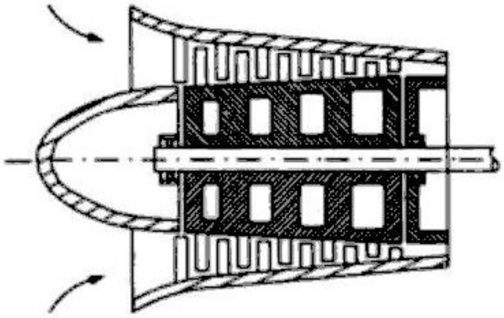
Chapter 1

AXIAL FLOW COMPRESSOR

WORKING PRINCIPLE

An AFC is a pressure producing machine. The energy level of air or gas flowing through it is increased by the action of the rotor blades which exerts a torque on the fluid. This torque is supplied by external source, an electric motor or a gas turbine.

An AFC had the potential for both higher pressure ratio and higher efficiency than the centrifugal flow compressor. Another advantage for jet engines is much larger air flow for given frontal area.



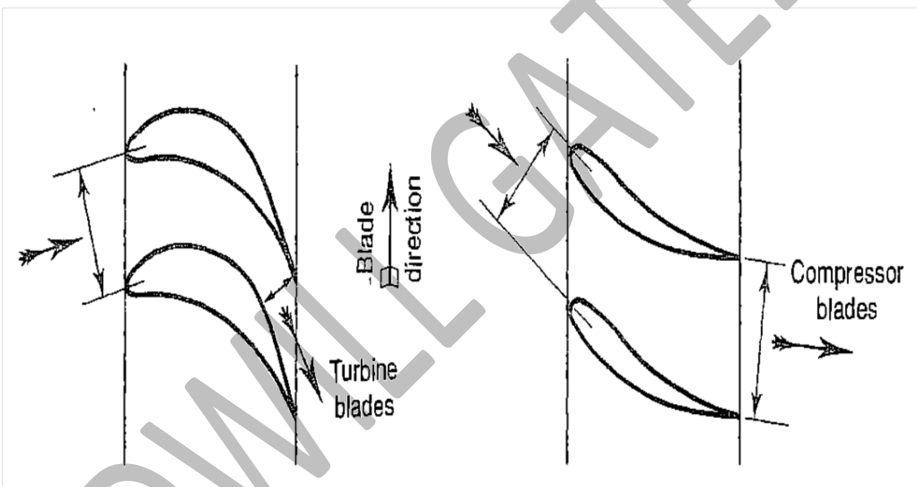
CONSTRUCTION

- It consists of an alternating sequence of fixed and moving sets of blades.
- The set of fixed blades are spaced around an outer stationary casing called the **stator**. The set of moving blades are fixed to a spindle called **rotor**.
- The rotor and stator blades must be as close as possible for smooth and efficient flow. The radius of the rotor hub and the length of the blades are designed so that there is only a very small tip clearance at the end of the rotor and stator blades.
- One set of stator blades and one set of rotor blades constitute a **stage.** The number of stages depends on the pressure ratio required.

OPERATION

- In an AFC the flow of air and fluid is along the initial direction and there is no change of radius for the flow.

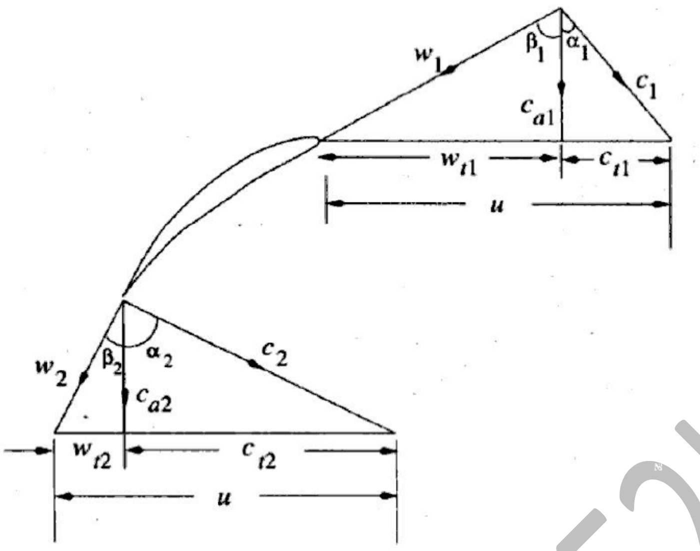
- In this the rotating blades impart kinetic energy to the air which is then converted into pressure rise.
- Stator serves to recover part of kinetic energy imparted to the working fluid.
- This process is repeated in as many stages as necessary to yield the required overall pressure ratio.
- It also redirects the fluid at an angle suitable for entry into the rotating blades of the following stage. Usually, at the entry one more stator is provided to guide the air to correctly enter the first rotor. These blades are sometimes referred as **inlet guide vanes (IGV)**.
- In many compressors, one to three rows of diffuser or straightening blades are installed after the last stage to straighten and slow down the air before it enters the combustion chamber.



STAGE VELOCITY TRIANGLES:

C: Absolute Velocity
U: Blade speed
w: Relative velocity
α_1 and α_2 : Air angles
β_1 and β_2 : Blade angles

Assumptions made –
Axial velocity is constant i.e. $Ca_1 = Ca_2 = Ca$
Blade speed i.e. $U_1 = U_2 = U$



From the Inlet velocity triangle,

$U = Ct_1 + Wt_1$

$U = Catan\ \alpha_1 + Catan\ \beta_1$

$U = Ca(\tan \alpha_1 + \tan \beta_1)$

From exit velocity triangle,

$U = Ct_2 + Wt_2$

$U = Catan\ \alpha_2 + Catan\ \beta_2$

$U = Ca\ (\tan \alpha_2 + \tan \beta_2)$

From (1) and (2)

$U = Ca\ (\tan \alpha_1 + \tan \beta_1) = Ca\ (\tan \alpha_2 + \tan \beta_2)$

Or, $U/Ca = 1/\phi = \tan \alpha_1 + \tan \beta_1 = \tan \alpha_2 + \tan \beta_2$

Or, **$\tan \alpha_2 - \tan \alpha_1 = \tan \beta_1 - \tan \beta_2$**

Work Input to the compressor:

$W = Ct_2 U_2 - Ct_1 U_1$

This is Euler's equation for compressors

$= U\ (Ct_2 - Ct_1)$

$W =$ **$UCa\ (\tan \alpha_2 - \tan \alpha_1)$**

$=$ **$UCa\ (\tan \beta_1 - \tan \beta_2)$**