



## SNS COLLEGE OF TECHNOLOGY



### Boiler Accessories- Impulse and Reaction turbine

#### 1. Introduction

Turbines are essential machines in thermodynamics that convert fluid energy into mechanical energy, typically used to generate electricity or power mechanical systems. The two major types of turbines, impulse and reaction turbines, operate on different principles of fluid dynamics but share a common goal of energy extraction from fluids like steam or water. Understanding their mechanisms is vital for applications in power generation and propulsion systems.

#### 2. Impulse Turbine

##### Working Principle:

An impulse turbine works on the principle of converting the kinetic energy of high-velocity jets of steam into mechanical work. In this type of turbine, the steam is expanded entirely in the nozzle, producing high-speed jets that strike the turbine blades, causing them to rotate.

##### Design and Components:

- **Nozzles:** Used to accelerate the steam to a high velocity.
- **Blades:** Fixed on the rotor, they deflect the steam jets and rotate the shaft.
- **Rotor:** The rotating component that converts steam's kinetic energy into mechanical energy.

##### Stages of Operation:

1. **Steam Expansion:** Steam expands through the nozzle, converting potential energy into kinetic energy.
2. **Steam Strikes Blades:** The high-velocity steam impacts the turbine blades.
3. **Rotor Movement:** The impact forces the rotor to rotate, generating mechanical power.

### **Thermodynamic Analysis:**

The pressure drop in an impulse turbine occurs only in the nozzles, not in the rotor. The blades operate under high velocity but remain unaffected by pressure changes.

### **Applications:**

Impulse turbines are typically used in power plants, where high-pressure steam is available and rapid energy extraction is required.

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## **3. Reaction Turbine**

### **Working Principle:**

Reaction turbines, in contrast, use the reactive force produced when steam or fluid expands both in the fixed and moving blades. In these turbines, the pressure drops occur across both the stationary and moving components, creating a continuous flow of energy.

### **Design and Components:**

- **Fixed Blades (Nozzles):** Where partial expansion of steam occurs.
- **Moving Blades:** These further expand the steam, utilizing both velocity and pressure for rotation.
- **Rotor and Casing:** Both experience pressure drops, with steam imparting force on both fixed and moving blades.

### **Stages of Operation:**

1. **Pressure Drop in Nozzles:** Initial steam expansion occurs in the nozzles.
2. **Further Expansion in Moving Blades:** Steam undergoes additional pressure drop, continuing to exert force on the rotor.
3. **Energy Transfer:** The rotor's rotation generates mechanical work.

### **Thermodynamic Analysis:**

Reaction turbines have pressure drops across both the stationary and rotating blades, leading to a more gradual but continuous energy transfer process.

### **Applications:**

Reaction turbines are often used in hydropower plants and large steam turbines where continuous, steady energy extraction is needed.

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## **4. Impulse vs. Reaction Turbine**

### **Key Differences:**

- **Design:** In impulse turbines, expansion occurs solely in the nozzles, whereas in reaction turbines, it occurs in both nozzles and moving blades.
- **Pressure Changes:** Impulse turbines experience no pressure drop across the rotor, whereas reaction turbines see pressure changes across both stationary and moving blades.
- **Energy Transfer:** Impulse turbines rely on kinetic energy, while reaction turbines utilize both pressure and kinetic energy for rotation.

### **Efficiency Comparison:**

Impulse turbines tend to be more efficient at handling high-pressure, high-velocity steam flows. Reaction turbines, though less efficient at high velocities, excel in applications with continuous energy needs, like hydropower systems.

### **Performance in Various Conditions:**

Impulse turbines perform better with high-speed steam or gas, making them ideal for applications like gas turbines and jet engines. Reaction turbines are more suited for low-speed, high-flow conditions like hydropower.

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## 5. Thermodynamic Cycle Analysis

### Rankine Cycle:

Both impulse and reaction turbines are typically part of a larger Rankine cycle, commonly used in thermal power plants. Steam undergoes phase changes, expansion, and compression during the cycle, with turbines responsible for the energy extraction during expansion.

### Isentropic Efficiency:

The efficiency of a turbine is measured by comparing the actual work output to the work output in an ideal, isentropic process. Isentropic efficiency indicates how closely a turbine approaches the ideal thermodynamic process.

### Entropy and Enthalpy Changes:

In turbines, entropy increases due to irreversibilities, such as friction and heat loss, while enthalpy decreases as the turbine extracts work from the fluid.

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## 6. Applications and Case Studies

### Real-World Applications:

- **Steam Power Plants:** Impulse turbines are common due to their ability to handle high-pressure steam.
- **Hydropower Plants:** Reaction turbines are the preferred choice in hydropower due to their suitability for low-velocity, high-flow fluids.
- **Aircraft Engines:** Gas turbines using the impulse principle are critical in aircraft jet engines.

### Case Study: Steam Power Plants

In modern steam power plants, impulse turbines are used to extract energy from high-pressure steam, followed by reaction turbines in the lower-pressure stages to maximize energy recovery.

### **Future Trends in Turbine Technology:**

Advances in materials and manufacturing techniques, such as 3D printing and nanotechnology, promise to increase turbine efficiency and lifespan. Efforts are also focused on reducing friction and improving blade aerodynamics to boost performance.

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## **7. Conclusion**

In summary, impulse and reaction turbines represent two different approaches to energy extraction from fluids, each with unique advantages and disadvantages depending on the application. While impulse turbines excel in high-pressure environments, reaction turbines are more suited for continuous, steady energy flow. Both play critical roles in energy generation and propulsion, with future advancements likely to improve their efficiency and sustainability in the face of rising energy demands.