SYED AMMAL ENGINEERING COLLEGE

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ME6604-GAS DYNAMICS AND JET PROPULSION

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TWO MARK QUESTIONS AND ANSWERS

UNIT I –ISENTROPIC FLOW

1. State the difference between compressible fluid and incompressible fluid
   a. Compressible
      1. Fluid velocities are appreciable compared with the velocity of sound
      2. Density is not constant
      3. Compressibility factor is greater than one.
   b. Incompressible
      1. Fluid velocities are small compared with the velocity of sound
      2. Density is constant
      3. Compressibility factor is one.

2. Define stagnation state , stagnation enthalpy and stagnation pressure?
   a. The state of a fluid attained by isentropically decelerating it to zero velocity at zero elevation is referred as stagnation state.
      (e.g.) Fluid in a reservoir (or) in a settling chamber.
   b. Stagnation pressure is the pressure of the gas when it is isentropically decelerated to zero velocity at zero elevation
   c. Stagnation enthalpy is the enthalpy of the gas when it is isentropically decelerated to zero velocity at zero elevation

3. Write the steady flow energy equation for an adiabatic flow of air.

   In an adiabatic flow q = 0. Therefore energy equation becomes.

$$h1 + \frac{c_1^2}{2} + gZ_1 = h_2 + \frac{c_2^2}{2} + gZ_2 + W_s$$

   Adiabatic energy equation is $h_0 = h + ½\ c^2$

4. Express the stagnation enthalpy in terms of static enthalpy and velocity of flow?
   Stagnation enthalpy,h_o =h + $C^2/2$
   Where h=static enthalpy, C= velocity of fluid

5. Explain Mach cone and Mach angle?

   Tangents drawn from the sourcepoint on the spheres define a conical surface referred to as mach cone.

   The angle between the Mach line and the direction of motion of the body that is flow direction is known as Mach angle.

6. Define adiabatic process and isentropic process?

   In thermodynamics, an isentropic process is an idealized thermodynamic process that is adiabatic and in which the work transfers of the system are frictionless; there is no transfer of heat or matter and the process is reversible

   In thermodynamics, an adiabatic process is one that occurs without transfer of heat or matter between a thermodynamic system and its surroundings. In an adiabatic process, energy is transferred only as work

7. Define Mach number

   Mach number is a non-dimensional number and is used for the analysis of compressible fluid flows

$$M = \sqrt{\frac{\text{int}\,ertiaforce}{elasticforce}}$$

$$= \sqrt{\frac{\rho A c^2}{KA}}$$

where K = Bulk modulus of elasticity $K = \rho\, a^2$

$$\therefore M = \sqrt{\frac{\rho A c^2}{\rho A a^2}} = \frac{c}{a}$$

8. Define zone of action and zone of silence?

   The region inside the Mach cone is called the zone of action and the region outside the Mach cone is termed as the zone of silence.

9. Distinguish between Mach wave and normal shock?

   Mach wave-the lines at which the pressure difference is concentrated and which generates the cone are called mach lines or mach wave

   Normal shock-a shock wave is nothing but a steep finite pressure wave.when the shock wave is right angle to the flow it is cslled normal shock.

10. Zone of silence is absent in subsonic flow. Why

    In sonic flow the source of disturbance velocity (c) is equal to the sound velocity(a) .under this condition the sound waves always exit at the present position of the point source and cannot move ahead of it.therefore the zone lying on the left of the source of disturbance (s) is called zone of silence because the waves do not reach this zone

11. What is the cross section of the nozzle required to increase the velocity of compressible fluid flow from (a) subsonic to supersonic (b) subsonic to sonic

    (a) subsonic to supersonic –Convergent to Divergent

    (b) subsonic to sonic- Convergent

12. What is subsonic,sonic ,transonic , supersonicand hypersonic flow with respect to Mach number
    a. M<1- Subsonic flow
    b. M=1- sonic flow
    c. M=0.8 to 1.2—transonic flow
    d. M>1- supersonic flow
    e. M>5- hypersonic flow

13. Where are the convergent nozzles and convergent –divergent nozzles used
    a. Steam turbines
    b. Rockets
    c. The supersonic gas turbine engine

14. Define open system and closed system
    a. Closed system-A system does not permit any mass transfer only energy transfer takes place
    b. Open system-energy transfer as well as mass transfer taken place.

15. Differentiate between adiabatic flow and diabatic flow
    a. Flow in constant area duct with heat transfer and without friction is known as adiabatic flow(Rayleigh flow)
    b. Flow in constant area duct with friction and without heat transfer is known as diabatic flow(Fanno flow)

16. What is the difference between intensive and extensive property.
    a. Intensive property-these properties are independent on the mass of the system Ex:pressure,temperature
    b. Extensive property- these properties are dependent on the mass of the system Ex:total volume ,total energy

17. What is meant by stagnation properties

    Stagnation properties are obtained by decelerating a gas isentropically to zero velocity at zero elevation.the stagnation properties of a gas is often used as a reference state.

18. What is impulse function

    The sum of pressure force and impulse force gives impulse function

    $F = pA + \rho AC^2$

19. How the area and velocity vary in supersonic flow of nozzle and diffuser

    For nozzle :area-decreases,velocity increases

    For diffuser –area increases ,velocity decreases

20. What is the advantage of usinf M^* (second kind of mach number)instead of M(local mach number)in some cases

    At high velocities M approaches infinity but M^*gives a finite value

    M is proportional to the f luid velocity (c) and sound velocity (a) but M* is proportional to the fluid velocity alone.

UNIT 2- FANNO AND RAYLEIGH FLOW

1. What are the assumption made for fanno flow?
   One dimensional steady flow.
   Flow takes place in constant sectional area.
   There is no heat transfer
   The gas is perfect with constant specific heats.

2. Explain chocking in Fanno flow?
   In a fanno line, any heating process (both subsonic and supersonic) will increase the enthalpy, entropy and mass flow rate. This will go upto the limiting state where mach number M* = 1. Further heating is not possible, because the entropy change will be negative which violates the second law of thermodynamics. Hence the mass flow rate is maximum at the critical state and is constant afterwards, then the flow is said to be "chocked flow".

3. Explain the difference between Fanno flow and Isothermal flow?

Fanno flow	Isothermal flow
Flow in a constant areaduct with friction andwithout heat transfer Static temperature is notconstant	Flow in a constant area duct withfriction and the heat transfer Static temperature remainsconstant

4. What are the three equation governing Fanno flow?
   Energy equation,
   continuity equation and
   equation of state.

5. Give two practical examples where the Fanno flow occurs?
   Flow in air breathing engines
   Flow in refrigeration and air conditioning
   Flow of fluids in long pipes.

6. What is Rayleigh line and Fanno line?
   Rayleigh line: Flow in a constant duct area with heat transfer and without friction is described by a curve is known as Rayleigh line.
   Fanno Line: Flow in a constant duct area without heat transfer and with friction is described by a curve is Fanno line

7. What are the assumptions of Fanno flow?
   One dimensional steady flow
   Flow takes place in constant sectional area
   There is no heat transfer
   The gas is perfect with constant specific heats

8. Define fanning's coefficient of skin friction
   It is the ratio between wall shear stress and dynamic head
   F = wall shear stress/dynamic head

9. Define oblique shock. Also mention where it occurs.
   The shock wave which is inclined at an angle to the two dimensional flow direction iscalled as oblique shock. When the flow is supersonic, the oblique shock occurs at thecorner due to the turning of supersonic flow.

10. Give the applications of isothermal flow with friction.
    In long ducts where sufficient time is available for the heat transfer to occur and therefore the temperature may remain constant.

11. State the assumptions made to derive the equations for isothermal flow.
    One dimensional flow with friction and heat transfer
    Constant area duct
    Perfect gas with constant specific heats and molecular weights

12. Give the assumptions made in Rayleigh flow
    One dimensional flow without friction and heat transfer
    Constant area duct
    Perfect gas with constant specific heats

13. What is chocked flow through a nozzle
    The mass flow rate of nozzle is increased by decreasing the back pressure.the maximum mass flow conditions are reached when the throat pressure ratio achieves critical value.after that there is no further increase in mass flow with decrease in back pressure this condition is called chocking.at chocking condition M=1

UNIT III- SHOCK WAVE &OBLIQUE WAVE

1. What is meant by shock wave?
A shock wave is nothing but a steep finite pressure wave. The shock wave may be described as a compression wave front in a supersonic flow field across which there is abrupt change in flow properties.

2. What is normal shock?
When the shock wave is at right angle to the flow, it is called normal shock.

3. What is oblique shock?
When the shock wave is inclined at an angle to the flow, it is called oblique shock.

4. What is Prandtl — Meyer relation?
Prandtl—Meyer relation which is the basis of other equation for shock waves. It gives the relationship between the gas velocities before and after the normal shock and the critical velocity of sound.

$$M_x^* \times M_y^* = 1$$

$$c_x \times c_y = a^{*2}$$

5. Define strength of shock wave.
It is defined as the ratio of difference in downstream and upstream shock pressures to upstream shock pressure . It is denoted by .

$$\xi = \frac{p_y - p_x}{p_x}$$

6. What are applications of moving shock wave?
It is used in

- Jet engines
- Shock tubes
- Supersonic wind tunnel
- Practical admission turbines.

7. Shock waves cannot develop subsonic flow? Why?
In subsonic flow, the velocity of fluid is less than the velocity of sound. Due to this reason, deceleration is not possible in subsonic *flow.* So shockwaves cannot develop in subsonic flow.

8. Define compression and rarefaction shocks? Is the latter possible.
A shock wave which is at a higher pressure than the fluid in to which it is moving is called compression shock wave.
A shock wave which is at a lower pressure than the fluid into which it is moving is called an expansion shock wave or rarefaction shock wave. It is not possible.

9. Write the equation for efficiency of a diffuser.

$$\eta_D = \frac{\frac{T_{01}}{T_1}\left[\frac{p_{0y}}{p_{0x}}\right]^{\frac{\gamma-1}{\gamma}} - 1}{\frac{\gamma-1}{2} M_1^2}$$

10. State the necessary conditions for a normal shock to occur in compressible flow.

- The compression wave is to be at right angle to the compressible flow.
- Flow should be supersonic.

11. Write down the Rankine—Hugoniot equation.

$$\frac{\rho_y}{\rho_x} = \frac{1 + \frac{\gamma+1}{\gamma-1} \times \frac{p_y}{p_x}}{\frac{\gamma+1}{\gamma-1} + \frac{p_y}{p_x}}$$

12. Is theflow through a normal shock an equilibrium one.
No. Since the fluid properties like pressure, temperature and density are changed during normal shock.

13. Give the diference between Normal and Oblique shocks.

Normal shock	Oblique shock
Shock wave is right angle to the flow	Shock wave is inclined at an angle to the flow
One dimensionsi flow	Two dimensional flow

14. What are properties changes across a normal shock?

- Stagnation pressure decreases.
- Stagnation temperature remains constant.
- Static temperature and static pressure increases.

15. Why the efficiency of a machine ,experiencing shock wave is considerably low

Shock may cause boundary layer separation and deviation of flow its designed direction.there will be a loss in stagnation pressure and increase in entropy across the shock.

16. What is the use of pitot tube in supersonic flow

Introduction of the pitot tube produces a curved shock a little distance upstream of its mouth.therefore it measures the stagnation pressure downstream the shock wave.

17. State assumptions made to derive the equations for isothermal flow.

- One dimensional flow with friction and heat transfer.
- Constant area duct
- Perfect gas with constant specific heats and molecular weights
- Isothermal flow i.e., the temperature is constant
- On account of constant temperature the friction factor may be assumed constant along
- the duct.

18.what are the beneficial and adverse effects of shock waves

Beneficial effects:

A strong shock wave is utilized to accelerate the flow to a high mach number in a shock tube.

On account of the abrupt changes of pressure,density etc,across the shock waves,they are profitably used in supersonic compressor to obtain considerably high pressure ratio in one stage.

Adverse effects

Shock waves cause undesirable interference with normal flow behavior.therefore the efficiency of turbo machineries decreases.

Shock waves create sonic flows in supersonic aircraft and damage the flow passage.

19. What do you understand by strong and weak wave

Since shock strength is proportional to (M_x^2-1),strong waves are a result of very high values of the upstream Mach number.A very strong shock is one for which P_2/P_1 is very large.

Mach waves are weak waves.A weak shock is that for which normalized pressure jump is very small ie

$$\frac{\Delta P}{P1} = \frac{P2-P1}{P1} << 1$$

UNIT IV –JET PROPULSION

1. What is thrust (or) drag?
The force which propels the aircraft towards at an given speed is called as thrust or propulsive force. This thrust mainly depends on the velocity of gases at the exit of the nozzle.

2. Define Effective Speed ratio.
The ratio of flight speed to jet velocity is known as effective speed ratio.

$$\sigma = \frac{U}{Cj}$$

3. Define specific thrust.
The thrust developed per unit mass flow rate is known as specific thrust .

$$F_{sp} = \frac{F}{\dot{m}}$$

4. What is Thrust Specific Fuel Consumption (TSFC)?
It is defined as the ratio of fuel consumption rate per unit thrust.

$$\text{TSFC (or) SFC} = \frac{\dot{m}_f}{F}$$

5. Define Specific Impulse.
The thrust developed per unit weight flow rate is known as specific impulse.

$$I_{sp} = \frac{F}{W}$$

..
6. Define propulsive efficiency.
It is defined as the ratio of propulsive power (or) thrust power to the power output of the engine.

$$\eta_P = \frac{\text{Propulsive power}}{\text{Power output}}$$

7. What are the main parts of Ramjet engine?
The main parts of Ramjet engine are:
(1) Supersonic diffuser
(ii) Subsonic diffuser
(iii) Combustion chamber
(iv) Discharge nozzle

18. What are the various types of air breathing (or) jet engine?
The various propulsive engines are:
(i) Ramjet engine (ii) Pulse jet engine
(iii) Turbojet engine (iv) Turboprop engine
(v) Turbofan engine

9. Give the expression for the thrust developed by a turbojet engine.

Thrust $F = \dot{m} c_j - \dot{m}_a u$

$\dot{m}$ = Mass of air-fuel mixture – kg / s

c_j = Velocity of jet – m/s

$\dot{m}_a$ = Mass of air – kg / s

u = Velocity of aircraft (or) Flight speed m/s

10. Define thermal efficiency.
It is the ratio of power output of the engine to the power input to the engine through fuel.

$$\eta_t = \frac{\text{Power output of the engine}}{\text{Power input to the engine}}$$

11. Define overall efficiency.
It is defined as the ratio of propulsive power to the power input to the engine.

$$\eta_0 = \frac{\text{Propulsive power (or) Thrust power}}{\text{Power input to the engine}}$$

12. What is ram effect?

In Rarnjet engine the subsonic and supersonic diffusers are used to convert the kinetic energy of the entering air into pressure energy. This energy transformation is called the Ram effect and the pressure rise is called the Ram pressure

13. Define Thrust Power (or) Propulsive Power.

Thrust power is the product of thrust and flight speed.
Thrust power P= Thrust (F) x Flight speed (u)

14. What is the type of compressor used in turbojet? Why?
Rotary compressor is used in turbojet engine due to its high thrust and high efficiency.

15. What is turboprop engine?
Turboprop engine is very similar to turbojet engine. In this type, a turbine which is used to drive the compressor and propeller.

16. Give the difference between Ramjet and Turbojet engine.

Ramjet Engine	Turbojet Engine
Compressor and turbine are not used.	Compressor and turbine are used.

Take off thrust is zero.	Low take off thrust.
Light weight	Weight is heavy compared to ramjet engine.
Cost is low.	Cost is high.

17. What is the dfference between turboprop and turbojet

Turbojet Engine	Turboprop Engine
Power produced by the turbine is used to drive the compressor.	Power produced by the turbine is used to drive the compressor and propeller.
Low take off thrust.	High take off thrust.
Low propulsive efficiency.	Propulsive efficiency is good.
Less space need compared to turboprop engine.	More space needed.
Reduction gear is not needed.	Reduction needed.

18. What is thrust augmentation? Or what are the benefits of thrust augmentation in a turbojet engine
To achieve .better take-off performance, additional fuel is burnt in the tail pipe between the turbine exhaust section and entrance section of the exhaust nozzle. This method of thrust augmentation increases the jet velocity and is known as after burning. It is used for fast and easier take off.

19. Why ramjet engine does not require a compressor and a turbine?
In rarmjet engine due to supersonic and subsonic diffuser, the static pressure of air is increased to ignition pressure. So there is no need of compressor and a turbine

20. Give the djfference between ramjet and pulsejet.

Ramjet Engine	Pulsejet Engine
Take off thrust is zero.	It develops thrust at zero speed.
There is no upper limit to the flight speed.	Flight speed is limited to 750 km/h.
The specific fi.iel consumption is better than other gas turbine power plants at high speed.	High rates of fuel consumption.

21. What is the basic djfference between rocket propulsion and jet propulsion.

S No.	Jet Propulsion	Rocket Propulsion
1.	Combustion takes place by using atmospheric air.	Combustion takes place by using its own oxygen supply.
2.	Altitude limitation.	No altitude limitation.

23. What is scram jet?
A supersonic combustion rarnjet engine is known as scram jet. In scram jet, the flow enters the combustor at supersonic velocity and comparatively lower temperature. The static pressure is high enough to provide the required expansion in the nozzle.

24. How is turbofan engine different from turbo prop engine?

Turbo Prop Engine	Turbo Fan Engine
Relatively low flight speed.	High flight speed as compared - to turbo prop engine.
By pass ratio is high.	By pass ratio is low.

25. Give the components of a turbo jet.
Diffucer,rotary compressor,combustion chamber,turbine,exhaust nozzle

26.what is a bypass engine and bypass ratio

Turbo fan engines are usually described as bypass engine.in this type of engine a portion of the total flow of air bypasses part of the compressor.

The ratio of mass flow rates of cold air and the hot air is known as bypass ratio.

27. What is after burning in turbojet engines

Large quantity of oxygen is available in the exhaust gas which can support the combustion of additional fuel.when the thrust of the engine is desired to be increased without changing the physical dimensions of the compressor,turbine etc.,additional quantity of fuel can be burnt in a section of the jet pipe to increase the velocity of the jet.this process is called reheating or after burning.

28. Name commonly used aircraft engines.
Turbojet engine, Turboprop engine,Turbofan engine

UNIT V-ROCKET PROPULSION

1. What is monopropellant ? Give one example

A liquid propellant which contains both the fuel and oxidizer in a single chemical is known as a monopropellant. It is stable at normal ambient conditions and liberate thermo-chemical energy on heating.
Examples: Nitroglycerine. Nitromethane.

2. Djferentiate Jet propulsion and Rocket propulsion. (or) Dfferentiate Air breathing engine and Rocket engine.

Jet Propulsion	Rocket Propulsion
Oxygen required for combustion purpose is taken from the atmosphere.	Oxygen is filled in a tank in the rocket engine itself and used for combustion purpose.
Altitude limitation.	No altitude limitation.
Flight speed always less than jet velocity,	Flight speed can be greater than jet velocity.
Reasonable efficiency.	Low efficiency except at extremely high flight speed.
Thrust decreases with altitude.	Thrust improves slightly with altitude.

3. What is bipropellant
If the fuel and oxidizer are different from each other in its chemical nature, then the propellant is called bipropellant.
Example: Liquid oxygen — Gasoline
Hydrogen peroxide — Hydrazine

4. Clasify the rocket engines based on source of energy employed
On the basis of source of energy employed, rocket engine can be classified as:
(1) Chemical rocket engines
(ii) Solar rocket engines
(iii) Nuclear rocket engines c
(iv) Electrical rocket engines

5. What is speafic impulse of a rocket?
The thrust developed per unit weight flow rate of the propellant is known as specific impulse.

$$Isp=F/Wp$$

6 .Define thrust.
The force which propels the rocket forward at a given speed is known as thrust.

7. Define specific propellant thrust.
The propellant consumption rate per unit thrust is known as specific propellant consumption.

$$SPC=Wp/F$$

8. What is weight flow coefficient?
It is the ratio of propellant flow rate to the throat force.

$Cw = Wp/ p_0A^*$

9. What is IWR?
IWR (Impulse to Weight Ratio) is the ratio of total impulse of the rocket to the total weight of the rocket.
$IWR = I_{total}/W_{total}$

10. Define characteristic velocity.
The ratio between effective jet velocity and thrust coefficient is known as characteristic velocity.

$$C^* = \frac{\text{Effective jet velocity}}{\text{Thrust coefficient}}$$

11. What is thrust coefficient?
It is the ratio of the thrust to the thrust force.

$Cf = F/ p_0A^*$

12. Define propulsive efficiency.
It is defined as the ratio of propulsive power to the power output of the engine.

$$\eta p = \frac{\text{Propulsive power}}{\text{power output of engine}}$$

13. Define thermal efficiency.
It is defined as the ratio of power output of the engine to the input power through fuel.

$$\eta_t = \frac{\text{Power output of the engine}}{\text{Power input to the engine}}$$

14. Define overall efficiency.
It is defined as the ratio of the propulsive power to the power input to the engine.
Propulsive power

$$\eta_o = \frac{\text{propulsive power}}{\text{power input to the engine}}$$

15. Define the terms: (i) UDMH; (iU RFNA; (iii) JATO; (iv) RA TO.
UDMH — Unsymmetrical dimethyl hydrazine
RFNA — Red fuming nitric acid
JATO — Jet-assisted take off
RATO — Rocket assisted take off

16. What is the use of inhibitors in solid propellants
They are used to regulate the burning of propellant

17. Why rocket is called as non breathing engine.can rocket work at vaccum.
    In air breathing engines combustion takes place by using atmospheric air.but in rocket engines combustion takes place by using its own oxygen supply.so it is called as non breathing engine

18. Mention any four specific applications of rocket
    Military,space,aircraft,communication

19. What is meant by hypergolic propellant
    Hypergolic propellant do not require ignition

20. Name any solid propellant fuels and oxidizers
    Fuels-plastics,polymers,polyvinyl chlorides
    Oxidizers-nitrates,perchlorates