Propulsion-2

1. What is an integral ram rocket?

A ducted rocket, some times called as an air-augmented rocket, combines the principles of rocket and ramjet engines, it gives higher performance (specific impulse) than a chemical rocket engine, while operating within the earth's atmosphere. Usually the term air-augmented rocket denotes mixing of air with the rocket exhaust (full-rich for after burning) in proportions that enabled the propulsion device to retain the characteristics of the rocket engine, for example, high static thrust and high thrust to weight ratio.

2) What is a rocket motor ?

A rocket motor is a device for converting the thermo chemical energy of one or more propellants into exhaust jet kinetic energy.

3) Explain Under and Over expanded nozzles.

An under expanded nozzle discharges the fluid at an exit pressure greater than external pressure because the exit area is too small for an optimum area ratio. The expansion of the fluid is there fore incomplete within the nozzle and must take place outside. The nozzle exit pressure is higher than the local atmospheric pressure.

In an over expanded nozzle, the fluid attains a lower exit pressure than the atmosphere as it has an exit area too large for optimum area ratio.

4) Explain linear aerospike nozzles.

The linear aero spike is an altitude compensation nozzle with a variation of the round axisymmetric aero spike nozzle axis. The flow is turned on a curved contour outer diverging nozzle wall. The nozzle has been shortened and has some internal oblique shock wave losses. The hot gas flow leaving the chamber expands around a central plug.

5) What are the advantages and disadvantages of using multiple nozzles?

If a single large nozzle is replaced by a cluster of smaller nozzles (all the same cumulative thrust), then it is possible to reduce the nozzle length. Similarly, if several replace a single large thrust chamber of a liquid engine smaller thrust chambers, the nozzle length will be shorter, reducing the vehicle length and thus the vehicle structure and inert mass.

The vehicle diameter at the cluster nozzle exit is somewhat larger, the vehicle drag is somewhat higher, and there is additional engine complexity and engine mass.

6) Define effective exhaust velocity.

The effective exhaust velocity 'c' is the average equivalent velocity at which propellant is ejected from the vehicle.

It is given in meters per second or feet per second.

7) Define specific impulse.

The thrust per kg of air flow is known as specific thrust or specific impulse. This specific impulse is a criterion of the size of engine required for producing a given total thrust.

8) Define specific propellant consumption.

The specific propellant consumption is the reciprocal of the specific impulse. It is defined as the required propellant weight flow to produce a unit of thrust force in an equivalent rocket.

9) Define mass ratio.

The mass ratio of a vehicle or a particular vehicle stage is defined to be the final mass after rocket operation, after propellants were consumed, divided by the initial mass before rocket operation.

10) Define impulse-to-weight ratio.

The impulse to weight ratio of a complete propulsion system is defined as the total impulse divided by the initial vehicle weight or loaded vehicle weight. A high value indicates an efficient design.

11) Explain the two types of thrust.

The thrust acting on a vehicle is composed of two terms. The first term, the momentum thrust is the product of the propellant mass flow rate and exhaust velocity relative to the vehicle. The second term, the pressure thrust consists of the product of the cross-sectional area of the exhaust jet leaving the vehicle and the difference between the exhaust pressure and the fluid pressure.

12) Define grain configuration.

The shape or geometry of the initial burning surfaces of a grain as it is intended to operate in a motor.

13) What is a cylindrical grain?

A grain in which the internal cross section is constant along the axis regardless of perforation shape.

14) What is Neutral Burning?

Motor burn time during which thrust, pressure, and burning surface area remain approximately constant, typically within about ±15%. Many grains undergo neutral burning.

15) What are perforations?

The central cavity port or flow passage of a propellant grain; its cross section may be a cylinder, a star shape, etc.

16) Define progressive and regressive burning.

Burn time during which thrust, pressure, and burning surface area increases is called progressive burning

Burn time during which thrust, pressure, and burning surface area decrease is called regressive burning.

17) What is a Silver in grain terminology?

Unburned propellant remaining (or lost—that is, expelled through the nozzle) at the time of web burnout is known as silver.

18) Define burning time and action time.

Burning time, Or Effective Burning Time, t_b is the interval from 10% maximum initial pressure (or thrust) to web burnout, with web burnout usually taken as the aft tangent-bisector point on the pressure-time trace.

Action Time, t_a is the burning time plus most of the time to burn silvers; typically, the interval between the initial and final 10% pressure (or thrust) points on the pressure-time trace.

19) What is an Inhibitor?

A layer or coating of slow or non burning material (usually, a polymeric rubber type with filler materials) applied (glued, painted, dipped, or sprayed) to a part of the grain's propellant surface to prevent burning on that surface. By preventing burning on inhibited surfaces the initial burning area can be controlled and reduced. Also called restrictor.

20) What is a Liner in grain terminology?

A sticky non-self-burning thin layer of polymeric-type material that is applied to the cases prior to casting the propellant n order to promote good bonding between the propellant and the case or the insulator. It also allows some axial motion between the grain periphery and the case.

21) What is an Internal Insulator?

An internal layer between the case and the propellant grain made of an adhesive, thermally insulating material that will not burn readily. Its purpose is to limit the heat transfer to the temperature rise of the case during rocket operation**.**

22) Define Volumetric loading fraction.

Volumetric Loading Fraction, V_f: is the ratio of propellant volume V_b to the chamber volume V_c (excluding nozzle) available for propellant, insulation, and restrictors

V_b = m/p:

$$V_f = V_b / V_c = I_t / (I_s \rho_b g_0 V_c)$$

Where I_t is the total impulse, I_s the specific impulse, and ρ_b the propellant density.

23) Define propellant mixture ratio for a bi-propellant.

The propellant mixture ratio for a bipropellant is the ratio at which the oxidizer and fuel are mixed and react to give hot gases. The mixture ratio r is defined as

$$\text{Mixture ratio, } r = \frac{\dot{m}_o}{\dot{m}_f} = \frac{\text{Oxidizer massflow rate}}{\text{Fuel mass flow rate}}$$

24 Mention some of the factors to be considered in selecting a liquid propellant.

1) Heat of combustion
2) Reaction rate
3) Average propellant density
4) Stability
5) Vapor pressure
6) Freezing point
7) Ignitability
8) Viscosity.
9) Specific Heat
10) Thermal Conductivity

25 What is the function of injectors.

The injector has to introduce and meter the flow of the liquid propellant to the combustion chamber, cause the liquids to be broken up into small droplets (a process called atomization),and mix the propellant in such a manner that the correctly proportionate mixture of fuel and oxidizer will result , with uniform propellant mass flow and composition over the chamber cross section.

26 What is TVC ?

Thrust vector control (TVC) is the internal change of direction of the thrust vector with respect to the symmetry axis of the rocket. By changing the direction of the thrust vector, a control moment about a lateral axis of the rocket can be generated.

27 What are the advantages and disadvantages of solid propellant rocket.

Advantages

a. Simple design (few or no moving parts).
b. Easy to operate (little preflight checkout).
c. Ready to operate quickly.
d. Will not leak, spill or slosh.
e. Thrust termination devices permits control over total impulse.

Disadvantages

1. Explosion and fire potential is large, failure can be catastrophic; most cannot accept bullet impact or being dropped on to a hard surface.
2. Many require environmental permit and safety features for transport on public conveyances.
3. If designed for reuse, it requires extensive factory rework and new propellants.
4. Requires an ignition system.
5. Each restart requires a separate ignition system and additional insulation

28 State the advantages and disadvantages of liquid propellant rocket.

Advantages

1. Highest specific impulse; for a fixed propellant mass
2. Can be largely checked out just prior to operation. Can be tested at full thrust on ground or launch pad prior to flight.
3. Can be designed for reuse after field services and checkout.
4. Thrust chamber (or some part of the vehicle) can be cooled and made light weight.
5. Most propellants have nontoxic exhaust, which is environmentally acceptable

Disadvantages

1. Relatively complex design
2. Tanks need to be pressurized by a separate pressurization subsystem. This can require high pressure inert gas storage (2000 to 10000 psi) for long periods of time.
3. More difficult to control combustion instability.
4. Usually requires more volume due to lower average propellant density and the relatively inefficient packaging of engine components.

29) What is the principle of arc jet ?

. Propellant is heated to high temperature in an electric arc and then expanded in a conventional nozzle. The high-current-density arc discharge is maintained by a sufficient voltage difference between cathode and anode.

30 Explain the principle of ion propulsion.

The principle of electrostatic or ion propulsion is simply the acceleration of charged particles by an electric filed. The propellant source feeds neutral atoms to an ion source and the positive ions generated are accelerated by one or more sets of electrodes which are maintained at zero potential, the ion source being at a high potential. The negative ions or electrons have to be returned eventually to the positively charged exhaust stream to maintain a neutral beam.

31 What is a Solar sail.

Solar sail is a big photon reflection surface. The power source for the sail is the sun and it is external to the vehicle. Approaches using nuclear explosions and pulsed nuclear fusion, has been analyzed. Concepts for transmitting radiation energy from earth stations to satellites have been proposed, but are not yet developed.

32 Explain the principle of electromagnetic thrusters.

According to electro magnetic theory, whenever a conductor carries a current perpendicular to a magnetic field, a body force is exerted on the conductor in a direction at right angles to both the current and the magnetic field. Unlike the ion

engine, this acceleration process yields a neutral exhaust beam. Another advantage is the relatively high thrust density, or thrust per unit area, which is normally about 10 to 1000 times of the ion engines.

33 Define hypersonic transport vechile.

A Hypersonic Vehicle is a vehicle that travels at least 4 times faster than the speed-of-sound, or greater than Mach 4.

A hypersonic vehicle can be an airplane, missile, or spacecraft. Some hypersonic vehicles have a special type of jet engine called a Supersonic Combustion Ramjet or scramjet to fly through the atmosphere. Sometimes, a hypersonic plane uses a rocket engine.

A Re-entry Vehicle is another type of Hypersonic Vehicle. A Re-entry Vehicle is a spacecraft that travels through space and re-enters the atmosphere of a planet, and most of the time, does not have an engine

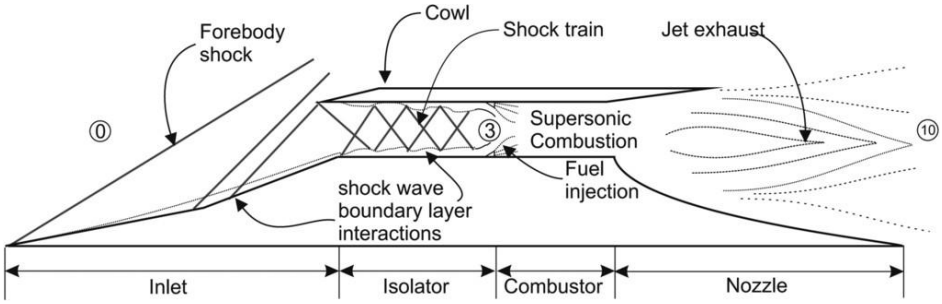
34 What is the need for supersonic combustion in hypersonic propulsion?

Supersonic combustion air-breathing engines have long been recognized as the most well-suited for hypersonic propulsion in the Mach 5-10 range. Designs for hypersonic engines have been around since the early 1900's.

Ramjet technology has been developing over the past eight decades and, except for marginal improvements, has been shown to be suited for atmospheric flight speeds up to Mach 5.

The desire for faster, more efficient engines gave birth to the idea of a scramjet, utilizing supersonic combustion and potentially expanding the speed envelope to the Mach 15 range. The promise of covering the entire planet at high speed from horizontal takeoff for both civil and military aircraft is an attractive prospect.

35 Draw a neat sketch of scramjet engine and list its parts.



36 What is the role of isolator in scramjet engine?

At flight speeds below Mach 8, combustion in a scramjet engine can

generate a large local pressure rise and separation of the boundary layer on the surfaces of the combustion duct. This separation, which can feed upstream of fuel injection, acts to further diffuse the core flow in the duct, and will affect the operation of the inlet, possibly causing an unstart of the engine.

The method use to alleviate this problem is the installation of a short duct between the inlet and the combustor known as an isolator.

In some engines (those which operate in the lower hypersonic regime between Mach 4 and 8) the combination of the diffusion in the isolator and heat release in the combustion decelerate the core flow to subsonic conditions, in what is called dual-mode combustion.

At speeds above Mach 8 the increased kinetic energy of the airflow through the engine means that the combustion generated pressure rise is not strong enough to cause boundary layer separation. Flow remains attached and supersonic throughout, and this is termed pure scramjet. In this case an isolator is not necessary.