AE8504 - PROPULSION-II

TWO MARKS QUESTIONS

UNIT – I

HYPERSONIC AIRBREATHING PROPULSION

1. Briefly explain scramjet engine?

   A scramjet is a variant of a ramjet air breathing jet engine in which combustion takes place in supersonic airflow.

2. How a scramjet does differ from ramjet engine?

   Scramjet engine combustion takes place in supersonic speed where in ramjet subsonic speed.

3. Define thrust.

   Thrust is a force which propels the engine in to the forward direction.

   Unit for thrust is Newton.

4. Define specific impulse.

   It is defined as the ratio of thrust to weight flow rate of air-fuel mixture.

   Unit for the specific impulse is seconds.

   $$\mathbf{Is = F/\dot{\omega}}$$

5. What is the function of nozzle?

   The function of the nozzle is to convert the pressure energy of the fluid into kinetic energy.

6. What is Mach number?

   Mach number is defined as the ratio of velocity of object to velocity of sound.

   $$\mathbf{M = c/a}$$

7. What are the burners used in the ramjet engine?
   - Can type burner
   - Baffle type burner

8. What is meant by ram effect?

   The function of the diffuser is to convert the kinetic energy of the entering air into pressure energy. This energy transformation is called ram effect.

9. What are the assumptions made for calculate the ideal efficiency of the ramjet engine?
   - Steady flow
   - One dimensional flow
   - Isentropic compression and expansion
   - Gas is perfect
   - Heat added at constant pressure
   - Very low Mach number in the combustion chamber.

10. Why ramjet engine does not require a compressor and a turbine?

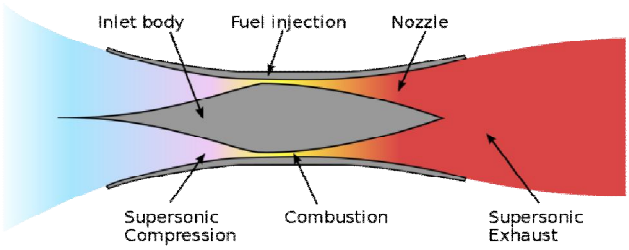
    In ramjet engine, due to subsonic and supersonic diffuser, the static pressure of the air is increased to ignition pressure. So there is no need of compressor and turbine.

11. What is the need for supersonic combustion?

    A scramjet (supersonic combusting ramjet) is a variant of a ramjet airbreathing jet engine which works on supersonic to obtain desired pressure ration and hence the combustion also takes place in supersonic airflow.

12. Sketch a scramjet engine with all the components.

    A **scramjet** (*supersonic combustion ramjet*) engine is variant of a ramjet air breathing combustion jet engine in which the combustion process takes place in supersonic airflow.
    - ***A Converging Inlet***, where incoming air is compressed and decelerated.
    - ***A Combustor***, where gaseous fuel is burned with atmospheric oxygen to produce heat.
    - ***A Diverging Nozzle***, where the heated air is accelerated to produce thrust.



13. What is the need for hypersonic vehicle?

    A Hypersonic Vehicle is a vehicle that travels at least 5 times faster than the speed-of-sound, or greater than Mach 5. A hypersonic vehicle can be an airplane, missile, or

spacecraft which is equipped with a special type of jet engine called a Supersonic Combustion Ramjet

14. Why hydrogen is the suitable fuel used for hypersonic propulsion?
    - Hydrogen fuel can burn rapidly and generate a large amount of thrust.
    - Hydrogen is extremely flammable; it only takes a small amount of energy to ignite it and make it burn.
15. Define propulsive efficiency of ramjet engine.

    The propulsive efficiency of ramjet engine is defined as the ratio of thrust power to power output.
16. Define combustion efficiency.

    The combustion efficiency is defined as the ratio of enthalpy rise of air to heat supplied to it.
17. Define diffuser efficiency.

    Diffuser efficiency is defined as the ratio of actual pressure rise to ideal pressure rise.
18. What are the advantages of ramjet engine?
    - Ramjet engine is very simple and does not have any moving part.
    - Cost is low.
    - Less maintenance.
    - There is no upper limit for flight speed.
    - Light weight when compared to turbojet engine.
19. What are the disadvantages of ramjet engine?
    - Since the takeoff thrust is zero, it is not possible to start a ramjet engine without an external launching device.
    - The combustor required flame holder to stabilize the combustion due to high speed of air.
    - It has low thermal efficiency.
    - It is very difficult to design a diffuser which will give good pressure recovery over a wide range of speeds.
20. What are the applications of ramjet engine?
    - It is widely used in high speed aircrafts and missiles due to its high thrust and high operational speed.
    - Subsonic ramjets are used in target weapons.
21. Explain critical inlet mode operation.

When the inlet can accept the mass flow of air required positioning the terminal shock just inside the cowl lip. This is called critical inlet operation.

22. What is subcritical operation?

When the inlet is not matched to the engine, the normal shock moves upstream. This is called as subcritical operation.

23. What is super critical operation?

When the inlet cannot capture the mass flow required by the engine, the terminal shock is sucked into the diffuser. This is called super critical operation.

24. What are the factors to be considered to select the fuel for ramjet engine?

- The calorific value of fuel
- The case with which it can be ignited
- Its physical properties
- Its storage ability
- Toxicity
- Corrosiveness

25. What are the factors affecting the combustion process?

- The burner geometry
- Physical and chemical characteristics of fuel
- The air fuel ratio
- The velocity of working fluid

UNIT-II

FUNDAMENTALS OF CHEMICAL ROCKET PROPULSION

1. Define total impulse.

The total impulse I_t is the thrust force F integrated over the burning time t.

$$I_t = \int_0^t F \, dt$$

2. Define specific impulse of a rocket.

Specific impulse Is is the total impulse per unit weight of propellant.

$$I_s = F/(\dot{m}g_0) = F/\dot{w}$$
$$I_t/(m_p g_0) = I_t/w$$

3. Define IWR?

   The ratio of total impulse of the rocket to total weight of the rocket is called as impulse weight ratio.

4. What is thrust coefficient?

   It is the ratio of the thrust to the throat force. Its is function of gas property k, the nozzle area ratio and the pressure ratio across the nozzle

5. Define specific propellant consumption.

   The propellant consumption rate per thrust is called as specific propellant consumption..

6. What is the condition for optimum thrust coefficient?

   The Thrust Coefficient determines the amplification of thrust due to gas expansion in the nozzle as compared to the thrust that would be exerted if the chamber pressure acted over the throat area.

$$\mathbf{F = C_f * P * A}$$

7. What is the advantage for rocket to have multiple stages?
   - Each stage of the rocket has fuel, as it burns, it separates and falls to earth. It lightens the rocket and it can go further.
   - Each stage can use a different type of rocket propellant.

8. What is the advantage of bell nozzle over conical nozzle?

   The bell nozzle has 20 % less than the length that would be required for a conical nozzle.

9. What is internal ballistics?

   The rocket motor's operation and design depend on the combustion characteristics of propellant, its burning rate, burning surface, and grain geometry. The branch of science describing these is known as internal ballistics.

10. Define characteristic velocity.

    It is the ratio of jet velocity to thrust coefficient.

11. Define characteristic exhaust velocity.

    It is a measure of the combustion performance of a rocket engine independent of nozzle performance, and is used to compare different propellants and propulsion systems

$$\mathbf{C^* = p\, A_t / \dot{m}}$$

12. Define overall efficiency.

    Overall efficiency is defined as the ratio of thrust power to heat supplied by the propellant.

13. Define thermal efficiency.

    Thermal efficiency is the ratio of power developed by the engine to heat supplied by the propellant.

14. Define effective jet velocity.

    The effective jet velocity is the ratio of thrust to mass flow rate of propellant. And also it is average equivalent velocity at which propellant is ejected from the vehicle

    C = F / mass flow rate

15. Write short notes on aero spike nozzle.

    The aero spike nozzle has common plug at its centre. The small combustion chambers arranged in a circle around a common plug. The gasses coming out from the chambers flow through the divergent section of the nozzle where they are expanded.

16. State the comparison between jet engines and rocket engines.

    In the jet engines, oxygen obtained from the surrounding atmosphere for combustion process. In the rocket engines, the propulsion unit consists of own oxygen supply for combustion purpose.

17. What are the classifications of rocket engine?

    Rocket engine classified as follows:

    Chemical rocket engines

    Nuclear rocket engines

    Electrical rocket engines

    Solar rocket engines

18. What is nozzle-less propulsion?

    In nozzleless propulsion the mass burning rate of the propellant in the duct is increased and the flow reaches sonic velocity the increased pressure in the duct is converted into thrust.

19. What is under expanded nozzle?

    It is a nozzle which discharges fluid at exit pressure greater than external pressure, because the exit area is too small.

20. What is over expanded nozzle?

    It is a nozzle which discharges fluid at exit pressure lower than external pressure, because the exit area is too large.

21. What are the advantages of conical nozzle?

    It has simple configuration

    It is relatively easy to fabricate.

22. Define effective speed ratio.

    It is the ratio of speed of flight to velocity of jet.

23. In rocket engine, how the propulsive efficiency varies with respect to speed ratio?

    In rocket engine, if the speed ratio is increased, the propulsive efficiency is also increased and reaches maximum value when the speed ratio is unity. After that, the propulsive efficiency is decreased with increase in speed ratio.

24. What is mean by static rocket testing?

    It is a location where rocket engines may be tested on the ground, under controlled conditions. A ground test program is generally required before the engine is certified for flight. Ground testing is very inexpensive in comparison to the cost of risking an entire mission or the lives of a flight crew.

25. What is pulse rocket motor?

    A **pulsed rocket motor** is typically defined as a multiple pulse solid-fuel rocket motor. The pulse rocket motor allows the motor to be burned in segments (or pulses) that burn until completion of that segment.

26. What is weight flow ratio?

    It is the ratio of propellant flow rate to the throat force.

UNIT-III

SOLID ROCKET PROPULSION

1. What are the advantages of solid propellant rocket engine?
   - Simple in design and construction
   - Less vibration due to absence of moving parts
   - Less maintenance
2. What are the disadvantages of solid propellant rocket engine?
   - It is difficult to stop the engine

- Low specific impulse
- Decrease of speed is not possible

3. What is mean by erosive burning?

   Erosive burning is the increase in the propellant burning rate in a motor as a result of the high velocity of combustion gases flowing over the surface. It occurs primarily in the port passage or perforation of the grain as the combustion gases flow towards the nozzle.

4. Show the equation that represents the pressure dependence on burn rate.

$$r = ap_1^n$$

   r is the burn rate, p_1 is chamber pressure, a empirical constant, n burn rate exponent

5. What is the use of strand burner?

   Strand burner is used to measure the burning rate of the solid propellant.

6. What is cold gas propellant?

   A cold gas propellant is stored at very high pressure gives a low performance allows a simple system and is usually very reliable. It has been used for roll control and altitude control.

7. What is gelled propellant?

   A gelled propellant is a thyrotrophic liquid with a gelling additive. It behaves like a jelly or thick paint. It will not spill or leak. Readily can burn flow under pressure will burn and is safer in some respects.

8. Define heterogeneous propellants.

   In heterogeneous propellants solid propellants plastics, polymers and polyvinylchloride are used as fuels. Nitrates and perchlorates are used as oxidizer.

9. Define homogenous propellants.

   In homogenous propellants solid propellants nitroglycerine and nitrocellulose are used. It combines the properties of fuels and oxidizer.

10. Define burning rate.

    The velocity at which a solid propellant is consumed during operation is called the burning rate.

11. What is monopropellant?

    A liquid propellant which contains both the fuel and oxidizer in a single chemical is known as monopropellant.

12. What is bipropellant?

If the fuel and oxidizer are different from each other in its chemical nature then the propellant is called bipropellant.

13. Classify the rocket engine based on source of energy employed?
    - Rocket engine can be classified as
    - chemical rocket engine
    - solar rocket engine
    - nuclear rocket engine
    - Electrical rocket engine.
14. What are the factors increase the burning rate?
    - Combustion chamber pressure
    - Initial temperature of the solid propellant prior to operation
    - Combustion gas temperature
    - Velocity of gas flow parallel to the burning surface
    - Motor motion
15. What the conditions of maximum propulsive efficiency?

    The jet velocity must be twice more than the free stream velocity for which the propulsive efficiency is 66.7%.
16. What are methods to reduce combustion instability in solid rocket motor?
    - Reducing instabilities occurring in solid by using viscous damping in the boundary layer
    - Reducing the payload mass
    - Acoustic energy is absorbed by the viscoelastic solid propellant, insulator and the motor case
17. Explain the types of solid propellant.

    NH_4NO_3, KNO_3, $KCLO_4$, NH_4CIO_4

UNIT-IV

LIQUID AND HYBRID ROCKET PROPULSION

1. List the type of liquid propellent.

OXIDISER	FUEL
1. Liquid Oxygen (LOX)	1. Gasoline
2. Hydrogen peroxide H_2O_2	2. Hydrazine
3. Nitrogen tetroxide	3. UDMH

4. Nitric acid (RFNA)	4. Ethyl alcohol

2. What are the disadvantages of liquid propellant rocket engine?
   - Manufacturing cost is high.
   - High vibration
   - The size and weight of the engine is more compared to solid propellant rocket.
3. What are the types of propellant feed system?
   - Gas pressure feed system
   - Pump feed system
4. What are the basic combustion processes?
   - Injection
   - Atomization
   - Mixing
   - Ignition
   - Chemical reaction between fuel and oxidizer.
5. What is the limitation of hybrid rocket engine?

   In the hybrid rocket engine, the nozzle erosion cannot be avoided.
6. What are the advantages of hybrid rocket engine?
   - Speed regulation is possible by regulating the supply of oxidizer
   - High load capacity
   - High fuel density
   - Lighter compared to liquid propellant rockets
7. Define Mixture ratio.

   The propellant mixture ratio for a bipropellant is the ratio at which the oxidizer and fuel are mixed and react to give hot gases.
8. What are the components of liquid propellant rocket engine?
   - Tanks for storing liquid fuel and oxygen
   - Preheater
   - Combustion chamber and nozzle
9. List out the selection criteria for choosing liquid propellant.
   - Economic factors
   - Performance of propellant
   - Toxicity, fire and explosion hazards

- Low freezing point, high specific gravity, stability.

10. What are cryogenic engines?

    A **cryogenic** rocket **engine** that uses a **cryogenic** fuel or oxidizer, that is, its fuel or oxidizer or both are gases liquefied and stored at very low temperatures. The combination of liquid hydrogen (LH2) (-253^0 C) fuel and the liquid oxygen (LOX) (-183) oxidizer is one of the most widely used.

11. What is hypergolic?

    Hypergolic propellant are fuels and oxidiser which ignites spontaneously on contact with each other and required no ignition source

    Hypergolic fuels includes hydrazine, monomethyl hydrazine (MMH) and Unsymmentrical dimethyl hydrazine (UDMH)

12. What is reverse hybrid system?

    In normal Hybrid propulsion the fuel used in solid from and the oxidizer in liquid form. Whereas reverse hybrid system the oxidizer of the propellant in solid and fuel in from.

13. What is need of hybrid rocket motor?

    Hybrid rockets provides high thrust rocket engine with good performance and also it reduce the complexity and cost of the rocket. Hence it has both the solid and liquid phase propellant advantages.

14. Write down three fuel – oxidizer combination for hybrid propellant rockets?

    - Beryllium hydride – Fluorine
    - Lithium hydride – chlorine trifluoride
    - Hydrocarbon – Nitrogen tetroxide
    - Lithium hydride – Nitrogen tetroxide

UNIT – V

ADVANCED PROPULSION TECHNIQUES

1. What are the disadvantages of pulsed plasma electrical propulsion system?
    - Low thrust
    - Teflon reaction products are toxic
    - Corrosive
2. What are the advantages of steady state plasma electromagnetic propulsion system?
    - Can be relatively simple
    - High specific impulse

- High thrust per unit area

3. What are the disadvantages of steady state plasma electromagnetic propulsion system?
    - Difficult to stimulate analytically
    - High specific power
    - Heavy power supply
4. What are the advantages of Hall thruster?
    - Desirable Isp range
    - Compact relatively simple power conditioning
    - Inert propellant
5. What are the disadvantages of Hall thruster?
    - Single propellant
    - High beam divergence
    - Erosion.
6. Explain solar sail.

    Solar sails are a form of spacecraft propulsion using radiation pressure exerted by sunlight on large mirrors. Each light particle has momentum, and when it strikes a reflective surface, it imparts that momentum to the reflective sheet, just like a collision of two billiard balls. As billions of light particles hit the sheet, they push the sail strongly enough to move a spacecraft.

7. What are the requirements for solar sail powered spacecraft?
    - Continuous force exerted by sunlight
    - A large ultrathin mirror
    - A separate launch vehicle.
8. What are the types of electrical rocket engines?
    - Arc plasma rocket engine
    - Ion rocket engine
    - Magneto- plasma rocket engine.
9. What are the components in Arc plasma rocket engine?
    - Propellant tank
    - Combustion chamber
    - Cooling system
    - Electric power supply.

10. What are the components in Magneto- plasma rocket engine?
    - Propellant tank
    - Propellant pump
    - Thrust chamber
    - Accelerator.
11. What is the principle of Ion propulsion system?

    Liquid fuel from the propellant tank is pumped to a vapourization chamber where the propellent is heated and vapourised and then passed into the ionization chamber for ionization, the resultant ions are then accelerated by an electric field. The high velocity ions coming from the unit produce thrust force.
12. What are the components in Ion rocket engine?
    - Propellant tank
    - Thrust chamber
    - Electric power supply
    - Vapourizing chamber.
13. What are the methods for ion generation?

    There are three methods for ion generation. They are
    - Surface contact
    - Electron bombardment and
    - Electric arc.
14. What are the advantages of electrical propulsion system?
    - Simple device and easy to control
    - Simple power containing
    - Low cost and relatively high thrust and efficiency
    - Can use many propellants including hydrazine augmentation.
15. What are the disadvantages of electrical propulsion system?
    - Lowest I_{sp}, Heat loss
    - Dissociation of gas
    - In direct of heating of gas and erosion.
16. What are the advantages of arc jet propulsion system?
    - Direct heating of gas.
    - Low voltage
    - Relatively simple device and high thrust.

- Can use catalytic hydrazine augmentation inert propellant.

17. What are the disadvantages of arc jet propulsion system?
    - Low efficiency
    - Erosion at high power and low specific impulse
    - High current, heavy wiring, heat loss
    - More complex power conditioning.
18. What are the advantages of ion jet propulsion system?
    - High specific impulse
    - High efficiency
    - Inert propellant.
19. What are the disadvantages of ion jet propulsion system?
    - Complex power conditioning and heavy power supply
    - High voltage, single propellant only
    - Low thrust per unit area.
20. What are the advantages of pulsed plasma electrical propulsion system?
    - Simple device and low power.
    - Because of solid propellants, no need of gas or liquid feed system and there is no zero gravity effects on propellants.