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Rocket Propulsion Terminology

1. **Rocket Propulsion** is a means of locomotion whereby thrust is produced by ejecting matter, which is stored in the vehicle being propelled.

2. **Chemical Rocket Propulsion** refers to those systems where the energy comes from a chemical reaction or combustion of a Fuel with an Oxidizer. In contrast, electric propulsion or nuclear propulsion uses a single propellant and energy from an electric power supply or a nuclear reaction.

3. The **Chamber Pressure** is the pressure in the combustion chamber of an operating rocket propulsion system.

4. **Propellant** is the stored matter that is energized and ejected. It can be a **Liquid Propellant** (stored in vehicle or missile tanks) or a **Solid Propellant** (stored inside its combustion chamber). Rocket propellants undergo a chemical reaction or a **Combustion Process** (usually at high chamber pressure and high temperature) that transforms them into hot gaseous reaction products or **Exhaust Gases**, which are then accelerated and ejected through a **Supersonic Nozzle**.

5. **Specific Impulse** is a parameter indicating propulsion system performance. It can be defined as the thrust of an equivalent rocket propulsion system (same chamber pressure, same propellant, same nozzle throat to exit area ratio) that has a propellant mass flow of unity. Higher values indicate a better system.

6. **Total Impulse** is the integral of thrust over the propulsion operating time. It is a measure of the total kinetic energy of the nozzle exhaust gas as released by the combustion of all the available propellant in the propulsion system. For constant thrust operation it is the average thrust multiplied by the effective propulsive operating duration or it is also the mass of the total expelled propellant multiplied by the average specific impulse.

7. **Bipropellants** refer to a propellant combination consisting of a liquid **Fuel** (e.g., kerosene or liquid hydrogen) and a liquid **Oxidizer** (e.g., nitrogen tetroxide or liquid oxygen), which when mixed, can react chemically to form hot combustion gas. If the fuel and the oxidizer react spontaneously (a chemical reaction occurs when they come in contact with each other), they are called **Hypergolic Propellants**. Liquid propellants that do not ignite spontaneously, require energy (usually an **Igniter**) to initiate combustion.

8. **Cryogenic propellants** are subcooled liquids at low temperature (such as liquid oxygen or liquid hydrogen); they are gases at ambient temperatures.

9. **Mixture Ratio** is the ratio of the liquid oxidizer flow rate divided by the liquid fuel flow rate. The best performance (highest specific impulse) is obtained at a specific optimum mixture ratio.

10. A **Liquid Propellant Rocket Engine** has these principal components: one or two **propellant tanks**, one or more **thrust chambers**, a **feed mechanism** (pumps — driven by a turbine or displacing the propellant in the tank(s) by high pressure inert gas), **piping** and **control valves**, and sometimes servo- valves (for starting, stopping, throttling, or mixture ratio control).

11. A **Rocket Engine** (it uses liquid propellants) and a **Rocket Motor** (solid propellants) are the two most common types of **Rocket Propulsion System**.

12. A **Rocket Engine** usually consists of one or more **Thrust Chambers**, one or more **Tanks** for storing propellants, a **Feed Mechanism** to force the liquids into the thrust chamber, a **Power Source** to provide energy to the feed mechanism, suitable **Piping** and **Valves** to transfer the liquid propellants, a structure to transmit the thrust force to the vehicle, and **Controls** to initiate and regulate the propellant flow rates.

13. The **Thrust Chamber**, also often called **Thruster** (usually for low thrust and repeated starts), has an **Injector** (where propellants are introduced and metered), a **Combustion Chamber** (where liquid propellants react and burn) and a converging-diverging **Nozzle**, where the hot combustion gas is accelerated and ejected at supersonic velocities.

14. The engine **Feed Mechanism** can be a **Pressurized System**, where high pressure gas expels the liquid propellants from its tanks, or a **Turbopump System**, where pumps feed the propellants to the thrust chamber; the **Propellant Pumps** in turn are driven by a **Turbine** that can derive its power from hot gases generated in a **Gas Generator** (really a second combustion chamber).

15. A **Rocket Motor** uses solid propellants and a simple motor usually has these key components: the propellant **Grain** (the shaped mass of solid propellant), the motor **Case**, which is a pressure vessel containing the grain, **Insulation** for preventing the case from becoming too hot, a supersonic **Nozzle** to accelerate the gasified, reacted propellant, and a mounting provision to hold the motor to the vehicle or missile. Cases are really pressure vessels constructed from heat treated alloy metal (steel, titanium) or from filament reinforced plastic (usually an epoxy plastic) with fibers made of either glass, Kevlar, or carbon.

16. **Solid Rocket Propellant** typically consists of an oxidizer (usually a crystalline solid like ammonium perchlorate), an organic **Fuel** (such as a rubbery polymer like polybutadiene, which also acts as the glue to hold the grain together), and various **additives** to improve performance, storage, thrust-time profile, manufacture, aging, etc. Additives include liquid **Plasticizers**, **Explosives**, **Burning Rate Catalysts**, etc.

17. The **Burning Rate** is the rate of regression of the burning grain surfaces as propellant is consumed or burnt (inches per second) in a direction normal to the surface. Surfaces that are bonded to the case walls or to insulators, will not burn. **Inhibitors** are layers of non-burning materials that are glued to exposed grain surfaces so that they will not burn. The propellant flow and, therefore, also the thrust are proportional to this burning rate and the exposed burning surface. The burning rate varies with chamber pressure and the initial ambient temperature of the grain.

18. The **Grain** has **Perforations**, **Slots**, **Grooves**, holes, or **Port Areas** so as to predetermine the amount of initial burning surface. Most grains are cast into and bonded to the case; some grains are bonded to a separate cartridge, which is then loaded or placed into the case.

19. The **Binder** is a thin layer of sticky rubbery material that promotes the adhesion of the grain to the case.

20. **Internal Insulators** are layers on the inside of the case wall made of material with low thermal conductivity; they protect the case from the hot combustion gases and prevent it from reaching the temperature where the case material loses its strength.

21. **External Insulators** are applied to the outside of liquid propellant tanks or solid propellant motor cases to protect against excessive heat transfer from hot air, when flying through the atmosphere at high speed.

22. **Igniters** burn igniter propellants, which then form hot gas at an elevated pressure and they in turn initiate the combustion of the main propellant, either a solid propellant or a non-hypergolic liquid bipropellant. The igniter is started by a small amount of electrical energy, (e.g., hot wire) or laser energy.

23. The **Safe** and **Arm Mechanism** is usually a complex electromechanical device. In the "safe" condition it prevents inadvertent or stray electrical currents from reaching the igniter. In the "arm" condition the igniter can be activated.

24. **Thrust Vector Control** allows the deflection of the thrust direction (usually the axis of the nozzle) through a small angle (up to 10 degrees) with respect to the vehicle axis. This allows the control of the vehicle's attitude and flight path by applying **Pitch** (nose up or down), **Yaw** (nose turns right or left) and **Roll Moments** (rotation about the missile's axis). Different mechanisms have been used, including **Gimbal** suspension of the thrust chamber, **Flexible Nozzles**, or **Jet Vanes**.

25. **Attitude Control** (vehicle rotation) and a limited amount of **Flight Velocity Change** can also be achieved by a series of small thrusters, which are located in various locations on the vehicle. By **Pulsing** individual thrusters or pairs of

thrusters (repeated short duration operations) the vehicle can be rotated and maneuvered.

26. The **Nozzle Area Ratio** is the nozzle exit area divided by the nozzle throat area. For optimum gas expansion in a nozzle the gas pressure at the nozzle exit is equal to the local ambient atmosphere pressure. Typical values of this nozzle area ratio are between 4 and 20 for expansion to sea-level pressure and between 40 and 200 for operation at very high altitude (space vacuum).

27. In uncooled nozzles the gradual **Erosion** of the nozzle throat causes a small increase in nozzle cross-sectional area and thus a small decrease in chamber pressure and thrust.

28. An **Ablative Chamber** or **Nozzle Well** absorbs heat (from the hot gases) by having some of the heated ablative well material (e.g., reinforced organic fibers in an organic matrix or phenolic resins) vaporized, endothermically decomposed into gaseous species, or charred. The evaporated gas products flow out of the ablative material and form a protective cooler gas layer at the wall's surface.