

 Benha University Subject: Turbo- Machinery(B)

 Faculty of Engineering- Shoubra Year: fourth Mech. Power

 Mech. Power Department Sheet No (4) 2014/2015

1. An axial flow compressor has a tip diameter of 0.95 m and a hub diameter of 0.85 m. The absolute velocity of air makes an angle of 28o measured from the axial direction and relative velocity angle is 56o. The absolute velocity outlet angle is 56o and the relative velocity outlet angle is 28o.The rotor rotates at 5000 rpm and the density of air is 1.2 kg/m3. Determine:
2. The axial velocity.
3. The mass flow rate.
4. The power required.
5. The flow angles at the hub.
6. The degree of reaction at the hub.
7. An axial flow compressor has the following data:

Blade velocity at root: 157.5m/s

Blade velocity at mean radius: 210m/s

Blade velocity at tip: 262.5m/s

Stagnation temperature rise in this stage: 20K

Axial velocity constant from root to tip= 157.5m/s

Work done factor: 0.92

Degree of reaction at mean radius: 50%

Calculate the stage air angles at the root, mean, and tip for a free vortex design.

1. An alternative design proposal to that in problem (2) is to have 50% reaction along the whole blade what then the air and blade angle to be?
2. An axial flow compressor stage has the following data:

Air inlet stagnation temperature: 295K

Blade angle at outlet measured from the axial direction: 328

Flow coefficient: 0.56

Relative inlet Mach number: 0.78

Degree of reaction: 0.5

Find the stagnation temperature rise in the first stage of the compressor.

1. An axial flow compressor has the following design data:

Inlet stagnation temperature: 290K Inlet stagnation pressure: 1 bar

Stage stagnation temperature rise: 24K

Mass flow of air: 22kg/s Axial velocity through the stage: 155.5m/s

Rotational speed: 152rev/s Work done factor: 0.93

Mean blade speed: 205m/s Reaction at the mean radius: 50%

Determine:

1. the blade and air angles at the mean radius
2. The mean radius, and
3. the blade height.
4. An axial flow compressor has an overall pressure ratio of 4.5:1, and a mean blade speed of 245 m/s. Each stage is of 50% reaction and the relative air angles are the same (30o) for each stage. The axial velocity is 158 m/s and is constant through the stage. If the polytropic efficiency is 87%, calculate the number of stages required. Assume T01 = 290K.
5. In an axial flow compressor, air enters at a stagnation temperature of 290K and 1 bar. The axial velocity of air is 180 m/s (constant throughout the stage), the absolute velocity at the inlet is 185 m/s, the work done factor is 0.86, and the degree of reaction is 50%. If the stage efficiency is 0.86, calculate the air angles at the rotor inlet and outlet and the static temperature at the inlet of the first stage and stage pressure ratio. Assume a rotor speed of 200 m/s.
6. In an axial flow compressor air enters the compressor at 1 bar and 290K. The first stage of the compressor is designed on free vortex principles, with no inlet guide vanes. The rotational speed is 5500 rpm and stagnation temperature rise is 22K. The hub tip ratio is 0.5, the work done factor is 0.92, and the isentropic efficiency of the stage is 0.90. Assuming an inlet velocity of 145 m/s, calculate

1. The tip radius and corresponding rotor air angles, if the Mach number relative to the tip is limited to 0.96.

2. The mass flow at compressor inlet.

3. The stagnation pressure ratio and power required to drive the compressor.

4. The rotor air angles at the root section.

1. The following design data apply to an axial flow compressor:

Overall pressure ratio: 4.5 Mass flow: 3.5kg/s

Polytropic efficiency: 0.87 Stagnation temperature rise per stage: 22k

Absolute velocity approaching the last rotor: 160m/s

Absolute velocity angle; measured from the axial direction: 20o

Work done factor: 0.85

Mean diameter of the last stage rotor is: 18.5cm

Ambient pressure: 1.0bar Ambient temperature: 290K

Calculate

1. the number of stages required,
2. pressure ratio of the first and last stages,
3. rotational speed,
4. the length of the last stage rotor blade at inlet to the stage. Assume equal temperature rise in all stages, and symmetrical velocity diagram.
5. A 10 stage axial flow compressor is designed for stagnation pressure ratio of 4.5:1. The overall isentropic efficiency of the compressor is 88% and stagnation temperature at inlet is 290K. Assume equal temperature rise in all stages, and work done factor is 0.87. Determine the air angles of a stage at the design radius where the blade speed is 218 m/s. Assume a constant axial velocity of 165 m/s, and the degree of reaction is 76%.
6. An axial flow compressor has a tip diameter of 0.9 m, hub diameter of 0.42 m, work done factor is 0.93, and runs at 5400 rpm. Angles of absolute velocities at inlet and exit are 28o and 58o, respectively and velocity diagram is symmetrical. Assume air density of 1.5 kg/m3, calculate mass flow rate, work absorbed by the compressor, flow angles and degree of reaction at the hub for a free vortex design.