Steam Turbines Using Thermal Engineering

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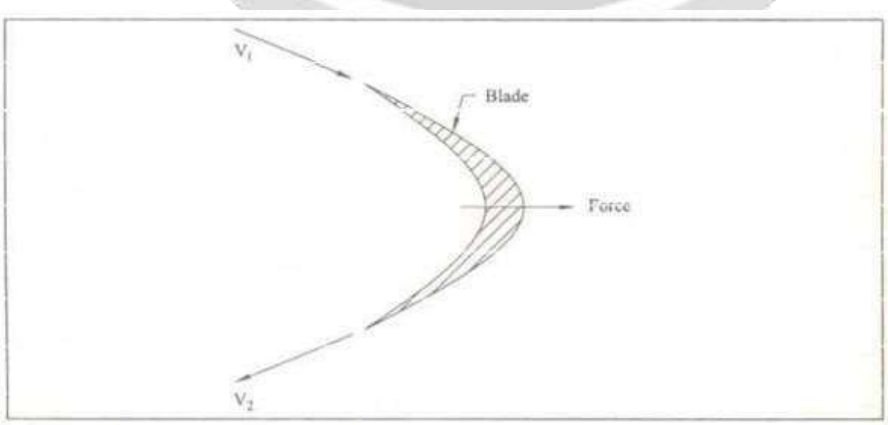
Abstract

A steam turbine is a machine that extracts thermal energy from pressurized steam and uses it to do mechanical work on a rotating output shaft. Its modern manifestation was invented by Charles Parsons in 1884. Fabrication of a modern steam turbine involves advanced metalwork to form high-grade steel alloys into precision parts using technologies that first became available in the 20th century; continued advances in durability and efficiency of steam turbines remains central to the energy economics of the 21st century.The steam turbine is a form of heat engine that derives much of its improvement in thermodynamic efficiency from the use of multiple stages in the expansion of the steam, which results in a closer approach to the ideal reversible expansion process.Steam turbine is an excellent prime mover to convert heat energy of steam to mechanical energy. Of all heat engines and prime movers the steam turbine is nearest to the ideal and it is widely used in power plants and in all industries where power is needed for process.

Keywords- Turbine, pressure, blades, rotor.

1.INTRODUCTION

A steam turbine is a key unit in a steam power plant from which we get power. A steam turbine is a turbo-machine and a prime mover in which potential energy of steam is transformed into kinetic energy and this kinetic energy is then transformed into mechanical energy of rotation of shaft of turbine. In reciprocating steam engines, the pressure energy of steam is utilised and dynamic action of Steam is negligible. In steam engines, steam acts on piston as a load or weight and so, the action of steam is - static. Steam engines may be operated without any expansion or drop of pressure in the cylinder. The expansive property of steam is not utilised to fullest extent even in the best types of multi expansion steam engines. The steam is caused to fall in pressure in a nozzle during admission to the turbine, due to this fall in pressure; certain amount of heat energy is converted into kinetic energy. A steam turbine consists of a number of curved blades fixed uniformly on the rim of a wheel which is fastened to a shaft and we obtain power from this shaft. The high velocity steam from nozzles impinges on the blades of turbine, suffers a change in the direction of motion and thus gives rise to change in momentum and so a force. This constitutes the driving force of the turbine. The blades obtain no motive force from the static pressure of steam or from any impact of steam jet because blades are designed and curved in such a ways that steam enters the blades without any shock and will glide ON and OFF the blades.



2.PRINCIPLE OF OPERATION

A nozzle in which heat energy of high pressure steam is converted into kinetic energyso that steam issues from the nozzle with very high velocity.
Blades which change the direction of steam issuing from the nozzle so that a forceacts on blades due to change of momentum and rotatesthem.So, the basic principle of operation a steam turbine is generation of high velocity steamjet by expansion of high pressure steam in a nozzle and motive power in the turbine is obtained by change in momentum of the high velocity steam jet by allowing it to impinge on curved blades. Steam turbines are steady flow machines, have large exhaust outlets (fordischarging used steam) and the speed of flow is very high. So, they can handle large volume of steam and produce higher power and the processes are assumed to be adiabatic. Steam turbines are capable of expanding steam to the lowest exhaust pressure obtainable in the condenser. The turbine is a constant high speed machine and really must be operated condensing in order to take full advantage of greater range of steam expansion.
Steam turbines are mainly used for electric power generation and for large marine propulsion. These are also used for direct drives of fans, compressors, pumps etc.

3.TYPES OF STEAM TURBINES

Steam turbines may be classified in many ways. Considering the action of steam which is most important factor, steam turbines are mainly classified as :

1.Impulse turbines.

Impulse reaction turbines (In practice known as - reactionturbines).If the flow of steam through the nozzles and moving blades of a turbine takes place in such a way that steam is expanded and entire pressure drop takes place in nozzles only and pressure at the outside of blades is equal to inside of blades, then such a turbine is known as - impulse turbine.

In these turbines, the pressure drop takes place in nozzles only and not in moving blades. This is obtained by making the blade passage of constant cross sectional area.

In impulse reaction turbines, the pressure drop takes place in nozzles as well as moving blades. The drop of pressure of steam while flowing through the moving blades results in the generation of kinetic energy within the moving blades giving rise to reaction and adds to the driving force which is then transmitted through the rotor to the turbine shaft. This turbine works on the principles of both impulse and reaction. This is achieved by making the blade passage of varying cross sectional area.

2.Impulse Turbine

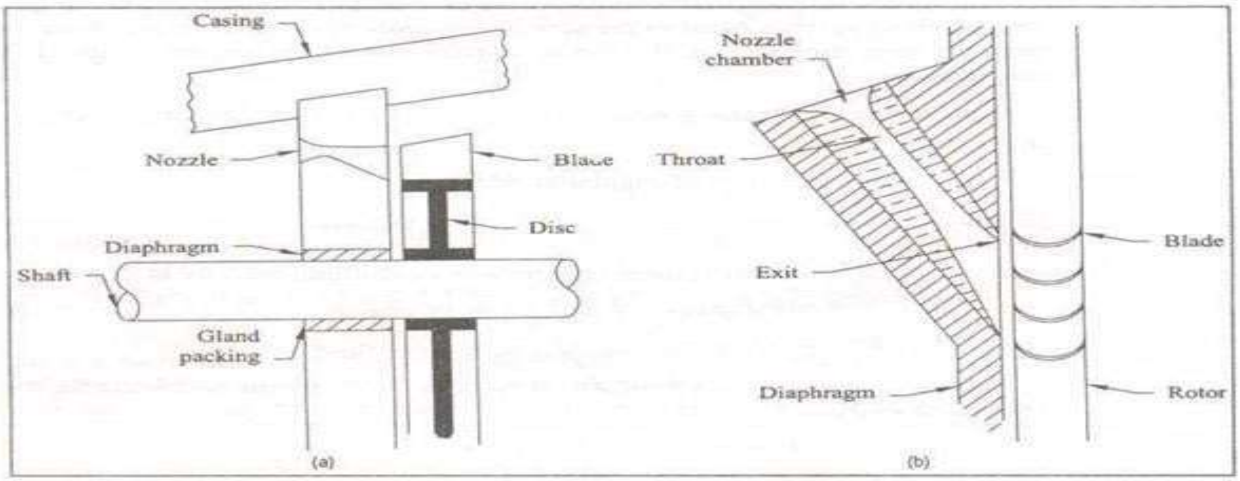
The turbines in which complete process of expansion of steam takes place in stationary nozzles and the kinetic energy is converted into mechanical work on the turbine blades are known as -Impulse turbines. In impulse turbines, the entire pressure drop takes place innozzles only. The pressure drops from steam chest pressure to condenser or exhaust pressure. The pressure in the blade passages remains approximately constant and is equal to condenser pressure.

An impulse turbine for its operation, depends wholly on the impulsive force of high velocity steam jets, which are obtained by expansion of steam in nozzles. The action of steam jet impinging on the blades is said to be impulse and the rotation of rotor is dueto impulsive forces of steam jets.

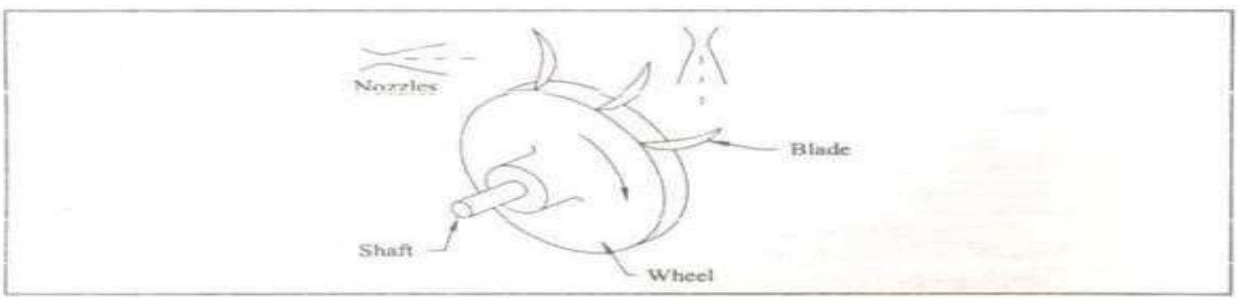
Generally, converging - diverging nozzles are used. Due to relatively large expansion ratio, steam leaves the nozzles at a very high velocity (Even supersonic). The steam at high velocity impinges over blades, both pressure and enthalpy remain constant, work transfer takes place, velocity reduces gradually and steam comes out with appreciable velocity . The nozzle angle is inclined at a fixed angle to tangent of rotor wheel.

Mostly, impulse turbines are axial flow turbines and they have zero degree of reaction (discussed later). The entire pressure drop takes place in nozzles resulting in enthalpy drop. The energy transfer is derived from a change of absolute velocity.

Impulse turbines are generally employed where relatively small amounts of power are required and where rotor diameter is fairly small.



ARRANGEMENT OF A SIMPLE IMPULSE TURBINE.



3.De-Lavel Turbine

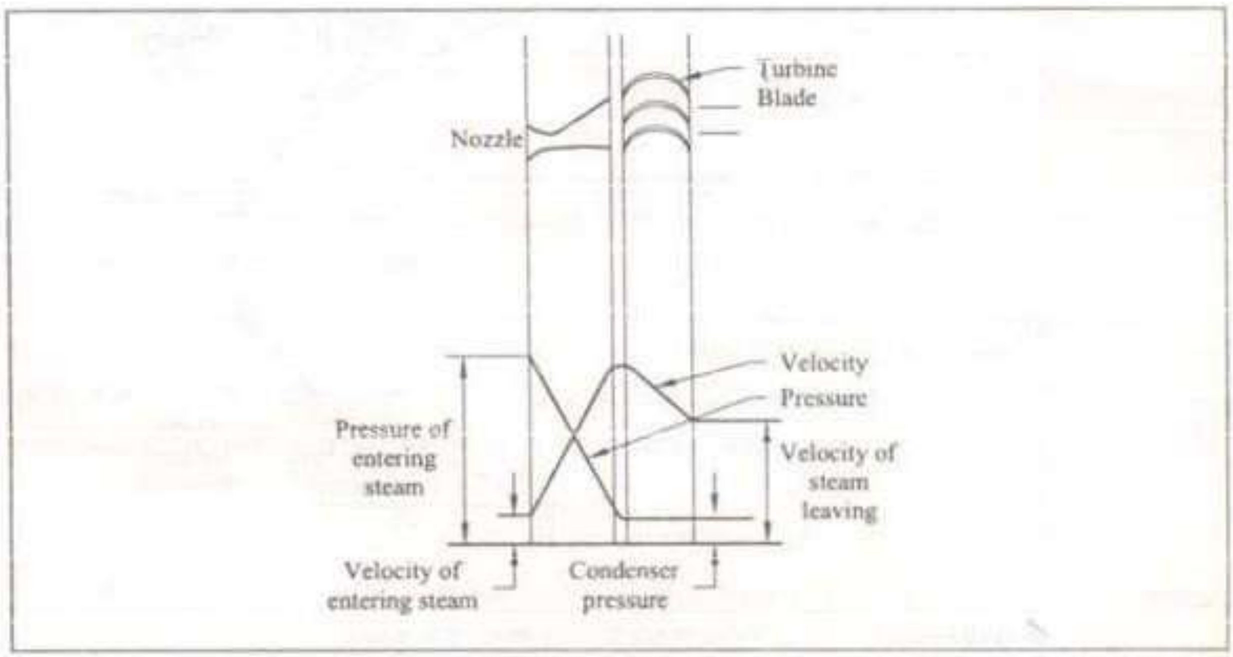
A De-lavel turbine named after Swedish Engineer De-lavel is the simplest impulse turbineand is commonly used.

4.Runner and Bucket of de-lavel turbine

The essential parts of an impulse turbine are - nozzles, blades and casing.In nozzles, the expansive property of steam is utilised to produce jets of steam with veryhigh velocity. The nozzle guides the steam to flow in the designed direction.

5.Pressure & Velocity Variation in Impulse Turbine

The fig. shows the variation of pressure and velocity of steam in a simple impulse turbine while it flows through nozzles and blades.



6.Parson's Reaction Turbine

A Parson's reaction turbine is the simplest type of reaction turbine and is commonly used. Themain components of it are:

-Casing.
-Guide mechanism.
-Runner.
-Draft tube.

The casing is an air tight metallic case in which steam from boiler under high pressure is distributed around the fixed blades which are positioned at the entrance. The casing is so designed that steam enters the fixed blades with uniform velocity.

The guide mechanism consists of fixed or guide blades. They allow the steam to enter the rotor without shock and they allow required quantity of steam to enter the turbine. The guide blades may be opened or closed by a regulating shaft which allows steam to flow according to the need.

7.CYCLES USED IN STEAM TURBINES

Steam turbine power plants are based on the Rankine cycle investigated by a Scotch Engineer and Scientist William Rankine (1820 -1872). Rankine cycle for Steam turbine power plant with ideal turbines and pumps and superheated and saturated steam as a working fluid respectively as shown below. A conventional power plant steam for such a consideration .

The steam turbine is fed with steam under temperature t1, pressure p1, and enthalpy h1. Expanding within the turbine, steam produces work Wt and goes into the condenser under conditions p2 and h2. Hence its rejects heat Qr to cooling water and the resulted condensate with enthalpy h3

8.SPEED REGULATION

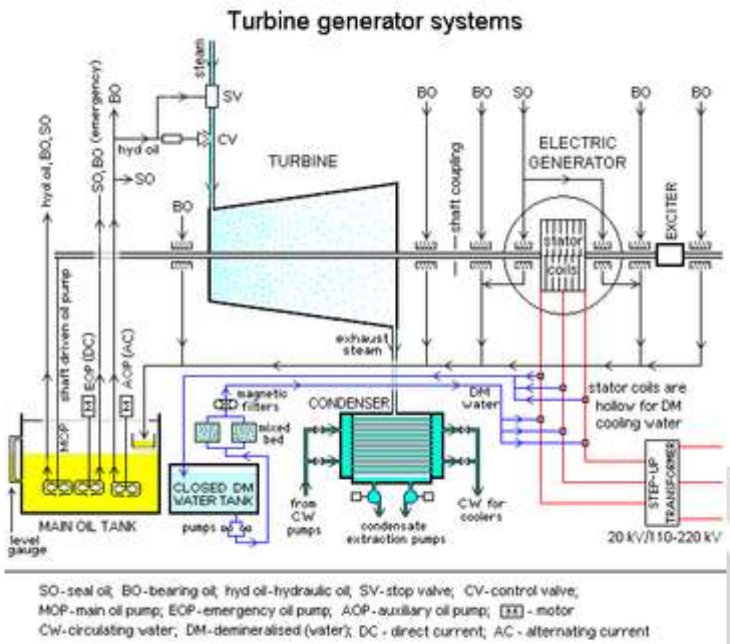


Diagram of a steam turbine generator system

The control of a turbine with a governor is essential, as turbines need to be run up slowly to prevent damage and some applications (such as the generation of alternating current electricity) require precise speed control.Uncontrolled acceleration of the turbine rotor can lead to an overspeed trip, which causes the governor and throttle valves that control the flow of steam to the turbine to close. If these valves fail then the turbine may continue accelerating until it breaks apart, often catastrophically. Turbines are expensive to make, requiring precision manufacture and special quality materials.

During normal operation in synchronization with the electricity network, power plants are governed with a five percent droop speed control. This means the full load speed is 100% and the no-load speed is 105%. This is required for the stable operation of the network without hunting and drop-outs of power plants. Normally the changes in speed are minor. Adjustments in power output are made by slowly raising the droop curve by increasing the spring pressure on a centrifugal governor. Generally this is a basic system requirement for all power plants because the older and newer plants have to be compatible in response to the instantaneous changes in frequency without depending on outside communication.

9.CONCLUSION

Steam turbines act as steam engines that convert heat energy into mechanical energy.Steam turbines extract thermal energy from steam that is exposed to extremely high pressures.Due to its rotary motion, the steam turbines are used to drive motors for the electricity generation.Steam turbines are the most important machines in the energy conversion field. Their cumulative mechanical and electrical installed power exceeds that of any other type of unit by far. Their design and operational procedures are very advanced, and they can be regarded as mature technological components. They are characterized by the highest stage efficiency among all “prime movers”

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