



# Steam Backpressure Turbines

Steam turbines are one of the oldest and most versatile prime mover technologies still used in industry to drive electric generators, pumps, fans, and different types of compressors. Steam turbines have been used to generate power for about 100 years, after plants began to replace their older reciprocating steam engines. The steam turbine design provided higher efficiencies, was more versatile, and, in many situations, was more economical than buying power from outside sources. Steam turbines can range in size from very small (10 HP) with a single stage of nozzles up to very large units with many stages that produce thousands of horsepower.



Figure 1: Turbine Internal Design

## DEFINITION

A steam backpressure turbine is a device that converts the thermal energy of steam into mechanical work. A steam turbine fundamentally consists of a rotor carrying blades, the casing in which the rotor turns, and the nozzles through which the steam is allowed to expand.

## How Steam Backpressure Turbines Work

First, the heat energy of the steam (Btu/lb.) is converted into kinetic energy (velocity) by expanding the steam isentropically from a higher pressure to a lower pressure through a nozzle. Steam emerges from the nozzle at a high velocity

Second, the velocity of the steam is converted into mechanical work by directing the steam against the blades mounted on a turning rotor. A “stage” typically consists of one set of stationary nozzles and one or more rows of rotating blades immediately downstream of the nozzles.

Steam turbines are designed to meet a wide array of applications and performance specifications. Steam turbines for a large utility operation may be designed with several pressure casings and complex design types that maximize the efficiency of the steam thermal cycle in the power plant. In industrial process applications, steam turbines are generally smaller and operate at a lower steam pressure; therefore, the design is less complicated for reliability and cost reasons.

The backpressure turbine design allows the plant to capture mechanical work while providing a very effective way of reducing steam pressures for different process requirements. Steam turbines capture the mechanical work ability of steam, and they extract steam at different stages to supply different pressures to the processes in the plant. Since the exhausted steam is also used for process applications, the thermal efficiency of a steam turbine system is very high. Boilers can burn different fuels such as black liquor, wood waste, sawdust, fuel oil, coal, methane, etc. This provides great flexibility when using a steam turbine in a plant operation.

### Advantages of Backpressure Steam Turbines

What are the advantages of backpressure steam turbines?

- They can provide mechanical work and reduce steam pressures for the plant process applications.
- They can operate at different RPMs, unlike an electrical motor; thus, they can be directly coupled to a pump, fan, or other device without a reduction gear system.
- Boilers can use different fuels to generate the steam for the steam turbine.
- Backpressure steam turbines can accommodate different steam pressures from very high to low steam pressures.
- Steam temperatures are not a problem and can be dealt with safely.
- Backpressure steam turbines use simple rotary motion, which eliminates the old style of a reciprocating motion and the vibration.
- These turbines extract steam for different steam pressures required by process applications very efficiently.
- They can use superheated or saturated steam for the motive force.

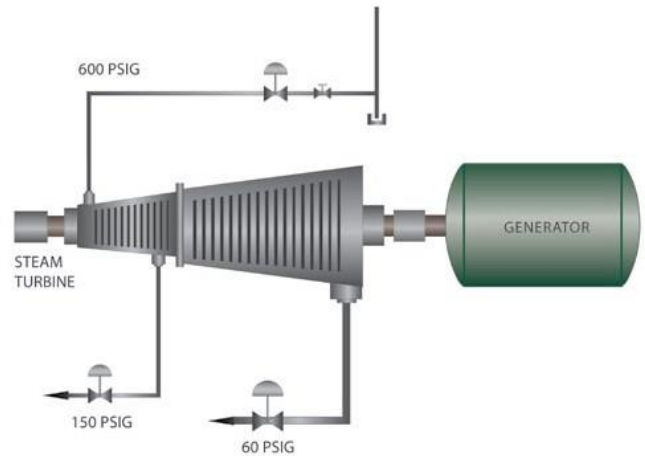


Figure 2: Two-Stage Extraction

### Applications

Steam backpressure turbines are used as the prime movers in industry in the following applications:

- Compressors (air and gases)
- Machine drives
- Blowers
- Pumps
- Electric generators

### CALCULATIONS

The output power of the turbine depends on the mass flow rate of steam, the turbine efficiency, and the difference in enthalpy between the inlet and the exhaust of the turbine. In practice, the enthalpy of steam at the exhaust is determined by the backpressure and the turbine efficiency.

This Excel sheet calculates the power that turbines can generate with specific inlet and outlet conditions.

Inlet Steam Properties		Sat. Temp	
Inlet Steam Pressure :	175.0 psig	377.4 °F	
Degree of Superheat :	10.0 °F	State	Superheated
Inlet Temperature :	387.4 °F	Enthalpy	1,205 Btu/lb
Steam Flow :	45,000 lb/hr	Entropy	1.558 Btu/lb °F

Turbine Data		Shaft Energy	
Efficiency :	47.3 %	718.7 hp	

Outlet Steam Properties		Sat. Temp	
Outlet Steam Pressure :	50.0 psig	297.7 °F	
Outlet Temperature :	297.7 °F	State	Saturated
Degree of Superheat :	0.0 °F	Enthalpy (Isentropic)	1119 Btu/lb
Steam Quality :	0.98	Enthalpy (Actual)	1164 Btu/lb

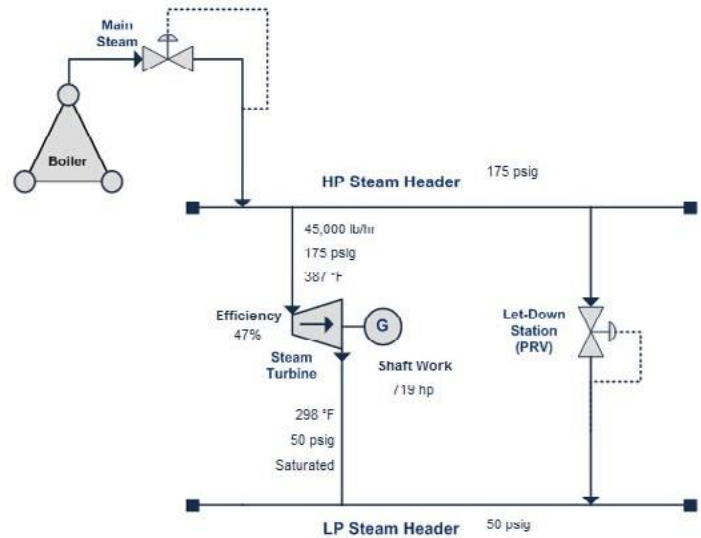


Figure 3: Steam Turbine Calculator

Inlet steam pressure:	175 psig (saturated)
Outlet steam pressure:	50 psig (100% quality)
Steam flow rate:	45,000 lbs. per hour
Output of the turbine:	713 HP
Enthalpy of steam at the turbine inlet:	Hg (175 psig) (189.7 psia) 1,198.1 Btu/lb.
Enthalpy of steam at the turbine exhaust:	Hg (50 psig) (64.7 psia) 1,113 Btu/lb. enthalpy isentropic, and 1,158 Btu/lb. actual
Isentropic turbine efficiency, taking into account steam leakage and mechanical losses:	$e \approx 47.3\%$

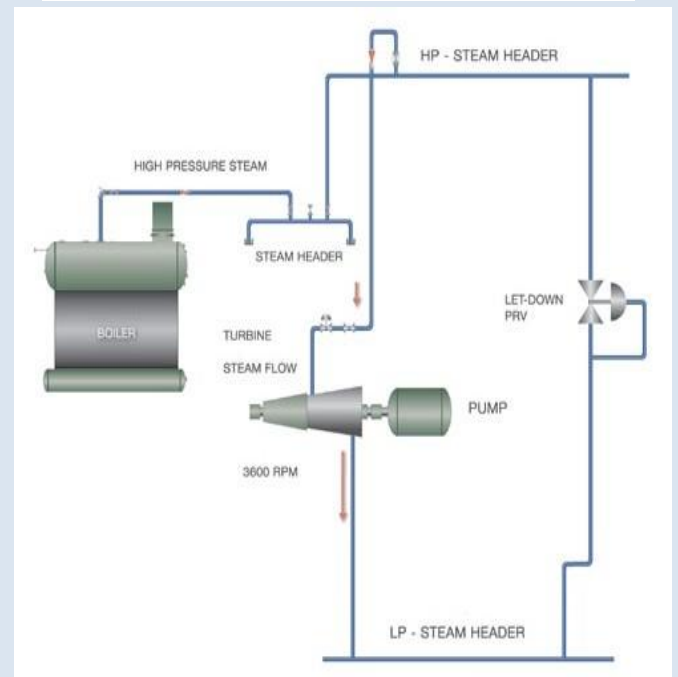


Figure 4: Example Layout Drawing



## ABOUT US

Invengo personnel are experts in the field of steam and condensate systems engineering.

Our services include design engineering, requests for quotations, standard operating procedures, root cause analysis, system optimization, steam balancing and project management. We can review your entire steam and condensate system from steam generation to distribution to end user processes and condensate recovery.

Invengo Engineering provides current and relevant world class steam system training globally. Please visit our website for our current training calendar.

We also offer fully customized training. We have an extensive topic library of over 88 different steam subjects that can be tailored to in-depth training for you and your plant personnel.