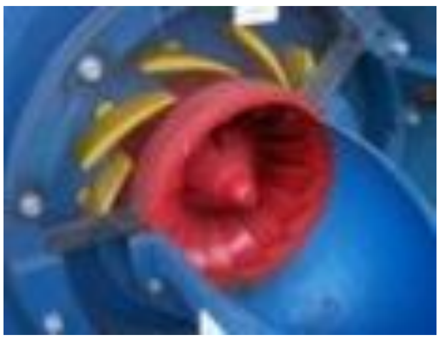
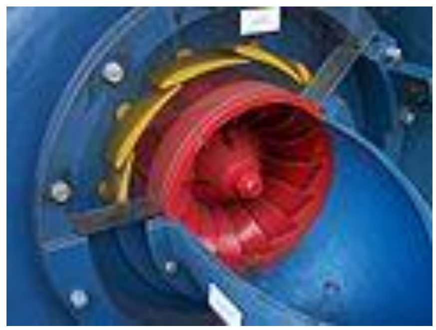
FRANCIS TURBINE

The **Francis turbine** is a type of water turbine that was developed by James B. Francis in Lowell, MA. It is an inward-flow reaction turbine that combines radial and axial flow concepts.

Francis turbines are the most common water turbine in use today. They operate in a head range of ten meters to several hundred meters and are primarily used for electrical power production.

The Francis turbine is a *reaction turbine*, which means that the working fluid changes pressure as it moves through the turbine, giving up its energy. A casement is needed to contain the water flow. The turbine is located between the high-pressure water source and the low-pressure water exit, usually at the base of a dam.





The inlet is spiral shaped. Guide vanes direct the water tangentially to the turbine wheel, known as a *runner*. This radial flow acts on the runner's vanes, causing the runner to spin. The guide vanes (or wicket gate) may be adjustable to allow efficient turbine operation for a range of water flow conditions.

As the water moves through the runner, its spinning radius decreases, further acting on the runner. For an analogy, imagine swinging a ball on a string around in a circle; if the string is pulled short, the ball spins faster due to the conservation of angular momentum. This property, in addition to the water's pressure, helps Francis and other inward-flow turbines harness water energy efficiently.

Water wheels have been used historically to power mills of all types, but they are inefficient. Nineteenth-century efficiency improvements of water turbines allowed them to compete with steam engines (wherever water was available).

In 1826 Benoit Fourneyron developed a high efficiency (80%) outward-flow water turbine. Water was directed tangentially through the turbine runner, causing it to spin. Jean-Victor Poncelet designed an inward-flow turbine in about 1820 that used the same principles. S. B. Howd obtained a U.S. patent in 1838 for a similar design.

In 1848 James B. Francis, while working as head engineer of the Locks and Canals company in the water-powered factory city of Lowell, Massachusetts, improved on these designs to create a turbine with 90% efficiency. He applied scientific principles and testing methods to produce a very efficient turbine design. More importantly, his mathematical and graphical calculation methods improved turbine design and engineering. His analytical methods allowed confident design of high efficiency turbines to exactly match a site's flow conditions.

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