

Module -4

1. Design and performance analysis of axial flow turbines:

- Turbine stage, work done, degree of reaction,
- losses and efficiency, flow passage;
- subsonic, transonic and supersonic turbines,
- multi-staging of turbine; exit flow conditions;
- turbine cooling.

2. Design and performance analysis of radial turbines:

- Thermodynamics and aerodynamics of radial turbines;
- radial turbine characteristics;
- losses and efficiency;
- design of radial turbine

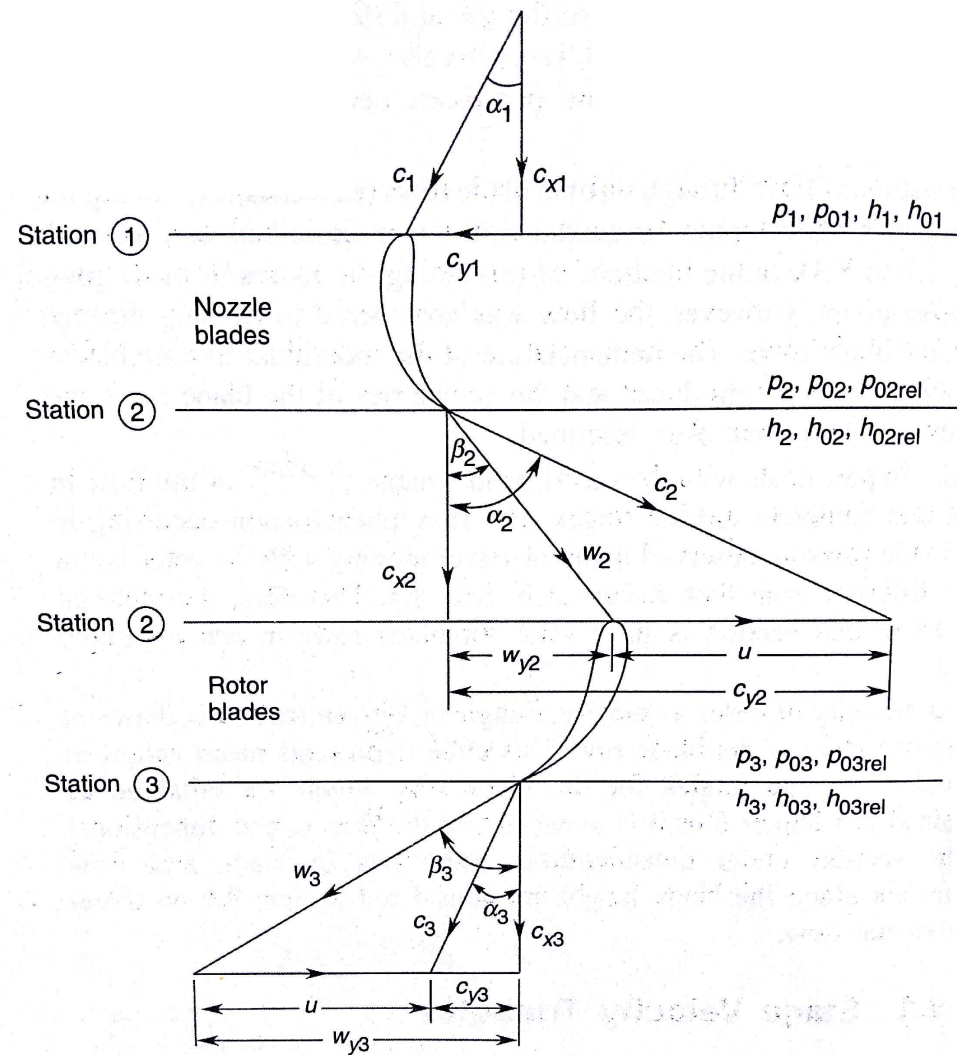
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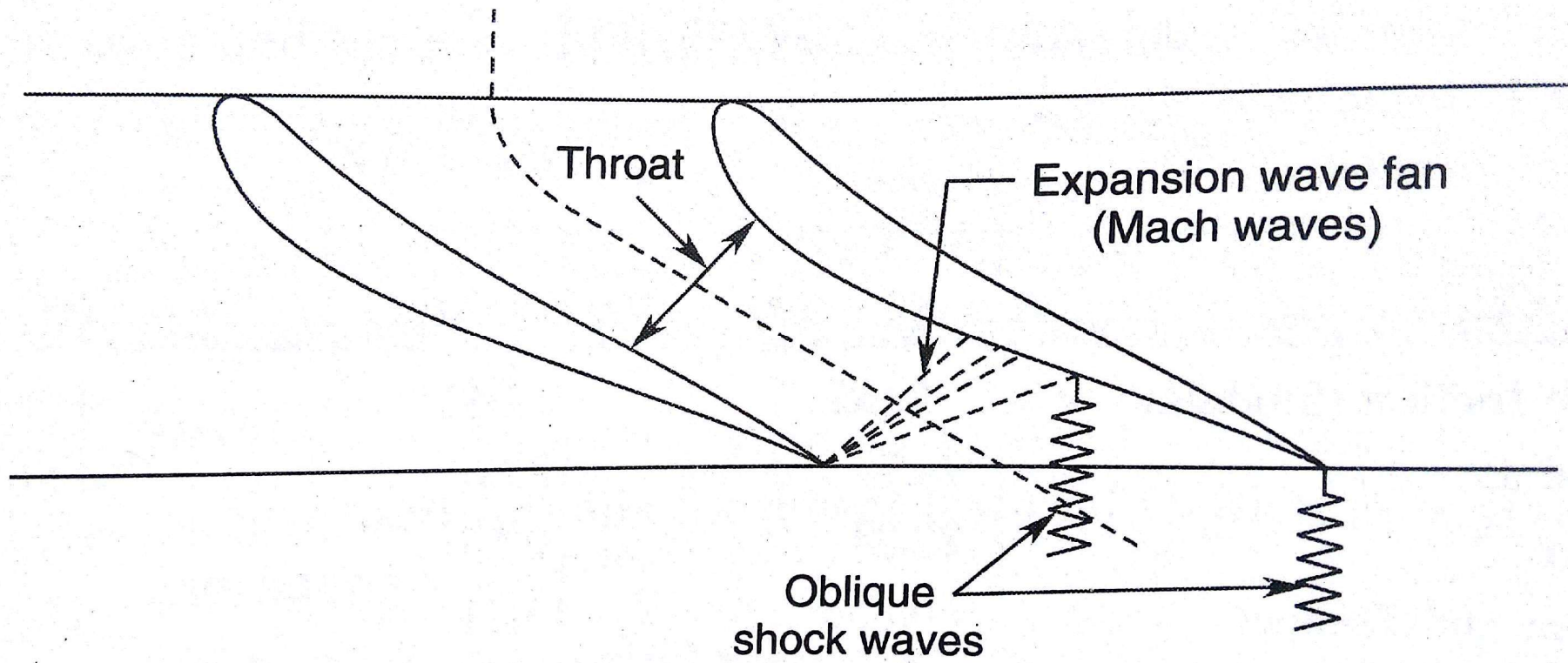
Turbine Stage



Velocity triangles for a turbine stage

Supersonic Turbine

Supersonic Turbine



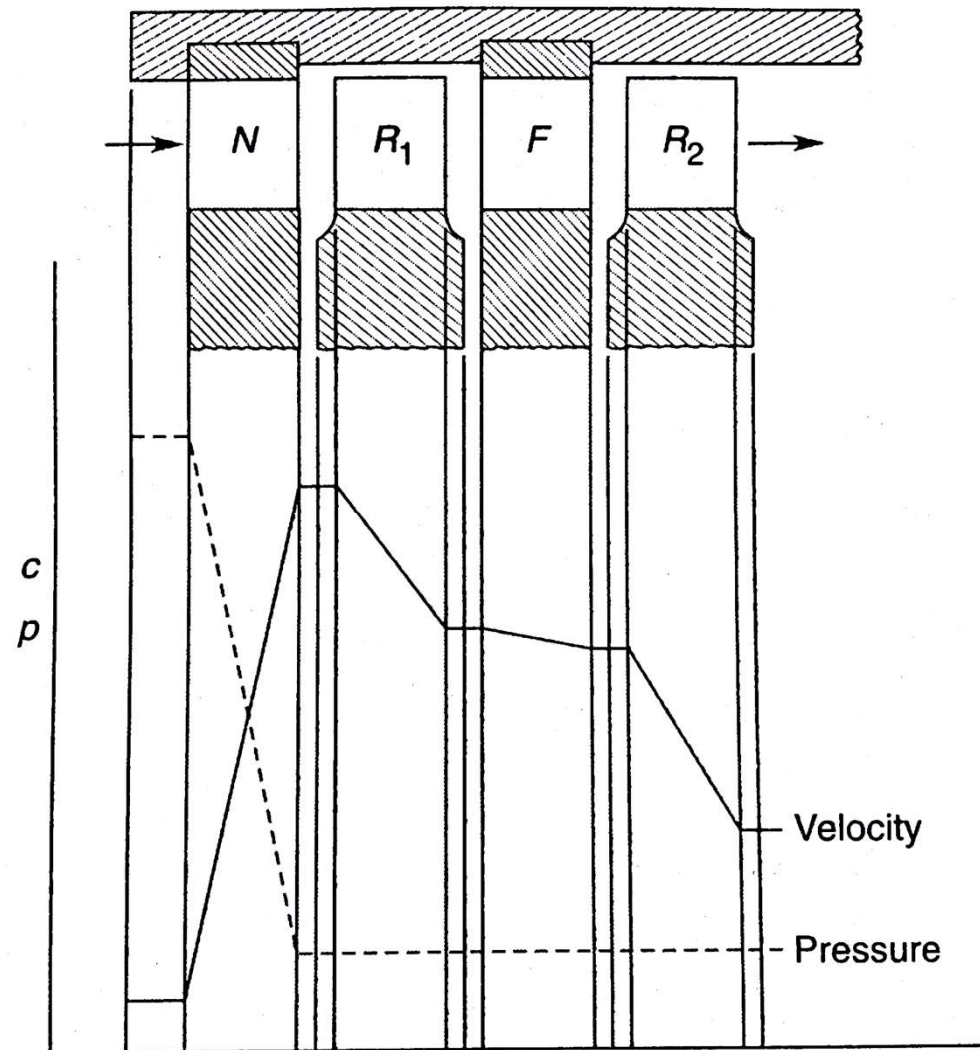
Multi-staging of turbines

1. Impulse Turbine

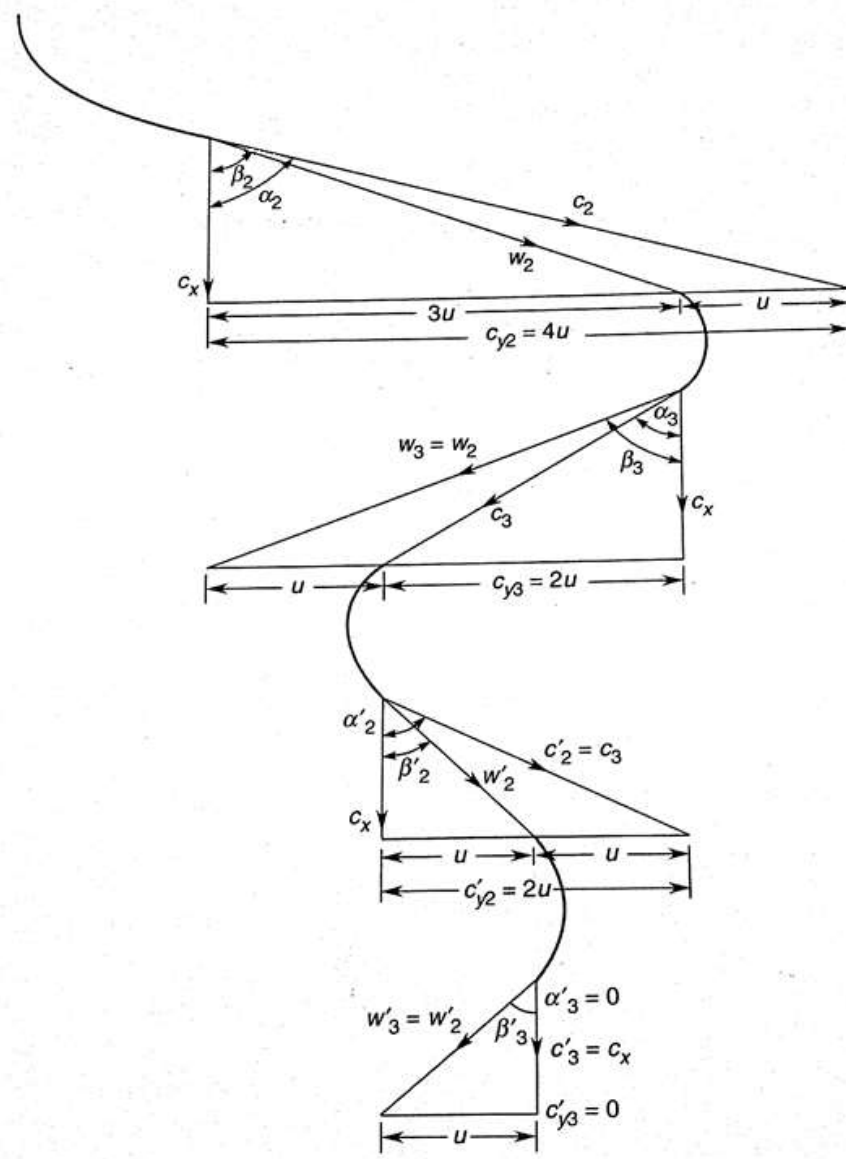
1. Velocity compounded impulse turbine
2. Pressure compounded impulse turbine

2. Reaction Turbine

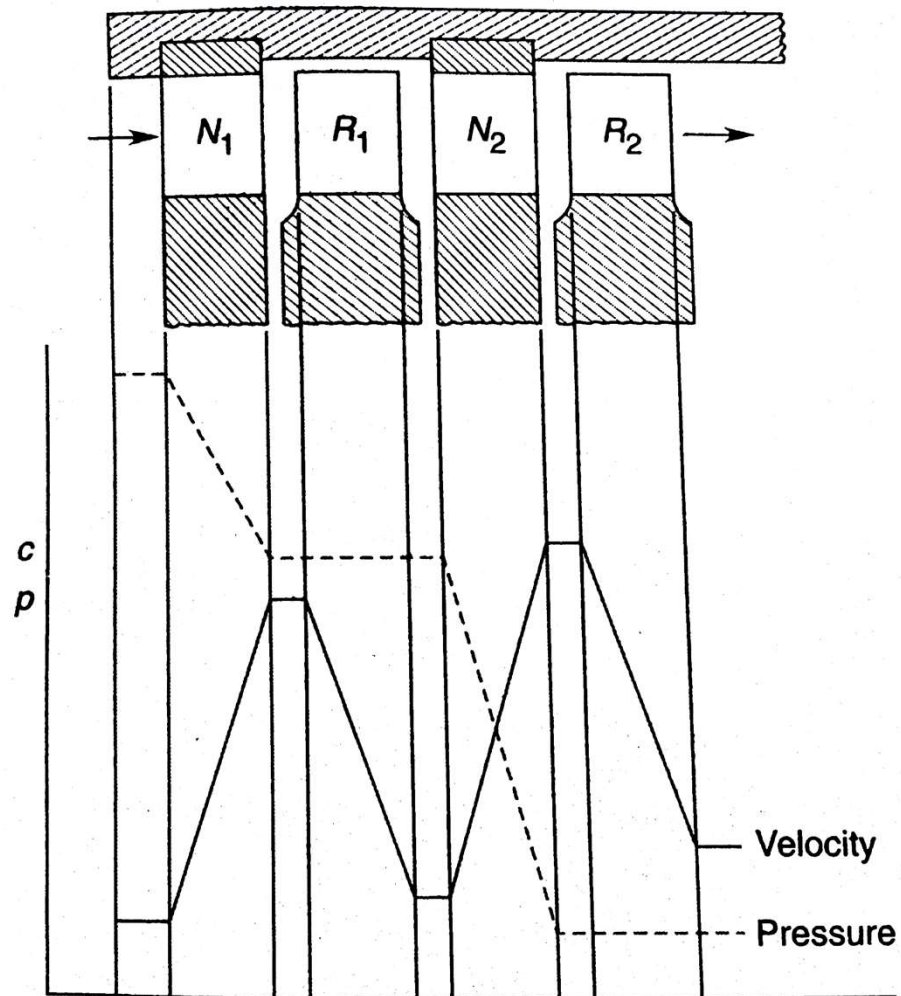
Velocity compounded impulse turbine



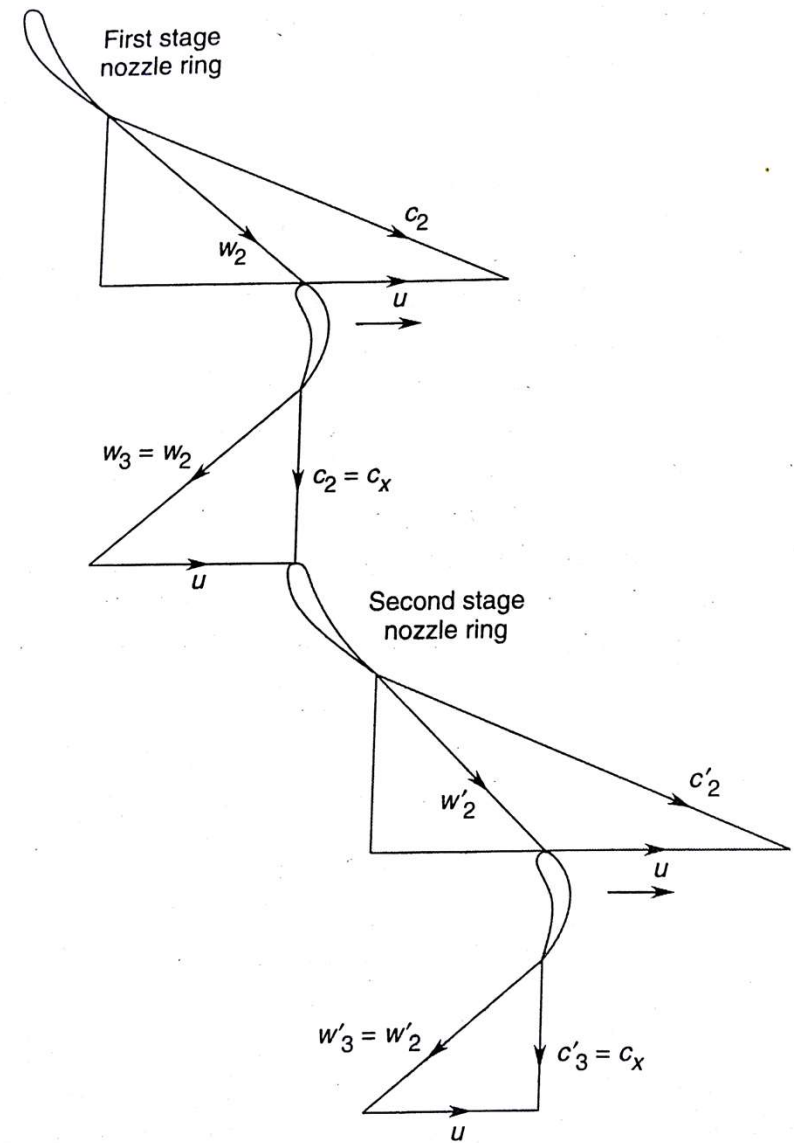
Velocity compounded impulse turbine



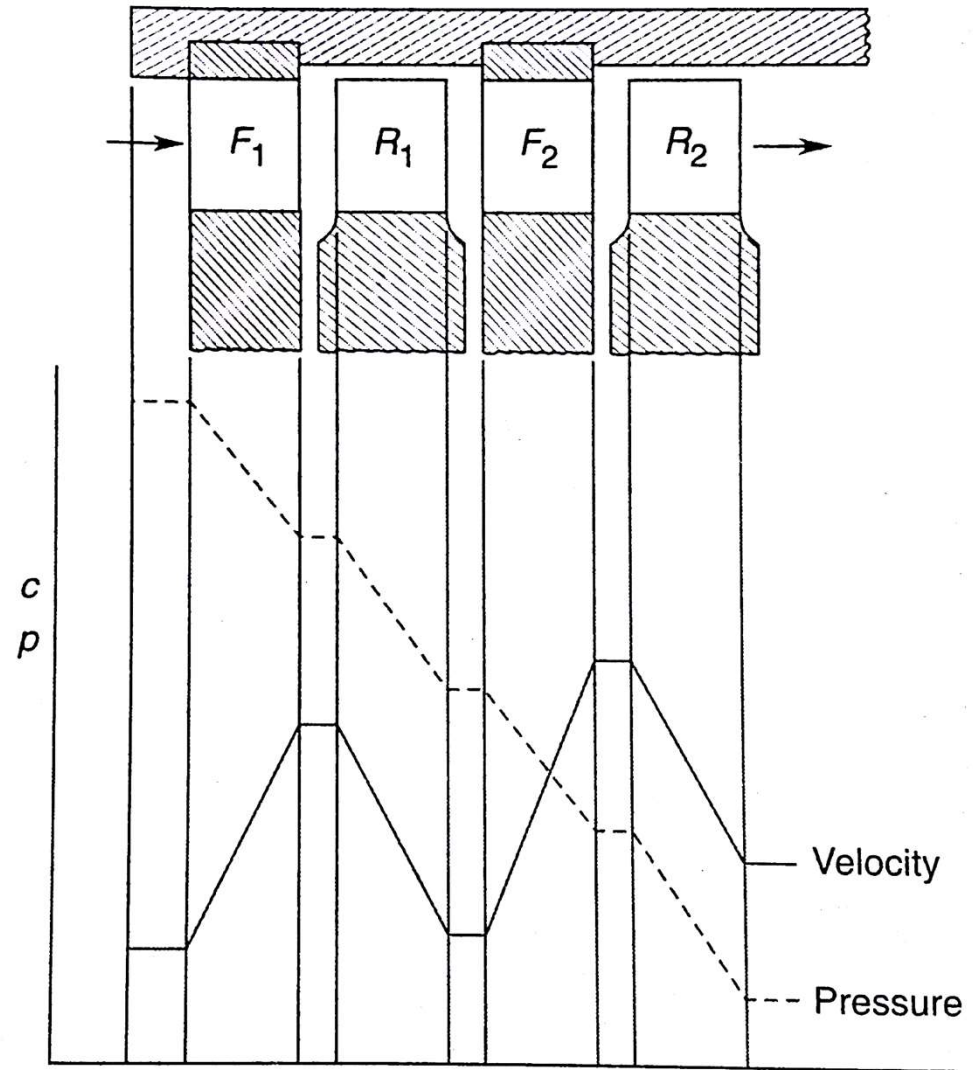
Pressure compounded impulse turbine



Pressure compounded impulse turbine



Reaction Turbine



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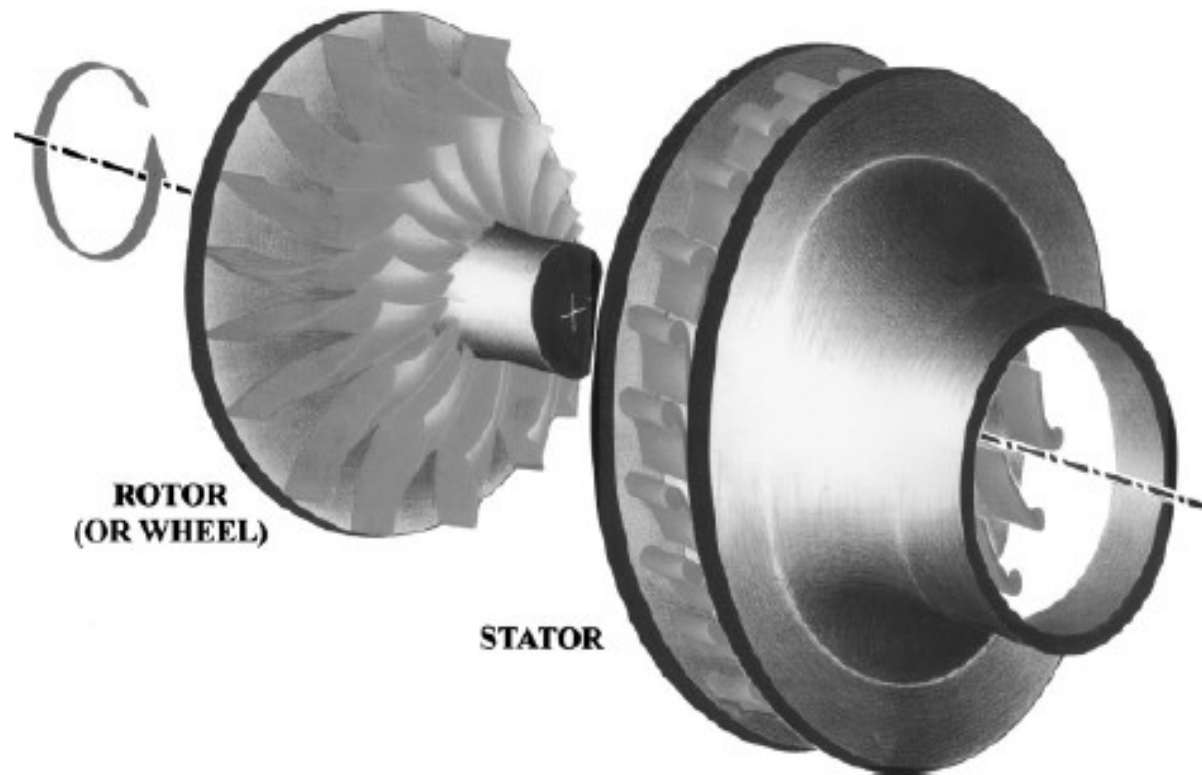
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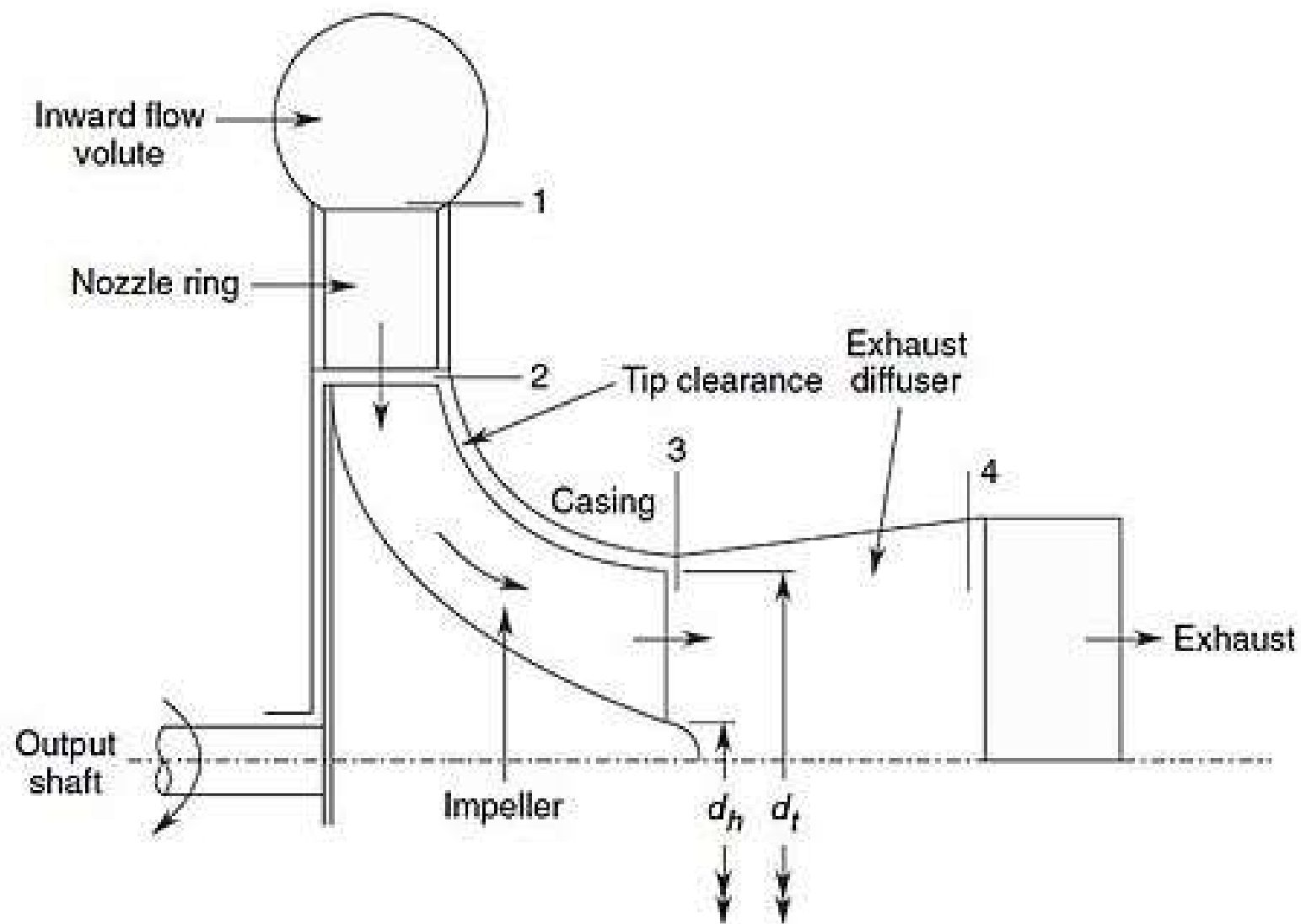
2. Design and performance analysis of radial turbines:

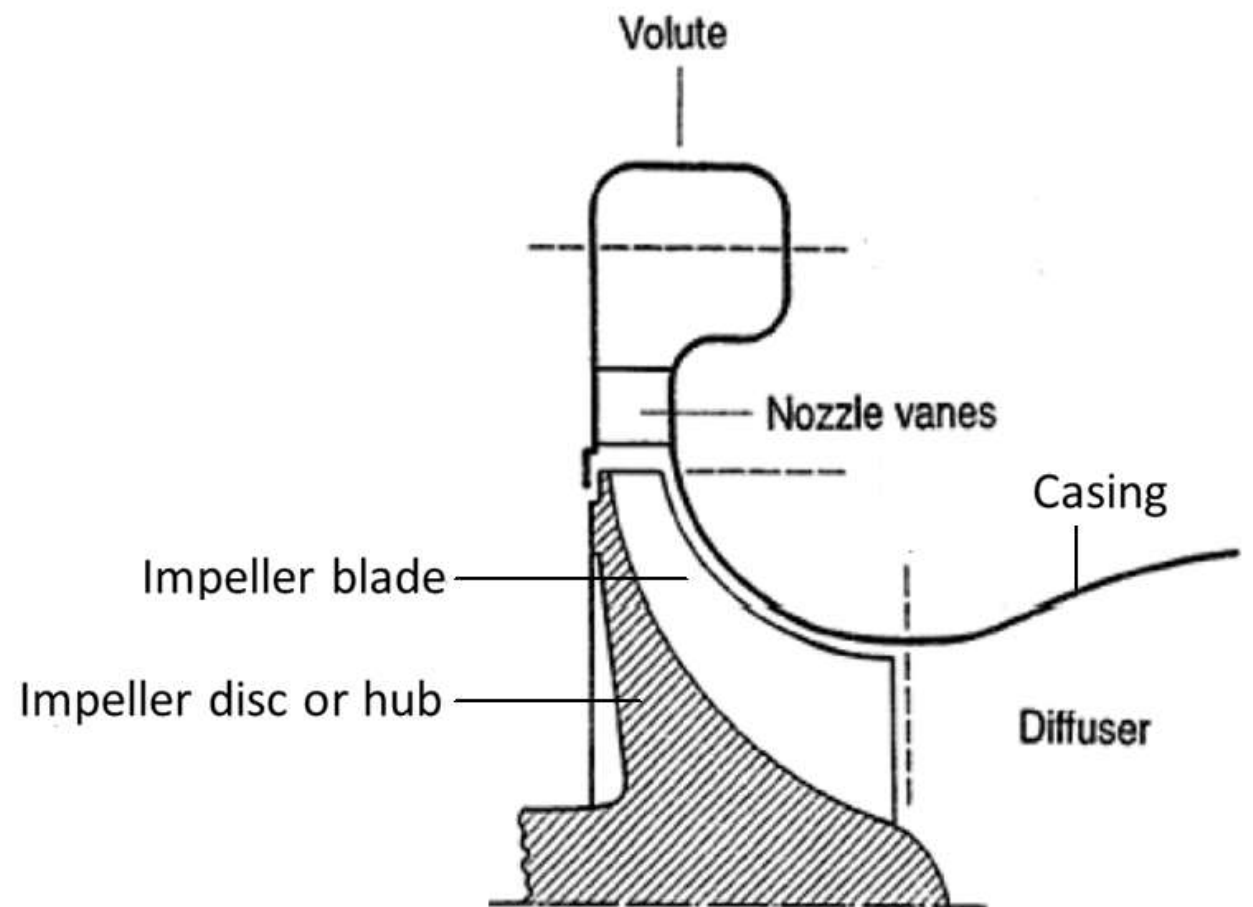
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Radial Turbines



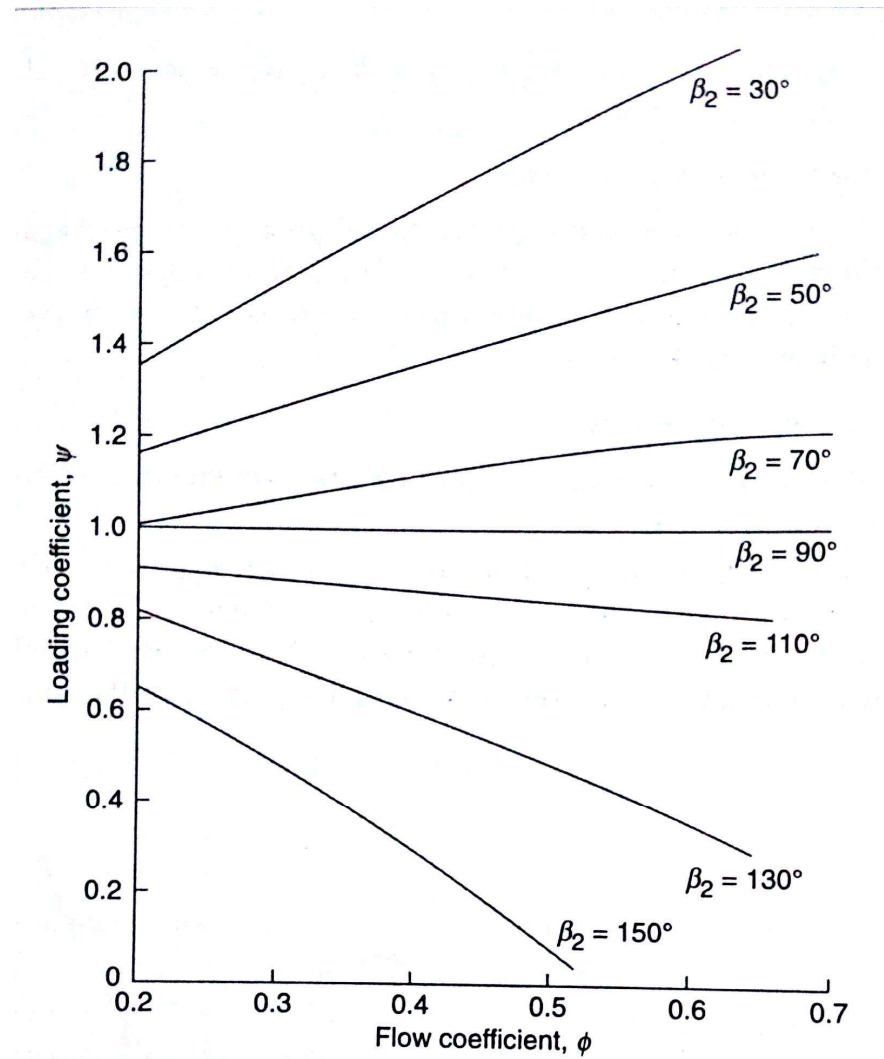
1. A radial turbine looks similar to a centrifugal compressor.
2. The diffuser vanes are replaced by a ring of nozzle guide vanes.
3. Gas flow with a high tangential velocity is directed inwards and leaves the rotor with a small whirl velocity as practicable near the axis of rotation.
4. The rotor is normally followed by a diffuser at the outlet to reduce the exhaust velocity to a negligible value.
5. Under normal design conditions, the relative velocity at the rotor tip is radial (zero incidence) and the absolute velocity at the exit is axial ($\alpha_3=0$).

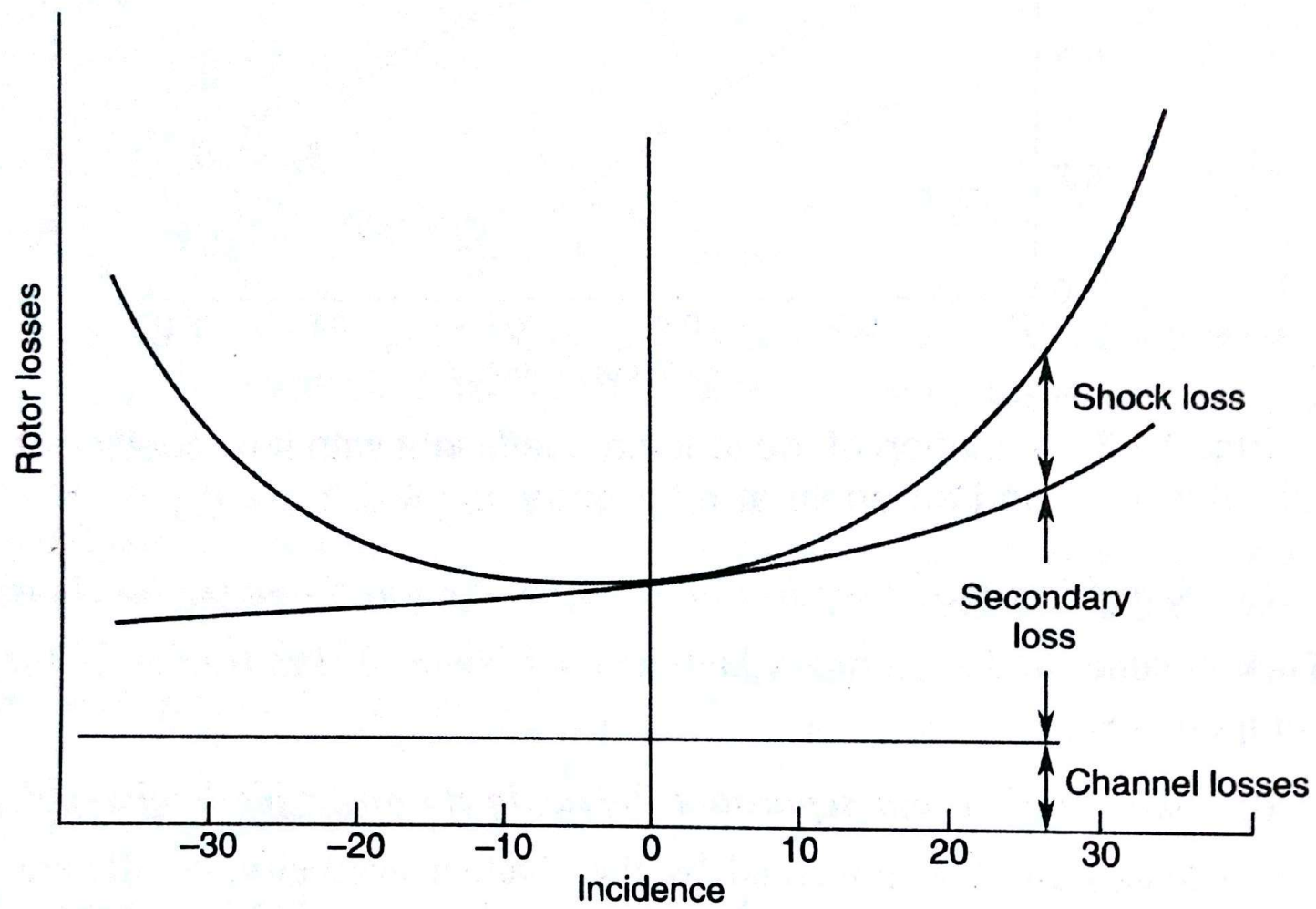




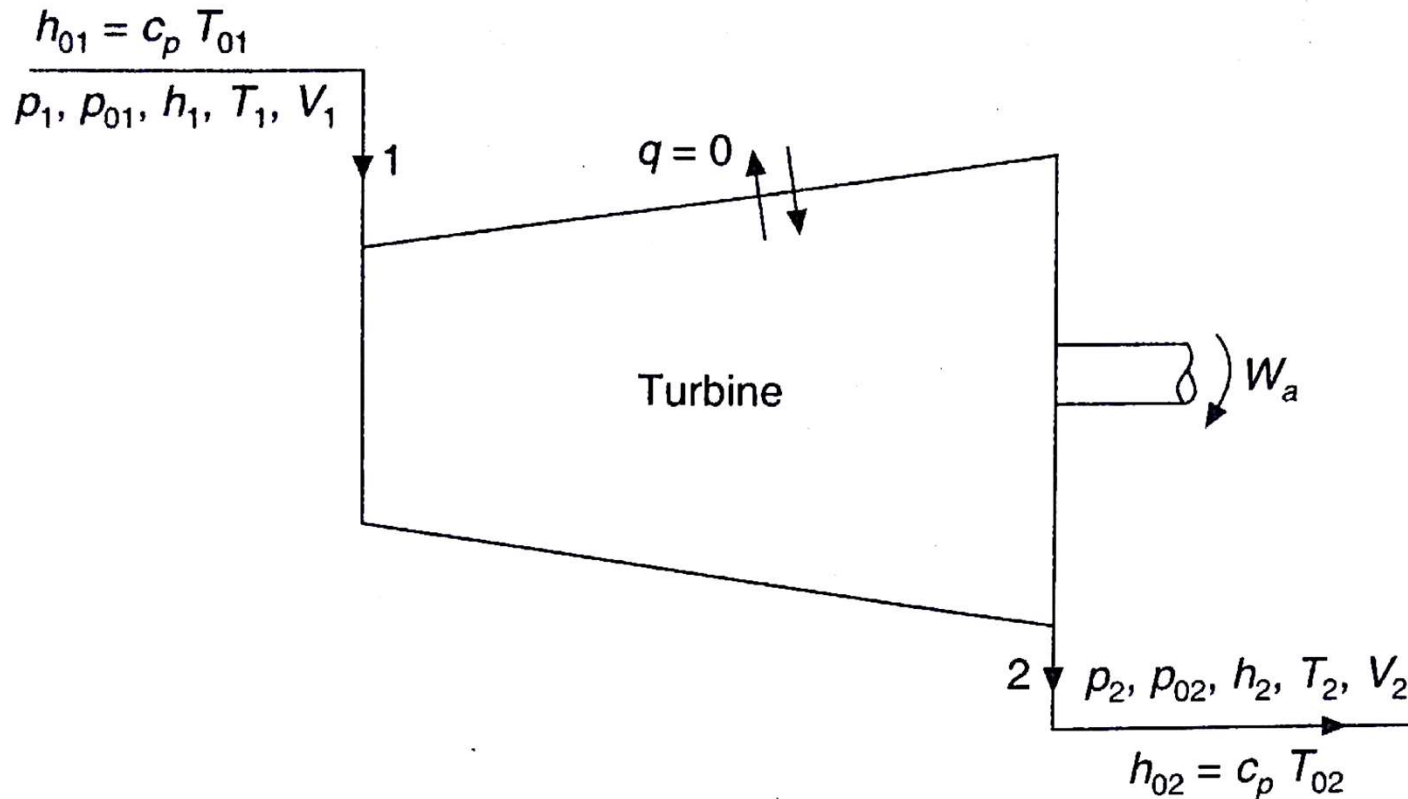
- Radial turbines are capable of extracting a large stage shaft work in situations with low mass-flow rates.
- Radial turbine also offers little sensitivity to tip clearances, in contrast to axial-flow turbines.
- Bulkiness and heavy weight virtually prohibits its use in propulsion devices.
- Radial turbines are best used in micro gas turbines, turbochargers and stationery power plants.

Stage losses





Thermodynamics and Aerodynamics of Radial Turbines



Expansion process in turbine.

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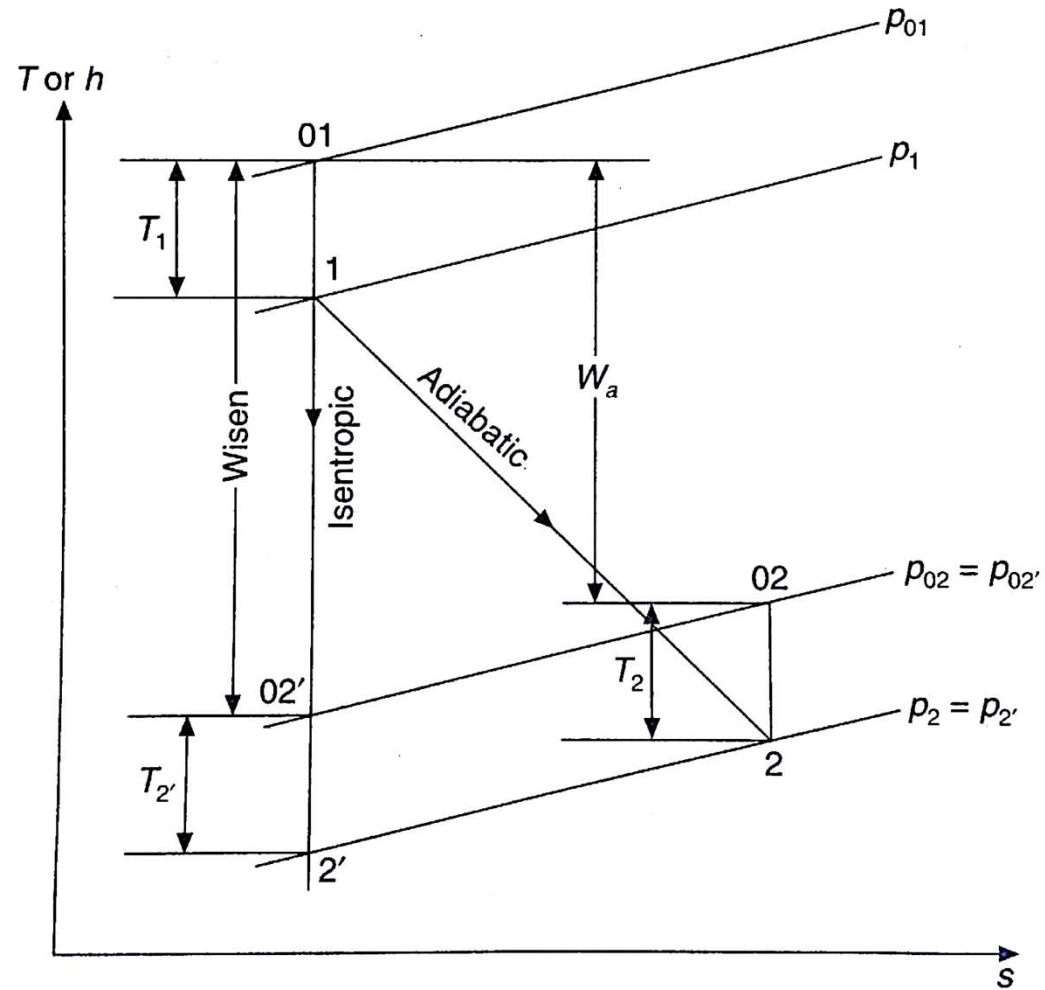
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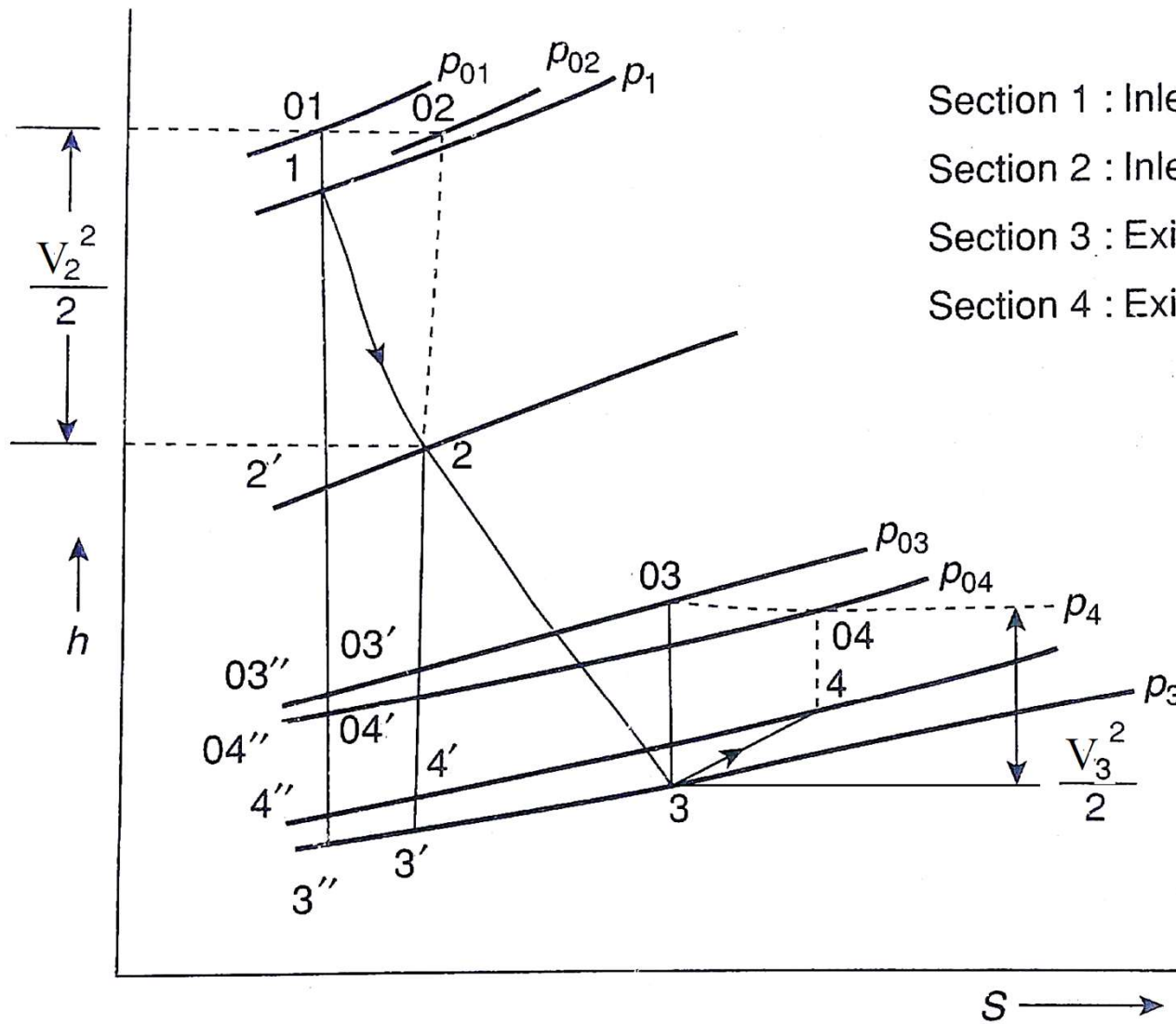
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Ideal and actual expansion processes in a stage.

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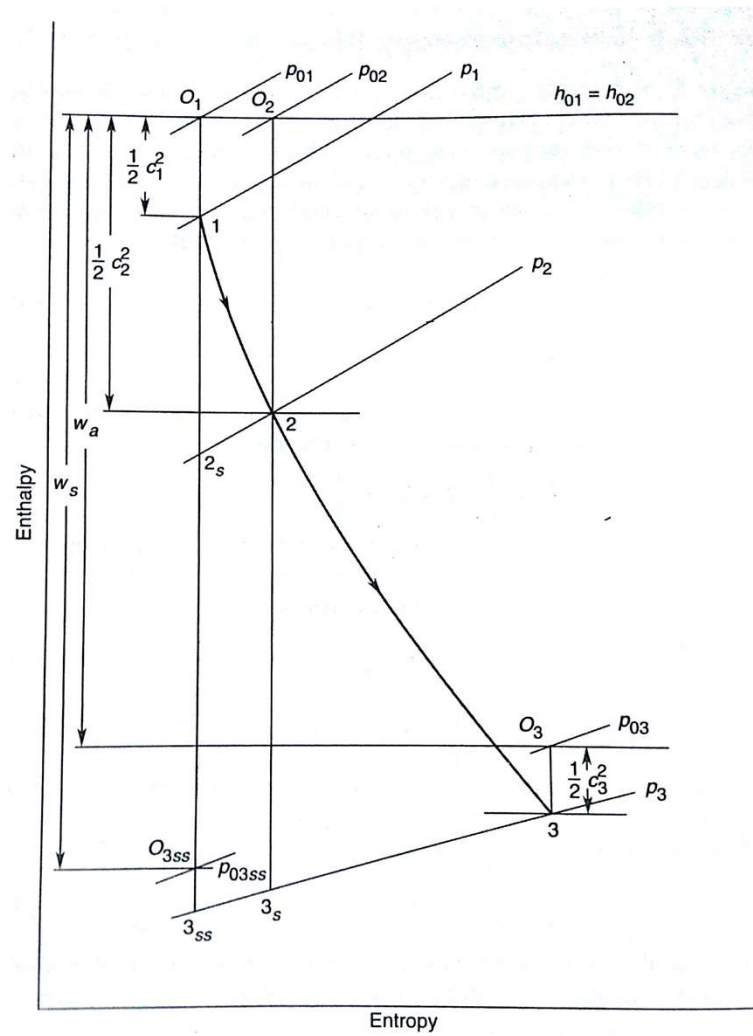


Section 1 : Inlet to nozzle/guide vanes

Section 2 : Inlet to rotor blade

Section 3 : Exit from rotor blades

Section 4 : Exit from diffuser section



Enthalpy-entropy diagram for flow through an IFR turbine stage

Thermodynamics and Aerodynamics of Radial Turbines

