TURBINES IN ACTION

Broadly speaking, we divide turbines into four kinds according to the type of fluid that drives them: water, wind, steam, and gas. Although all four types work in essentially the same way—spinning around as the fluid moves against them—they are subtly different and have to be engineered in very different ways. Steam turbines, for example, turn incredibly quickly because steam is produced under high-pressure. Wind turbines that make electricity turn relatively slowly (mainly for safety reasons), so they need to be huge to capture decent amounts of energy. Gas turbines need to be made from specially resilient alloys because they work at such high temperatures. Water turbines are often very big because they have to extract energy from an entire river, dammed and diverted to flow past them.

Water turbines

Water wheels, which date back over 2000 years to the time of the ancient Greeks, were the original water turbines. Today, the same principle is used to make electricity in hydroelectric power plants. The basic idea of hydroelectric power is that you dam a river to harness its energy. Instead of the river flowing freely downhill from its hill or mountain source toward the sea, you make it fall through a height (called a head) so it picks up speed (in other words, so its potential energy is converted to kinetic energy), then channel it through a pipe called a penstock past a turbine and generator. Hydroelectricity is effectively a three-step energy conversion:

- The river's original potential energy (which it has because it starts from high ground) is turned into kinetic energy when the water falls through a height.
- The kinetic energy in the moving water is converted into mechanical energy by a water turbine.
- The spinning water turbine drives a generator that turns the mechanical energy into electrical energy.

Different kinds of water turbine are used depending on the geography of the area, how much water is available (the flow), and the distance over which it can be made to fall (the head). Some hydroelectric plants use bucket-like impulse turbines (typically Pelton wheels); others use Francis, Kaplan, or Deriaz reaction turbines. The type of turbine is chosen carefully to extract the maximum amount of energy from the water.

Steam turbines

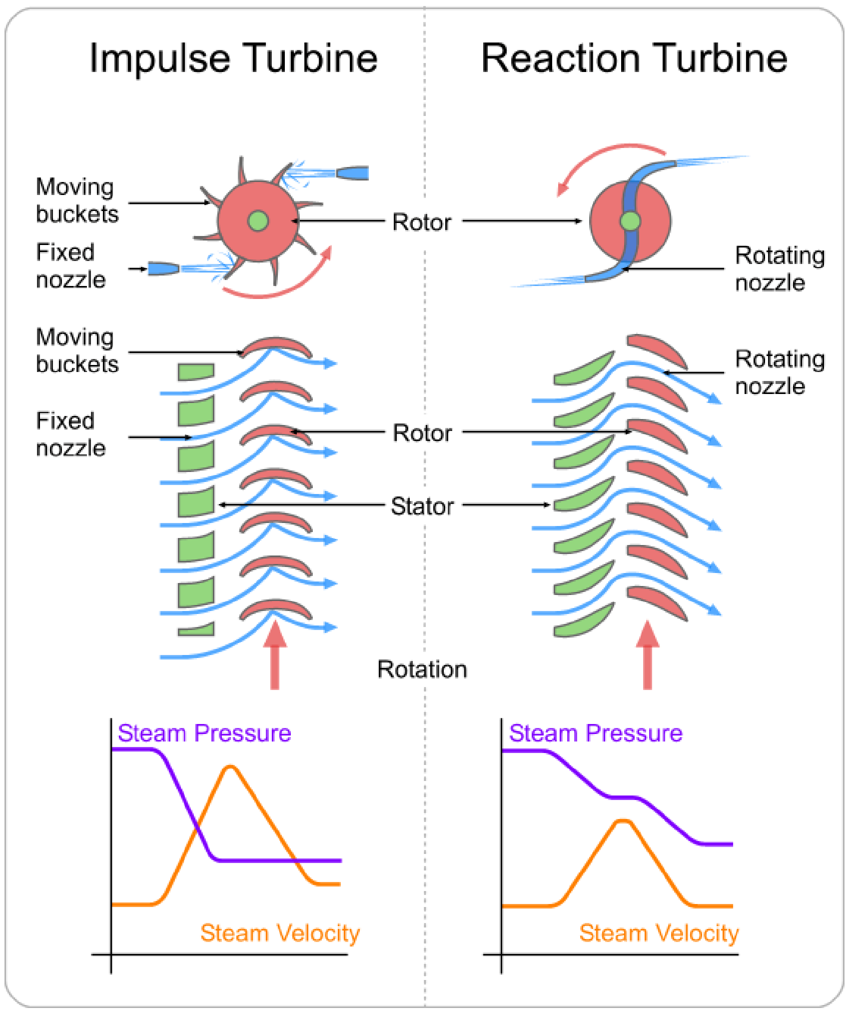
Steam turbines evolved from the steam engines that changed the world in the 18th and 19th centuries. A steam engine burns coal on an open fire to release the heat it contains. The heat is used to boil water and make steam, which pushes a piston in a cylinder to power a machine such as a railroad locomotive. This is quite inefficient (it wastes energy) for a whole variety of reasons. A much better design takes the steam and channels it past the blades of a turbine, which spins around like a propeller and drives the machine as it goes.

Steam turbines were pioneered by British engineer Charles Parsons (1854–1931), who used them to power a famously speedy motorboat called Turbinia in 1889. Since then, they've been used in many different ways. Virtually all power plants generate electricity using steam turbines. In a coal-fired plant, coal is burned in a furnace and used to heat water to make steam that spins high-speed turbines connected to electricity generators. In a nuclear power plant, the heat that makes the steam comes from atomic reactions.

Unlike water and wind turbines, which place a single rotating turbine in the flow of liquid or gas, steam turbines have a whole series of turbines (each of which is known as a stage) arranged in a sequence inside what is effectively a closed pipe. As the steam enters the pipe, it's channelled past each stage in turn so progressively more of its energy is extracted. If you've ever watched a kettle boiling, you'll know that steam expands and moves very quickly if it's directed through a nozzle. For that reason, steam turbines turn at very high speeds—many times faster than wind or water turbines.

Gas turbines

Airplane jet engines are a bit like steam turbines in that they have multiple stages. Instead of steam, they're driven by a mixture of the air sucked in at the front of the engine and the incredibly hot gases made by burning huge quantities of kerosene (petroleum-based fuel). Somewhat less powerful gas turbine engines are also used in modern railroad locomotives and industrial machines. See our article on jet engines for more details.



A device similar to a turbine but operating in reverse, i.e., driven, is a compressor or pump. The axial compressor in many gas turbine engines is a common example. Here again, both reaction and impulse are employed and again, in modern axial compressors, the degree of reaction and impulse will typically vary from the blade root to its periphery.

Claude Burdin coined the term from the Latin *turbo*, or vortex, during an 1828 engineering competition. Benoit Fourneyron, a student of Claude Burdin, built the first practical water turbine.

A working fluid contains potential energy (pressure head) and kinetic energy (velocity head). The fluid may be compressible or incompressible. Several physical principles are employed by turbines to collect this energy:

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