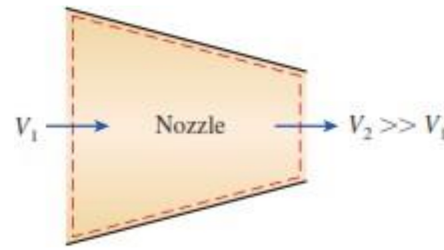
Steam Turbines

Nozzle:

A nozzle is a device that increases the velocity of a fluid at the expense of pressure. The cross-sectional area of a nozzle decreases in the flow direction. The rate of heat transfer between the fluid flowing through a nozzle and the surroundings is usually very small (Q ≈ 0) since the fluid has high velocities, and thus it does not spend enough time in the nozzle for any significant heat transfer to take place. Nozzles typically involve no work (W = 0) and any change in potential energy is negligible. But nozzles usually involve very high velocities, and as a fluid passes through a nozzle, it experiences large changes in its velocity. Therefore, the kinetic energy changes must be accounted for in analyzing the flow through nozzle.

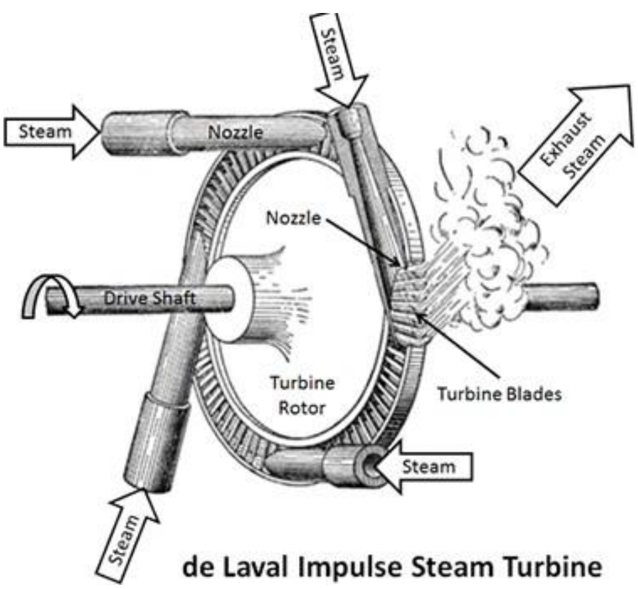


Turbine:

A turbine is a rotary mechanical device that extracts energy from the fast moving flow of water, gas, air or any other fluid and converts it into useful work. Turbine can be multistage. Each turbine stage consists of stationary stator row (guide vanes or nozzle ring) and rotating rotor row. In the guide vanes, high pressure and high temperature steam is expanded and results in high velocity. The guide vanes direct the flow to the rotor blades at an appropriate angle. In the rotor, the flow direction is changed and kinetic energy of the working fluid is absorbed by the rotor shaft which in turn rotates.

Types of steam turbines

Impulse Turbines: There is no change in the pressure of the steam as it passes through the moving blades. There is change only in the velocity of the steam flow. The steam jets in an impulse turbine are directed by the fixed nozzles at the turbine's bucket shaped rotor blades where the force exerted by the jets causes the rotor to turn while at the same time the velocity of the steam is reduced as it imparts its kinetic energy to the blades. The blades in turn change the direction of flow of the steam and this change of momentum corresponds to the increased momentum of the rotor. The entire pressure drop in the turbine stage occurs in the fixed nozzles in the stator and there is no pressure drop as the steam passes through the rotor blades since the cross section of the chamber between the blades is constant. Impulse turbines are therefore also known as constant pressure turbines. Steam impulse turbines usually operate at extremely high speeds of 30,000 r.p.m. or more and are thus subject to enormous centrifugal forces. For most practical applications the speed must be geared down. Other than that, the design is relatively simple and the turbine casing does not necessarily need to be pressure proof.



de Laval Impulse Steam Turbine

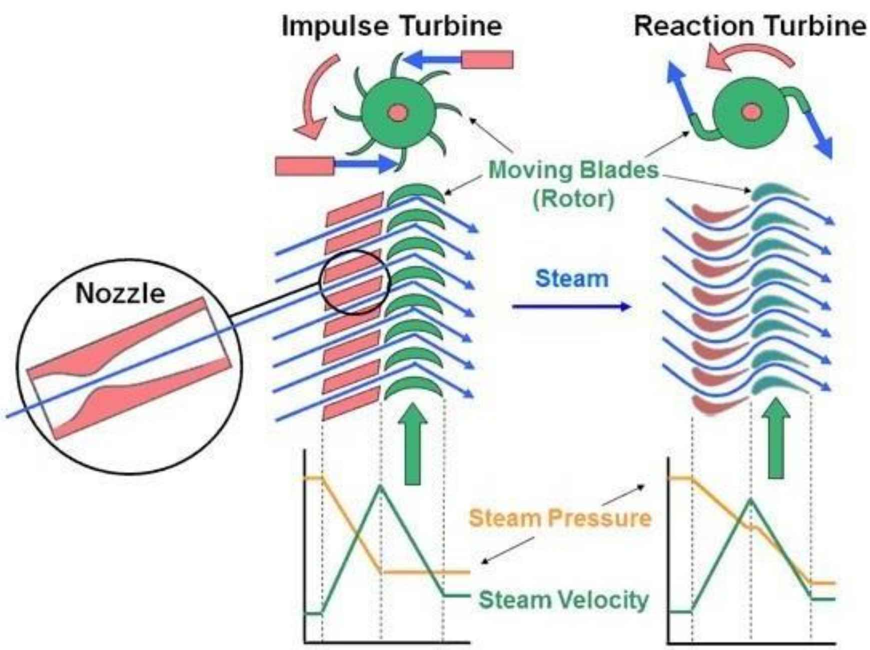
Reaction Turbines: There is change in both pressure and velocity as the steam flows through the moving blades. Both the fixed and the rotor blades of the reaction turbine are shaped more like aerofoils, arranged such that the cross section of the blades diminishes from the inlet side towards the exhaust side of the blades. This means that the cross section of the steam passages between both sets of fixed and rotor blades increases across the turbine stage. In this way both sets of blades essentially form nozzles so that as the steam progresses through both the stator and the rotor its pressure decreases causing its velocity to increase. The rotor becomes basically a set of rotating nozzles. As the steam emerges in a jet from between each set of rotor blades, it creates a reactive force on the blades which in turn creates the turning moment on the turbine rotor, just as in Hero's steam engine. (Newton's Third Law - For every action there is an equal and opposite reaction). Reaction turbines are generally much more efficient than impulse turbines and run at lower speeds which mean they don't necessarily need reduction gearing.

Moving blades

Stator, nozzle ring, fixed blades

Stator, nozzle ring, fixed blades

Impulse and Reaction Turbines velocity pressure graph



In case of impulse turbine, there is decrease in pressure and increase in velocity when fluid is passing through the nozzle. After that pressure remains constant and velocity decreases as it passing through the moving blades. For reaction turbine, there is decrease in pressure and increase in velocity when fluid is moving through the fixed blades and further there is decrease in pressure and velocity as fluid is moving through the moving blades.