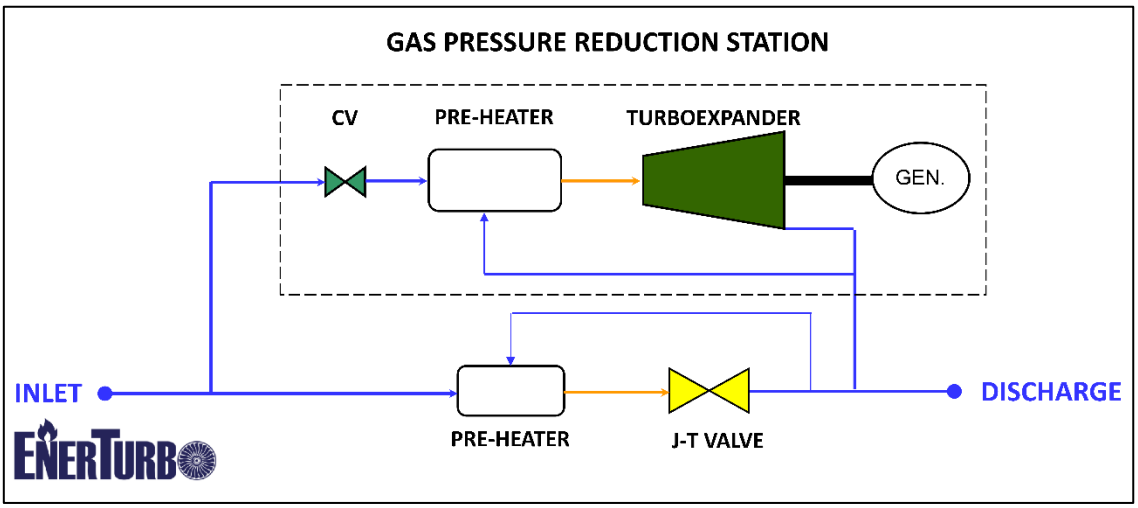
BACKGROUND

We are focused on increasing Energy Efficiency. Our philosophy is to utilize any and every ΔT and ΔP that is being ordinarily wasted, i.e. Energy Integration.

Efficient expansion is possible by utilizing turboexpanders for gas pressure reduction, as an alternative to gas throttling by expansion (J-T) valves. This is an example of Pressure (ΔP) Recovery. Turboexpander Mechanical Power as a by-product. It can drive another Rotating Machinery like a Compressor or a Pump, or a Generator for electric power generation.

Sometimes, turboexpanders are used in Heat (ΔT) Recovery from low-grade heat sources, such as geothermal, integral with an Organic Rankine Cycle (ORC).



Turboexpander Opportunities

- Gas Processing Applications: LNG – LPG – NGL
- Energy Recovery Applications: Pressure Letdown, Geothermal, Heat Recovery

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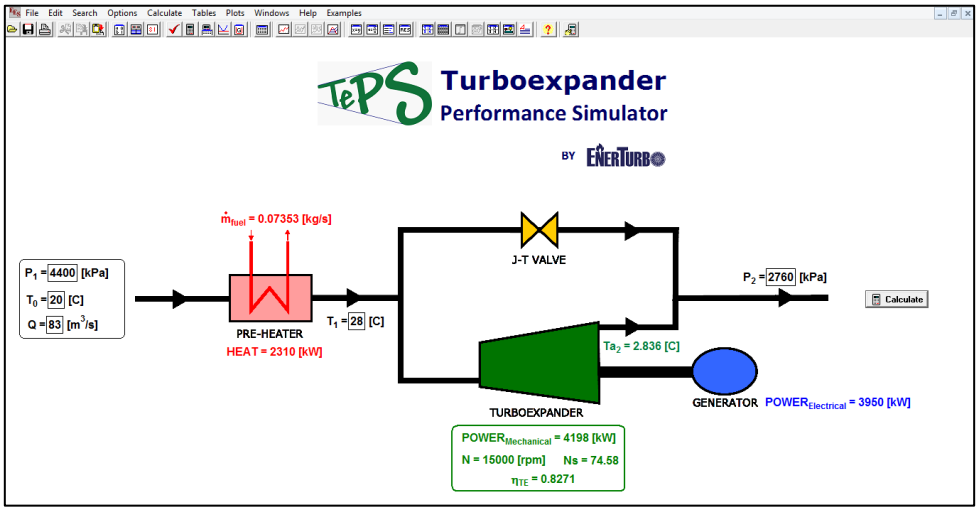
TURBOEXPANDER PERFORMANCE SIMULATOR

TePS, Turboexpander Performance Simulator, is an in-house software developed by EnerTurbo Rotating Machinery engineers.

TePS is developed following a need to predict power generation capacity and the desirable turboexpander design and performance for optimum operation under (usually) varying gas flow and pressure conditions.

Available commercial software packages demonstrate inefficiencies in prediction of turboexpander performance, due to lack of off-design calculations and/or accurate gas equation of state.

TePS offers high accuracy by including turboexpander predicted off-design performance and gas equation of state in the calculations.



TePS Capabilities and Applications

- Turboexpander plant (process) simulation
- Turboexpander gas-dynamic design; rotational speed and number of stages
- Turboexpander preliminary mechanical design
- Suitable for
  - Feasibility study and conceptual design
  - Detailed engineering design and procurement
  - Selection of the best turboexpander (vendor)

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CASE STUDIES

1. City Gate Station

The following Table is an example of selecting turboexpander design operating point to have the highest power generation potential throughout a year. The study was made possible by application of TePS based on a monthly variation of gas flow and pressure.

			Min.	Max.	Design
Station Inlet Flow	**Q_1**	**Sm^3/h**	177,000	780,000	667,000
Station Inlet Pressure	**P_1**	**bar**	33	56	32
Station Inlet Temperature	**T_1**	**°C**	5	32	34
Station Outlet Pressure	**P_2**	**bar**	18		
Power Generation	**W**	**kW**	-	-	9651
Average Annual Power Generation	**W_a**	**kW**	7356		

2. Steelmaking Plant

The following table demonstrates a trade-off between having more stages or higher rotational speed to improve turboexpander performance. The study was made possible by application of TePS.

			1-Stage	2-Stage	1-Stage
Pressure	**P_1 / P_2**	**bar**	42 / 6.2		
Temperature	**T_1 / T_2**	**°C**	25 / 15		
Flow rate	**$\dot{m}$**	**kg/s**	27.4		
Rotational Speed	**N**	**rpm**	13000	17000	31000
Specific Speed	**N_S**	**-**	34.26	58.00	71.42
Efficiency	**η_{TE}**	**%**	76.85	81.12	82.41
Power	**W**	**kW**	5863	6447	6451

For more detailed case studies, request the following documents:

- ENT-TE-CST-001: Turboexpander Operation at Mission Regulator Station
- ENT-TE-CST-002: Turboexpander Operation at Arlesheim City Gate Station

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SERVICES AND CAPABILITIES

1. Feasibility Study
2. Conceptual Design
3. Design Optimization
   - 3.1. Optimum Design Conditions
   - 3.2. Optimum Arrangement
   - 3.3. Optimum Turboexpander Gas-dynamic Design
     - 3.3.1. Number of Stages
     - 3.3.2. Rotational Speed
   - 3.4. Preliminary Turboexpander Mechanical Design
4. Turboexpander Selection and Specification
5. Basic Engineering Design and FEED
6. Detailed Engineering Design
7. Vendor Selection and Procurement
8. Procurement Services and Management
9. Installation and Commissioning Support Services and Management
10. EPC (Engineering, Procurement, Construction) or Turn-Key [by Joint Venture]
11. PMC (Project Management Consultant)
12. Technical Consulting Services at All Project Stages

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