Turbomachinery

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Mounting of a steam turbine produced by Siemens, Germany

Turbomachinery, in mechanical engineering, describes machines that transfer energy between a rotor and a fluid, including both turbines and compressors. While a turbine transfers energy from a fluid to a rotor, a compressor transfers energy from a rotor to a fluid. The two types of machines are governed by the same basic relationships including Newton's second Law of Motion and Euler's energy equation for compressible fluids. Centrifugal pumps are also turbomachines that transfer energy from a rotor to a fluid, usually a liquid, while turbines and compressors usually work with a gas.[1]

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Classification

A steam turbine from MAN SE subdidiary MAN Turbo

In general, the two kinds of turbomachines encountered in practice are open and closed turbomachines. Open machines such as propellers, windmills, and unshrouded fans act on an infinite extent of fluid, whereas, closed machines operate on a finite quantity of fluid as it passes through a housing or casing.

Turbomachines are also categorized according to the type of flow. When the flow is parallel to the axis of rotation, they are called axial flow machines, and when flow is perpendicular to the axis of rotation, they are referred to as radial (or centrifugal) flow machines. There is also a third category, called mixed flow machines, where both radial and axial flow velocity components are present.

Turbomachines may be further classified into two additional categories: those that absorb energy to increase the fluid pressure, i.e. pumps, fans, and compressors, and those that produce energy such as turbines by expanding flow to lower pressures. Of particular interest are applications which contain pumps, fans, compressors and turbines. These components are essential in almost all mechanical equipment systems, such as power and refrigeration cycles.[2]

Classification of fluid machinery in species and groups

machine type → **group ↓**	**machinery**	**combinations of power and machinery**	**engines**
open turbomachine	propeller		wind turbines
hydraulic fluid machinery (≈ incompressible fluids)	centrifugal pumps turbopumps and fans	Fluid couplings and clutches (hydrodynamic gearbox); Voith Turbo-Transmissions; pump-turbines (in pumped-storage hydroelectricity)	water turbines

thermal turbomachinery (compressible fluid)	compressors	gas turbines (inlet of GT consists of a compressor)	steam turbines ← turbine jet engines

Dimensionless ratios to describe turbomachinery

Pelton wheel being installed into Walchensee Hydroelectric Power Station.

The following dimensionless ratios are often used for the characterisation of fluid machines. They allow a comparison of flow machines with different dimensions and boundary conditions.

1. Pressure range **ψ**
2. Flow number **φ** (including delivery or volume number called)
3. Performance numbers **λ**
4. Run number **σ**
5. Diameter Number **δ**

Partial list of turbomachine topics

Many types of dynamic continuous flow turbomachinery are treated in Wikipedia. Below is a partial list of these topics. What is notable about these turbomachines is that the same fundamentals apply to all. Certainly there are significant differences between these machines and between the types of analysis that are typically applied to specific cases. This does not negate the fact that they are unified by the same underlying physics of fluid dynamics, gas dynamics, aerodynamics, hydrodynamics, and thermodynamics.

- Axial compressor
- Axial fan
- Centrifugal compressor
- Centrifugal fan
- Centrifugal pump
- Centrifugal type supercharger
- Francis turbine
- Gas turbine
- Industrial fans
- Jet engine
- Radial turbine
- Steam turbine
- Turbocharger
- Turboexpander
- Turbofans
- Turbojet
- Turboprop
- Turbopump
- Turboshaft
- Turbines

- Mechanical fan
- Mixed flow compressor
- Water turbine

Turbomachines

Definition

Any devices that extracts energy from or imparts energy to a continuously moving stream of fluid (liquid or gas) can be called a Turbomachine. Elaborating, a turbomachine is a power or head generating machine which employs the dynamic action of a rotating element, the rotor; the action of the rotor changes the energy level of the continuously flowing fluid through the machine. Turbines, compressors and fans are all members of this family of machines.

In contrast to Positive displacement machines especially of the reciprocating type which are low speed machines based on the mechanical and volumetric efficiency considerations, majority of turbomachines run at comparatively higher speeds without any mechanical problems and volumetric efficiency close to hundred per cent.

Categorization

Turbomachines can be categorized on the basis of the direction of energy conversion:

- Absorb power to increase the fluid pressure or head (ducted Fans, compressors and pumps).
- Produce power by expanding fluid to a lower pressure or head (hydraulic, steam and gas turbines).

Turbomachines can be categorized on the basis of the nature of flow path through the passage of the rotor:

- Axial Turbomachine's Velocity Diagram

Axial flow turbomachines - When the path of the through-flow is wholly or mainly parallel to the axis of rotation, the device is termed an axial flow turbomachine. Ex Kaplan Turbine.Therefore, the radial component of the fluid velocity is negligible. Since there is no change in the direction of the fluid, several axial stages can be used to increase power output.

In the figure:

- U = Blade velocity,
- V_f = Flow velocity,
- V = Absolute velocity,
- V_r = Relative velocity,
- V_w = Tangential or Whirl component of velocity.

- Radial Turbomachine's Velocity Diagram

  Radial flow turbomachines - When the path of the through-flow is wholly or mainly in a plane perpendicular to the rotation axis, the device is termed a radial flow turbomachine. Ex Centrifugal pump. Therefore, the change of radius between the entry and the exit is finite. A Radial turbomachine can be inward or outward flow type depending on the purpose that needs to be served. Outward flow type increases the energy level of the fluid and vice-versa. Due to continuous change in direction, several radial stages can't be used (mostly around 3 stages)

In the figure:

- U = Blade velocity,
- V_f = Flow velocity,
- V = Absolute velocity,
- V_r = Relative velocity,
- V_w = Tangential or Whirl component of velocity.

- **Mixed flow turbomachines** – When the flow is partly radial and partly axial, the device is termed a mixed flow turbomachine. It combines the advantages of both radial and axial type. Ex Francis Turbine.

Turbomachines can finally be classified on the Basis of whether pressure changes are absent or present respectively in the flow through the rotor:

- An Impulse Turbomachine Stage

  Impulse Turbomachines - There is no pressure change of the fluid or gas in the turbine blades (the moving blades) e.g. Pelton turbine. Do not require a pressure casement around the rotor since the fluid jet is created by the nozzle prior to reaching the blading on the rotor. All the pressure drop takes place in the stationary blades (the nozzles). Before reaching the turbine, the fluid's pressure head is changed to velocity head by accelerating the fluid with a nozzle. Newton's second law describes the transfer of energy.

- A Reaction Turbomachine Stage

  Reaction Turbomachines - Reaction turbines develop torque by reacting to the gas or fluid's pressure or mass. The pressure of the gas or fluid changes as it passes through the turbine rotor blades. A pressure casement is needed to contain the working fluid e.g. Francis turbines and most steam turbines. For compressible working fluids, multiple turbine stages are usually used to harness the expanding gas efficiently. Newton's third law describes the transfer of energy for reaction turbines.

http://en.wikipedia.org/wiki/Turbomachinery