SNS COLLEGE OF TECHNOLOGY
(An Autonomous Institution)

Department of Aerospace Engineering

23AST101-Fundamentals of Aerospace Engineering

UNIT-4:
POWER PLANTS

ROCKETS

Mr.N.Venkatesh (AP/Aerospace)

A **rocket engine** is a type of jet engine that produces thrust by expelling high-speed exhaust gases generated through the combustion of propellants. Unlike air-breathing engines (like jet engines), rocket engines carry both fuel and oxidizer, allowing them to operate in the vacuum of space.

Types of Rocket Engines

Rocket engines are classified based on their **propellant type**, **power source**, and **design**. The main types include:

1. Chemical Rocket Engines

These engines generate thrust by chemical reactions (combustion) between fuel and oxidizer.

A. Liquid-Propellant Rocket Engines (LRE)

Use **liquid fuel** (e.g., RP-1, LH2) and **liquid oxidizer** (e.g., LOX, N_2O_4).

Advantages: High efficiency, throttleable, restartable.

Disadvantages: Complex design, high cost.

Examples: SpaceX Merlin (Falcon 9), RS-25 (Space Shuttle).

B. Solid-Propellant Rocket Engines (SRB)

Use a **pre-mixed solid fuel-oxidizer** (e.g., APCP – Ammonium Perchlorate Composite Propellant).

Advantages: Simple, reliable, high thrust-to-weight ratio.

Disadvantages: Cannot be throttled or shut down once ignited.

Examples: Space Shuttle SRBs, SLS Boosters.

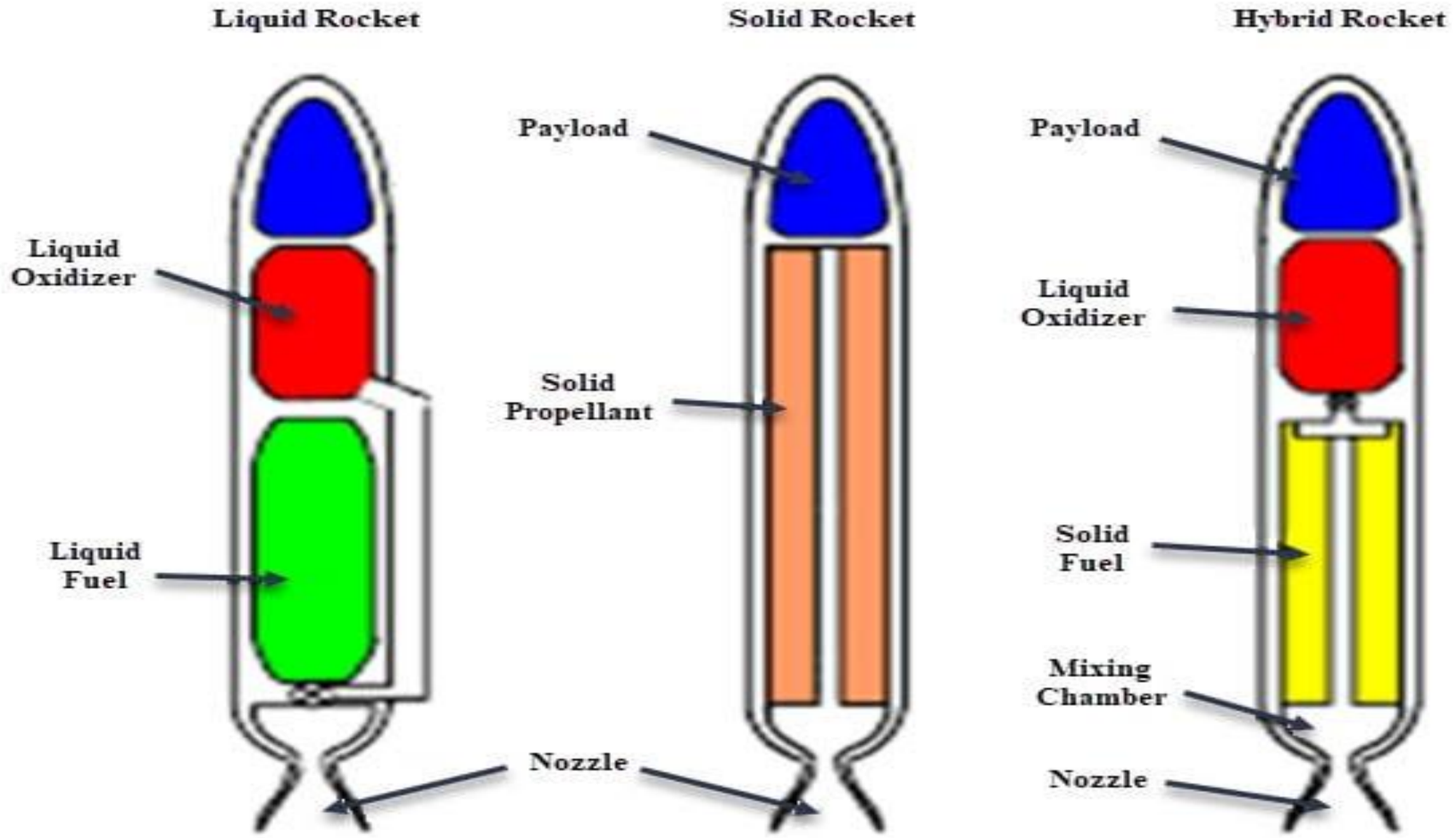
C. Hybrid Rocket Engines

Use a **solid fuel** and a **liquid/gaseous oxidizer** (or vice versa).

Advantages: Safer, throttleable, simpler than LRE.

Disadvantages: Lower performance than pure liquid/solid rockets.

Examples: Virgin Galactic SpaceShipTwo.


Liquid Rocket
Liquid Oxidizer
Liquid Fuel
Nozzle
Solid Rocket
Payload
Solid Propellant
Nozzle
Hybrid Rocket
Payload
Liquid Oxidizer
Solid Fuel
Mixing Chamber
Nozzle

2. Electric Propulsion Systems

These engines use **electric power** (solar/nuclear) to accelerate propellants.

A. Ion Thruster (Electrostatic)

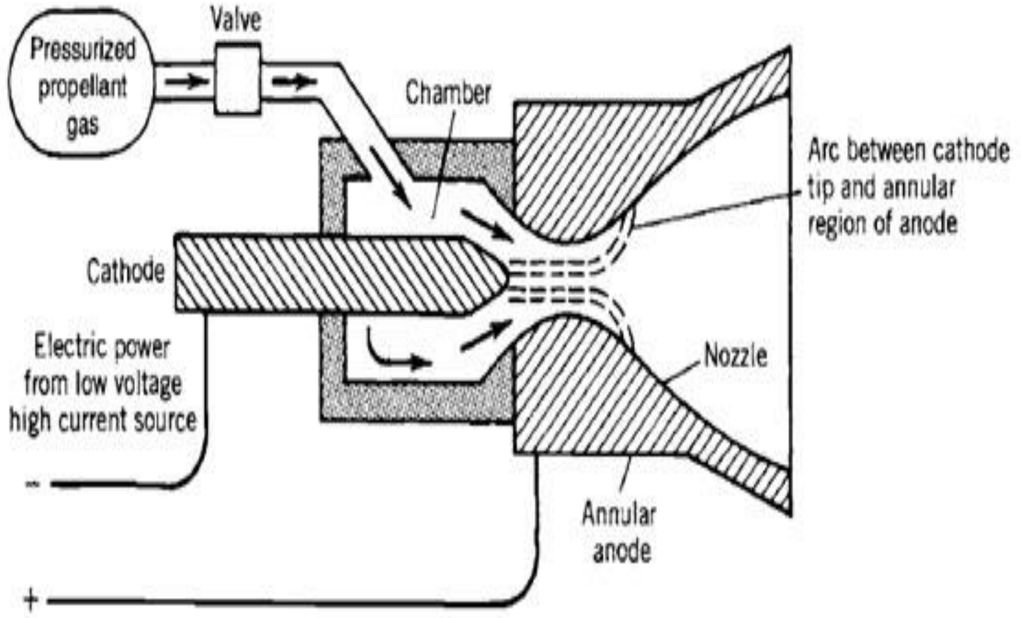
Uses **ionized gas (Xenon)** accelerated by electric fields.
Advantages: Extremely efficient (high ISP), long-duration operation.
Disadvantages: Very low thrust, requires high power.
Examples: NASA's Dawn spacecraft, SpaceX Starlink Hall-effect thrusters.

B. Plasma Thruster (Electromagnetic)

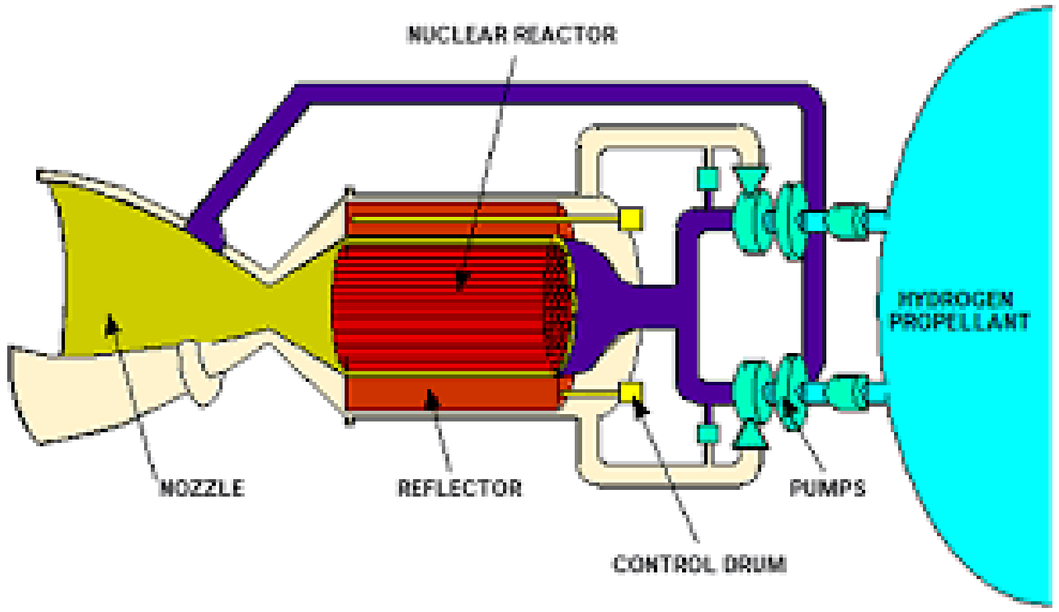
Uses **superheated plasma** accelerated by magnetic fields.
Examples: VASIMR (Variable Specific Impulse Magnetoplasma Rocket).

C. Electrothermal (Arcjet/Resistojet)

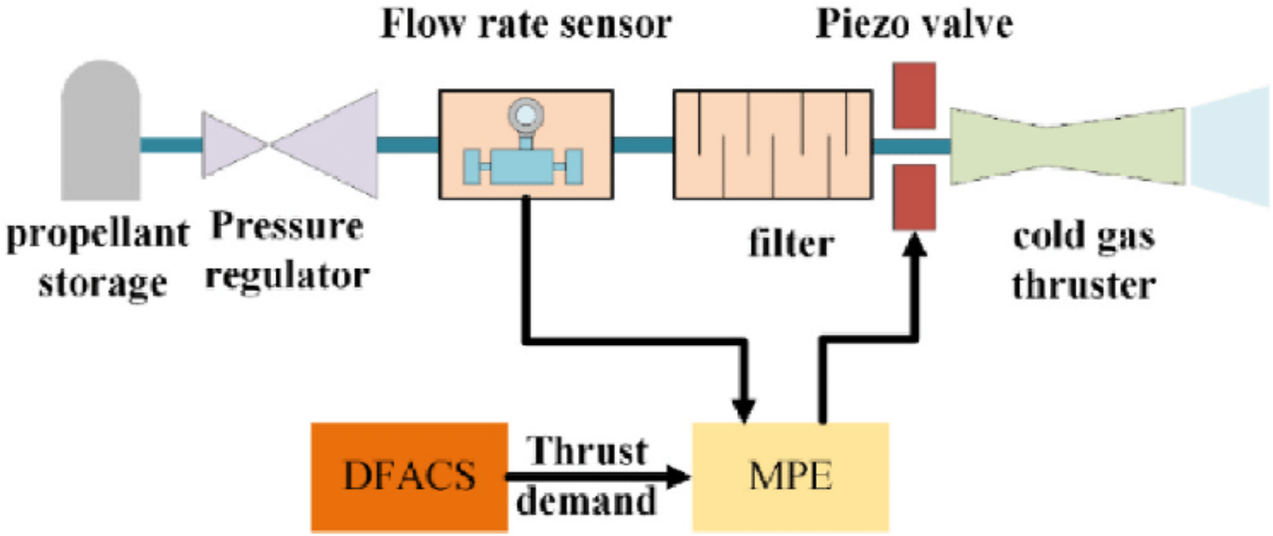
Heats propellant electrically before expansion.
Examples: Used in satellite station-keeping.



3. Nuclear Thermal Rocket (NTR)
Uses a **nuclear reactor** to heat hydrogen propellant.
Advantages: High efficiency (2× chemical rockets), good thrust.
Disadvantages: Radioactive risks, complex engineering.
Examples: NASA's NERVA (tested in the 1960s).



4. Cold Gas Thrusters
Uses **compressed gas (N_2, CO_2)** released through a nozzle.
Advantages: Simple, no combustion.
Disadvantages: Very low thrust and efficiency.
Examples: Used in spacecraft attitude control.



Thrust in Rocket Engines

- **Thrust** is the force produced by a rocket engine (measured in **Newtons or pounds-force, lbf**).
- **Thrust equation:**

$$F = \dot{m} \cdot v_e + (P_e - P_a) \cdot A_e$$

  - $\dot{m}$ = mass flow rate of exhaust
  - v_e = exhaust velocity
  - P_e = exit pressure
  - P_a = ambient pressure
  - A_e = nozzle exit area

Thrust Comparison of Different Engines

Engine Type	Thrust Range	Specific Impulse (ISP)
Solid Rocket	1 MN – 20 MN (e.g., SLS)	250–300 s
Liquid (RP-1/LOX)	500 kN – 8 MN (Falcon 9)	300–350 s
Liquid (LH2/LOX)	100 kN – 2 MN (RS-25)	450–460 s
Ion Thruster	0.1–5 N (very low)	2000–10,000 s
Nuclear Thermal	50–300 kN	800–1000 s

Conclusion

- **Chemical rockets** (liquid/solid) are used for **high-thrust** applications (launch vehicles).
- **Electric propulsion** is used for **deep-space missions** due to high efficiency but low thrust.
- **Nuclear and advanced propulsion** (e.g., VASIMR) may power future Mars missions.


THANK YOU!