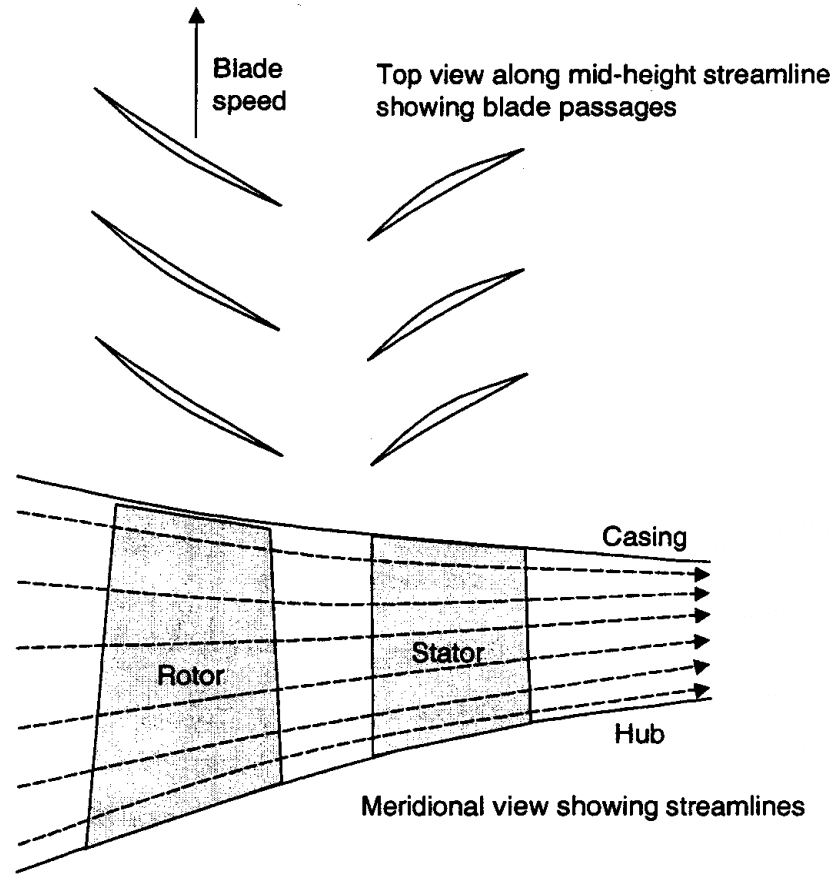
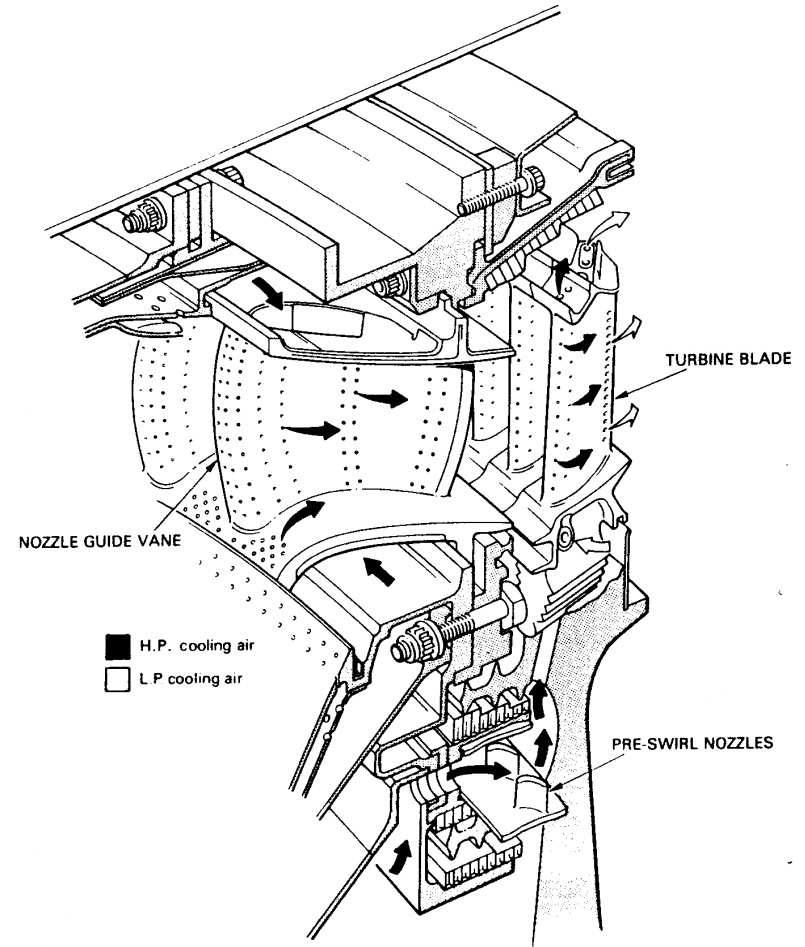


Compressor and turbine stages:



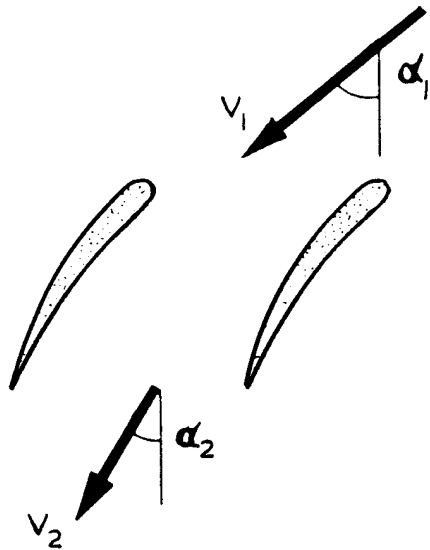
Compressor stage: rotor then stator



Turbine stage: stator then rotor

All turbomachines are intrinsically unsteady flow devices. However, by considering only one blade row at a time, it is possible to work in the frame of reference of an individual blade row where the fluid may be approximated by “steady” flow.

Compressor blade row

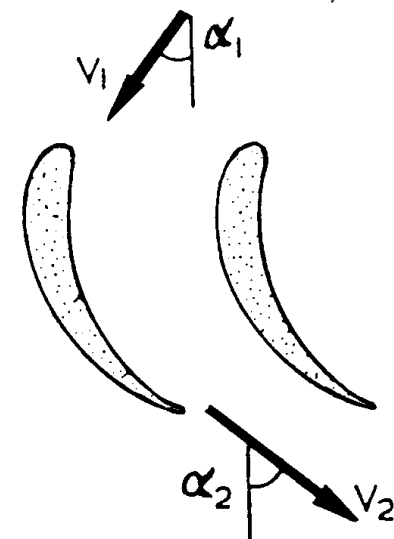


Area increase: pressure rise

Flow deceleration: thick boundary layers

Little flow turning: many stages

Turbine blade row



Area decrease: pressure drop

Flow acceleration: thin boundary layers

Large flow turning: few stages

Two important non-dimensional groups for turbomachinery (page 98-99):

Flow coefficient:

$$\phi = \frac{V_x}{U} = \frac{\text{axial velocity}}{\text{blade speed}}$$

This is a non-dimensional axial velocity and experience has shown that it must be in a specified range for a well-designed turbomachine.

Work coefficient:

$$\frac{\Delta h_0}{U^2} = \frac{\text{stagnation enthalpy change}}{\text{blade speed}^2}$$

This is a non-dimensional work input or extraction coefficient and experience has shown that different ranges are required for good compressors and turbines.

Axial core compressor (page 105):

For compressors there is no equivalent to the “Smith chart”. However, experience (sometimes very costly!) has shown that:

$$\text{Flow coefficient } V_x / U \approx 0.4 - 0.7$$

and

$$\text{Work coefficient } \Delta h_0 / U^2 \approx 0.35 - 0.50$$

The allowable work coefficient, $\Delta h_0 / U^2$, is much lower for a compressor stage than a turbine. This is because, in a compressor, the intrinsic pressure rise provides an adverse pressure gradient for the blade surface boundary layers. Thus the boundary layers become thicker more quickly and are liable to separate after only a small amount of flow turning. Hence axial flow compressors have many more stages than axial flow turbines.

Difference between compressors and turbines (page 95):

	Compressor	Turbine
Work transfer	work input	work output
Pressure change	pressure rise	pressure drop
Flow velocity	slow down (diffuse)	speed up (accelerate)
Flow width	increase	decrease
Turning	towards axial flow	beyond axial flow
Flow turning	small (typically 30°)	large (typically 100°)
Number of stages	many (typically 8 to 10)	few (typically 1 or 2)
Density change	increases	decreases
Blade height (constant V_x)	decrease	increase

Note: actual flow area is product of width and height. The height only changes by a small amount compared to the change in flow width.

How a turbomachine works:

In a compressor, to raise the pressure, the fluid must be slowed down as it passes through a blade row. In a turbine, to drop the pressure, the fluid must be accelerated as it passes through a blade row.

By having alternate stationary and moving blade rows and making use of the change of frame of reference, it is possible to always slow down (relative to the blade row) or always speed up the fluid.

For example: In a turbine the flow is accelerated in the stator (stationary blade row). However, because the rotor row is moving, the flow appears to be moving more slowly in the relative frame and so can be re-accelerated in the relative frame. This appears to be a deceleration in the absolute frame.