Francis turbine simple diagram

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The Francis turbine is a reaction turbine that operates on the principle of converting water"s kinetic energy into mechanical power through a combination of radial and axial flow. American engineer James B. Francis invented it in the mid-19th century. The Francis turbine is specifically designed to perform efficiently in a diverse range of water head and flow conditions, making it suitable for medium-head applications. Its distinguishing feature lies in the use of both fixed and moving guide vanes that direct the water flow toward the runner blades, facilitating optimal energy conversion.

This blog shall lay focus on Francis Turbine, its Working, Applications, Advantages and Disadvantages. This topic is important for your upcoming examinations like SSC JE ME and RRB JE Mechanical Engineering.

The major components of the Francis turbine include:

The spiral casing serves as the inlet for water into the turbine, allowing high-pressure water from the reservoir or dam to pass through. To ensure efficient striking of the turbine blades, the water"s circular movement is controlled by gradually reducing the casing"s diameter, maintaining uniform pressure and momentum for striking the runner blades effectively.

Stationary stay vanes and guide vanes work in tandem to guide the water flow toward the runner blades. Stay vanes prevent radial flow-induced swirling, improving the turbine"s efficiency.

The adjustable guide vanes play a vital role in controlling the angle of water striking the turbine blades, optimizing efficiency. They also regulate the flow rate of water into the runner blades, allowing the turbine"s power output to be adjusted based on the load.

The design of the runner blades directly impacts the turbine"s performance and efficiency. In a Francis turbine, the runner blades are divided into two parts: the lower half is shaped like small buckets, utilising impulse action for rotation, and the upper part utilising the reaction force of water flow. The combination of these forces facilitates the rotation of the runner.

The draft tube is employed to address the pressure difference at the exit of the runner. As the pressure is generally lower than atmospheric pressure, the tube gradually increases in the area to discharge water from the turbine"s exit to the tail race. This ensures smooth water flow and prevents direct discharge into the tail race.

In the above Velocity Triangle diagram,

With an absolute outlet velocity at 90? (v=90?), the velocity triangle diagram is as follows:

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The specific speed (Ns) of a turbine, which represents the speed of a geometrically similar turbine producing unit power under unit head, is given by the equation:

Where P represents shaft power and H indicates net head on the turbine.

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