SNS COLLEGE OF TECHNOLOGY
(An Autonomous Institution)

Department of Aerospace Engineering

23AST101-Fundamentals of Aerospace Engineering

UNIT-1:
History of Flight

Propulsion

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Aircraft propulsion systems generate thrust to move an aircraft forward. There are several types of propulsion systems used in aviation, each with specific applications depending on aircraft type and mission requirements.

Types of Aircraft Propulsion Systems

1. **Jet Propulsion (Gas Turbine Engines)**

Jet propulsion is the method of generating **thrust** by expelling high-speed exhaust gases. It is used in modern **airliners, fighter jets, UAVs, and spacecraft**. The core principle is based on **Newton's Third Law of Motion**: *For every action, there is an equal and opposite reaction*

Jet Engines Work

A jet engine operates through the following stages:

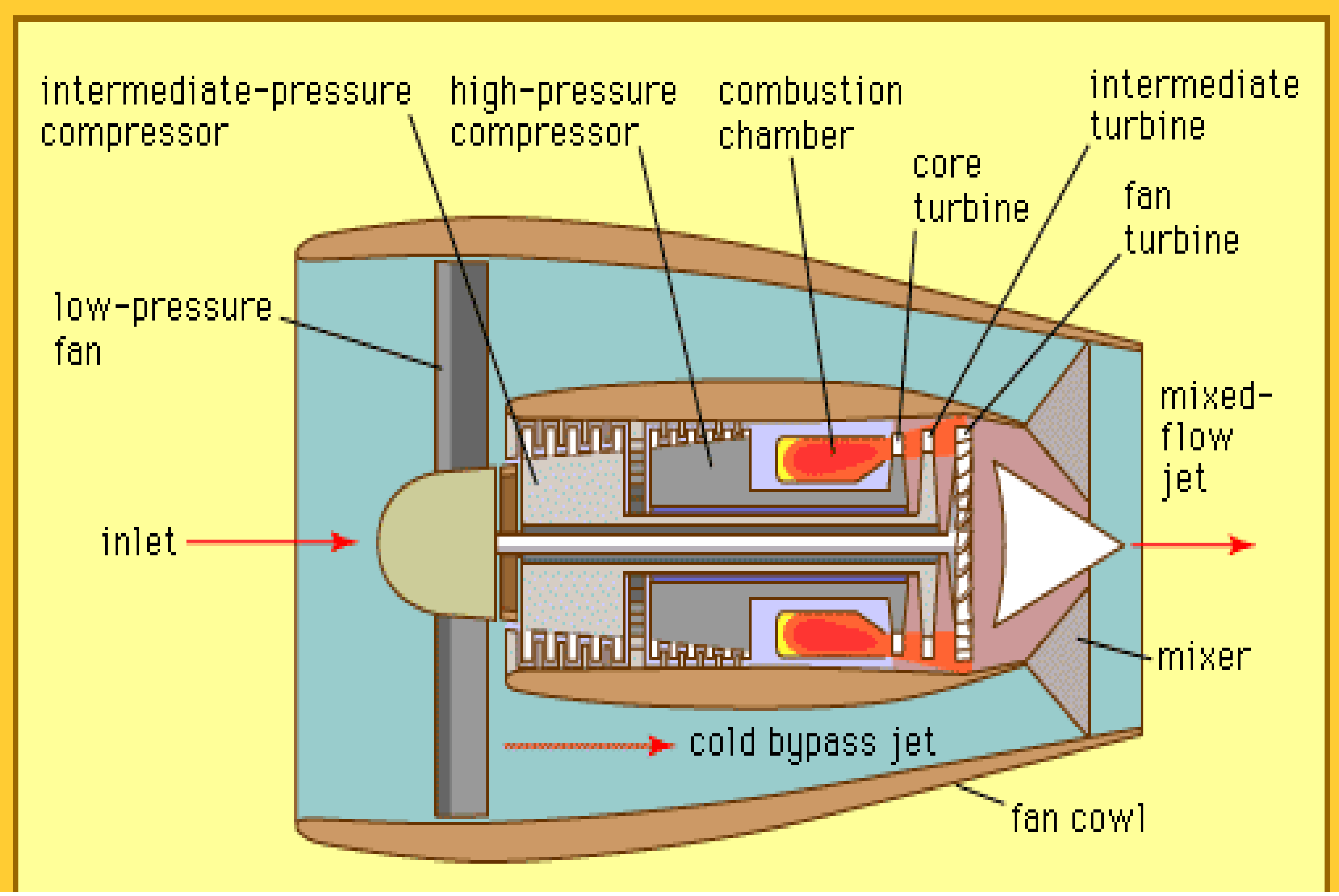
Intake – Air is drawn into the engine at high speed.

Compression – Air is compressed by axial or centrifugal compressors.

Combustion – Fuel (Jet A, JP-8) is injected and ignited.

Expansion & Turbine Power – Hot gases expand, spinning turbines.

Exhaust & Thrust – The accelerated gases **exit the nozzle, generating thrust.**



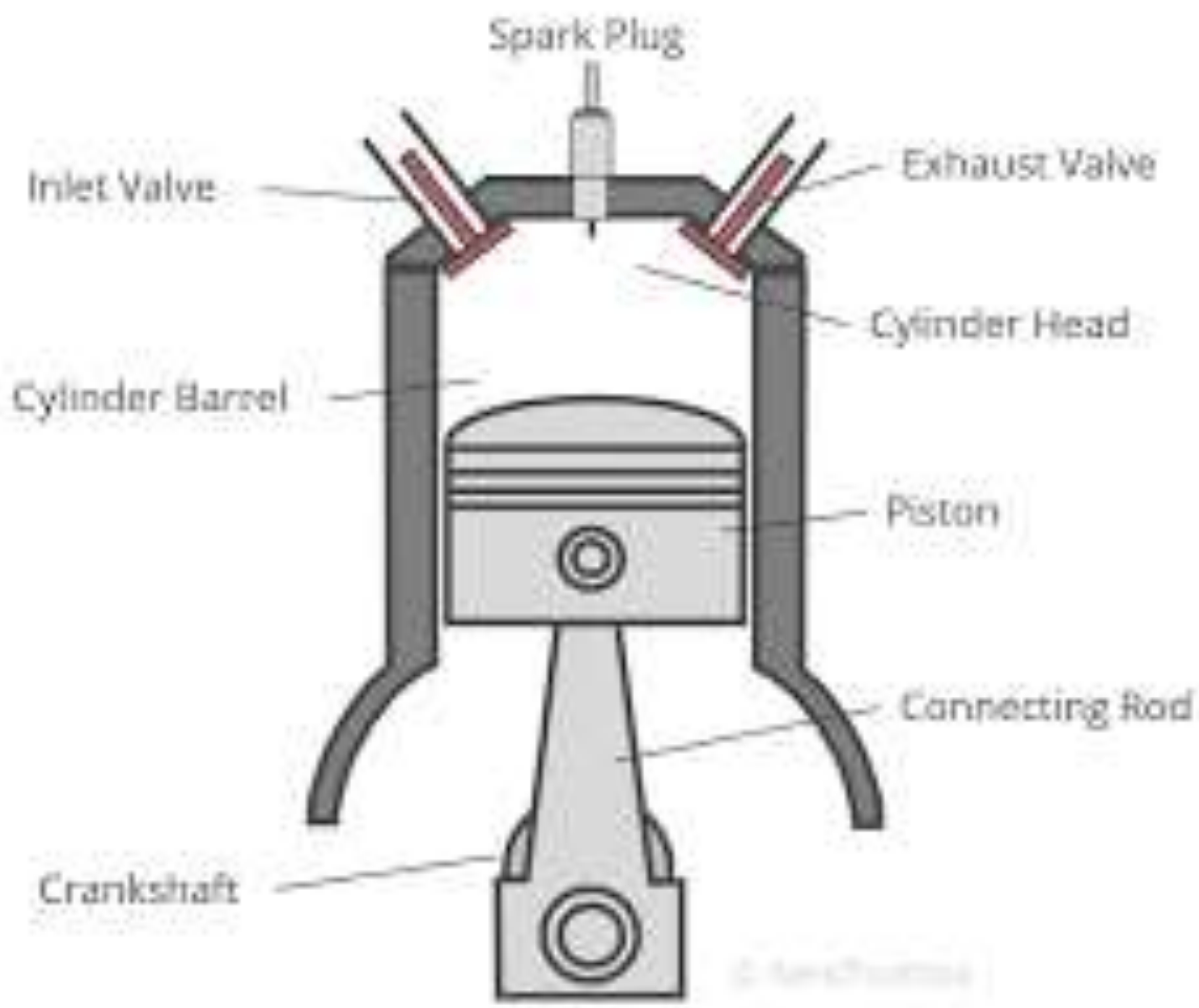
Common Use: Commercial jets, military aircraft, UAVs

Types of Jet Engines:

- **Turbojet**: High speed, supersonic aircraft (e.g., Concorde)
- **Turbofan**: Efficient for commercial airliners (e.g., Boeing 747)
- **Turboprop**: Hybrid of jet & propeller for regional aircraft (e.g., ATR 72)
- **Turboshaft**: Used in helicopters (e.g., Sikorsky UH-60)

2. Piston Engine (Reciprocating Engine)

A **piston engine** (reciprocating engine) is an internal combustion engine that generates power by burning fuel in cylinders, moving pistons up and down. This mechanical energy is converted into rotational motion, which drives a **propeller** to generate thrust.



Piston Engine Works

A typical **four-stroke cycle** is used in most aircraft piston engines
Intake – Air-fuel mixture enters the cylinder.
Compression – Piston moves up, compressing the mixture.
Power – Spark plug ignites the mixture, forcing the piston down.
Exhaust – Burned gases exit through the exhaust valve.
Key Components: Cylinder, piston, crankshaft, camshaft, spark plugs, carburetor/fuel injector.

Common Use: Small aircraft, general aviation, UAVs
Example: Cessna 172, Piper PA-28
Advantages: Simple, cost-effective, fuel-efficient for short distances
Disadvantages: Limited speed and altitude

3. Electric Propulsion

Electric propulsion (EP) uses electrical energy to accelerate propellant, providing high efficiency for space travel. Unlike chemical rockets, which burn fuel to create thrust, electric thrusters expel ionized particles at extremely high velocities, allowing spacecraft to travel longer distances with less fuel.

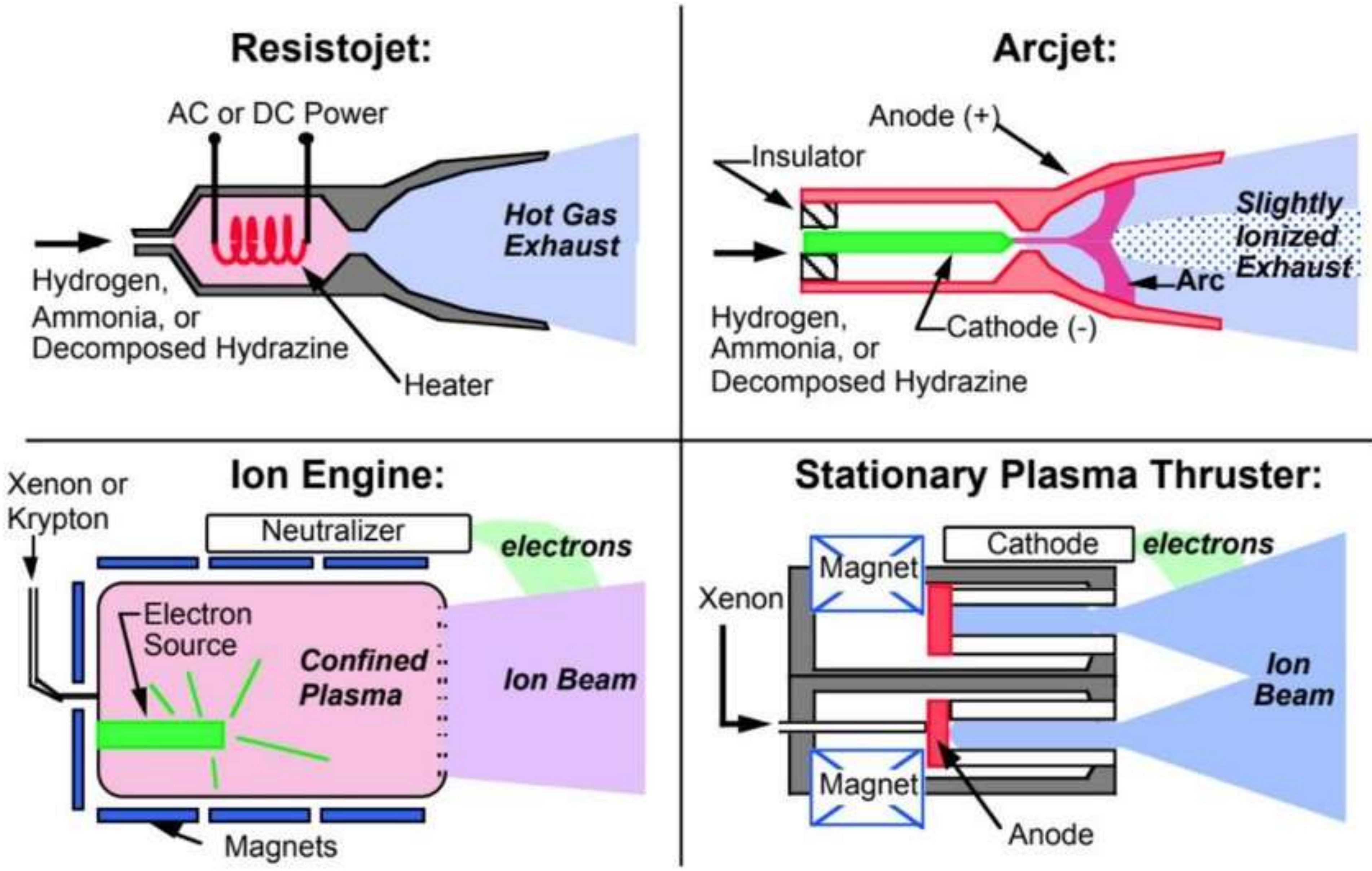
Key Features of Electric Propulsion

✅ **High Specific Impulse (Isp)** – Up to **10× more efficient** than chemical rockets.

✅ **Low Thrust** – Ideal for long-duration missions, but **not for takeoff from Earth**.

✅ **Extended Lifespan** – Reduces fuel mass, enabling deep-space exploration.

Common Use: Drones, light aircraft, future urban air mobility (UAM)
Example: Pipistrel Alpha Electro, Eviation Alice
Advantages: Low emissions, quieter, efficient for short-range flights
Challenges: Battery weight, energy density limitations

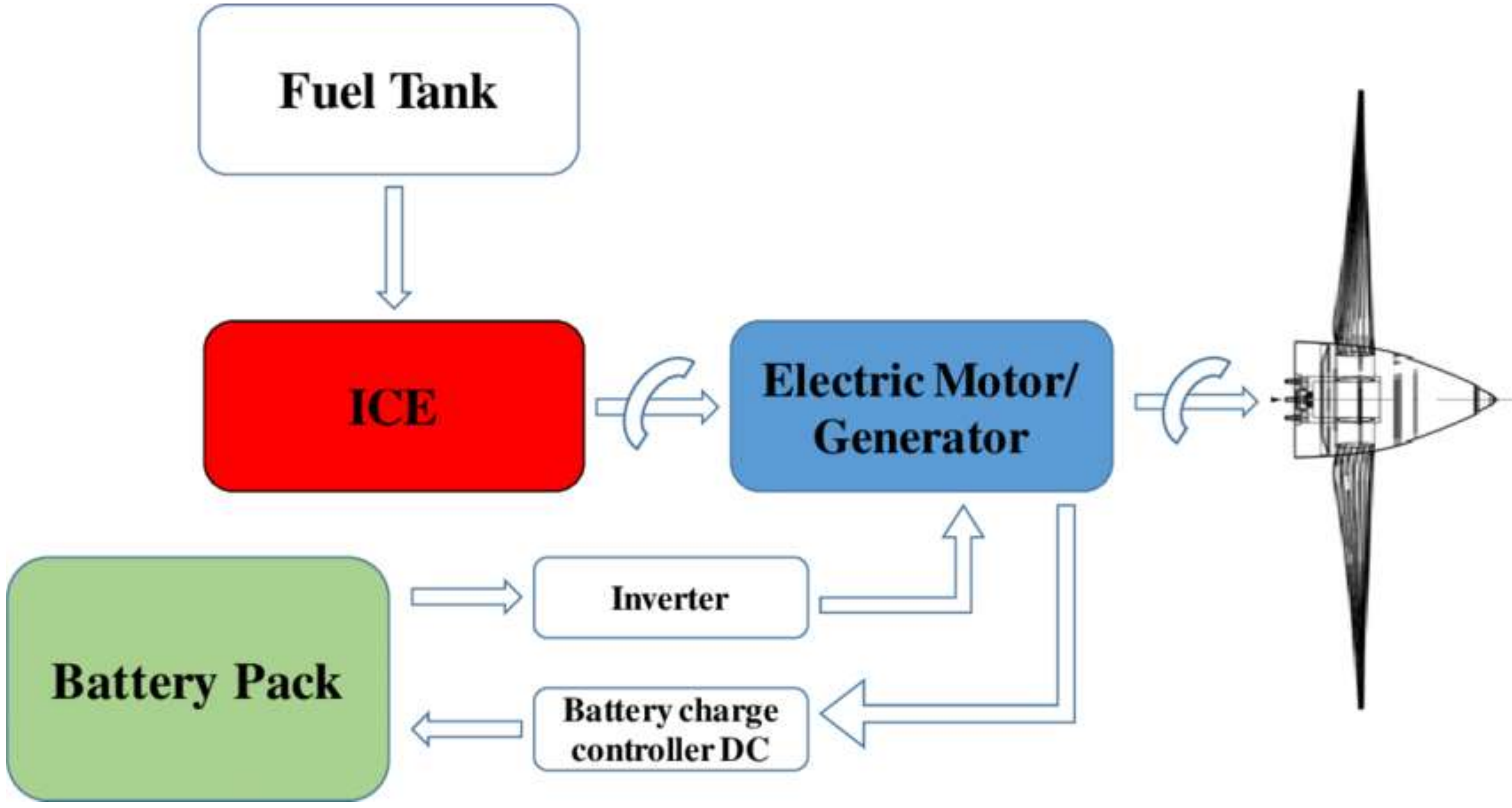


4. Hybrid Propulsion

Hybrid propulsion combines elements of both solid and liquid rocket engines, using a solid fuel and a liquid (or gaseous) oxidizer. This design offers a balance between the simplicity of solid rockets and the controllability of liquid engines.

Hybrid Rocket Propulsion Works
Fuel: Solid (e.g., rubber-based, paraffin wax, or metalized fuels)
Oxidizer: Liquid or gaseous (e.g., liquid oxygen (LOX), nitrous oxide, hydrogen peroxide)
Combustion Process:

- The **oxidizer is injected** into the combustion chamber.
- The **solid fuel burns upon contact**, creating thrust.
- The burn can be **controlled (throttled or shut off)** by regulating the oxidizer flow.



Common Use: Future aircraft, experimental planes
Example: Airbus E-Fan X, Boeing hybrid concepts
Advantages: Combines fuel and electric power for efficiency
Challenges: Complexity, weight management

5. Rocket Propulsion

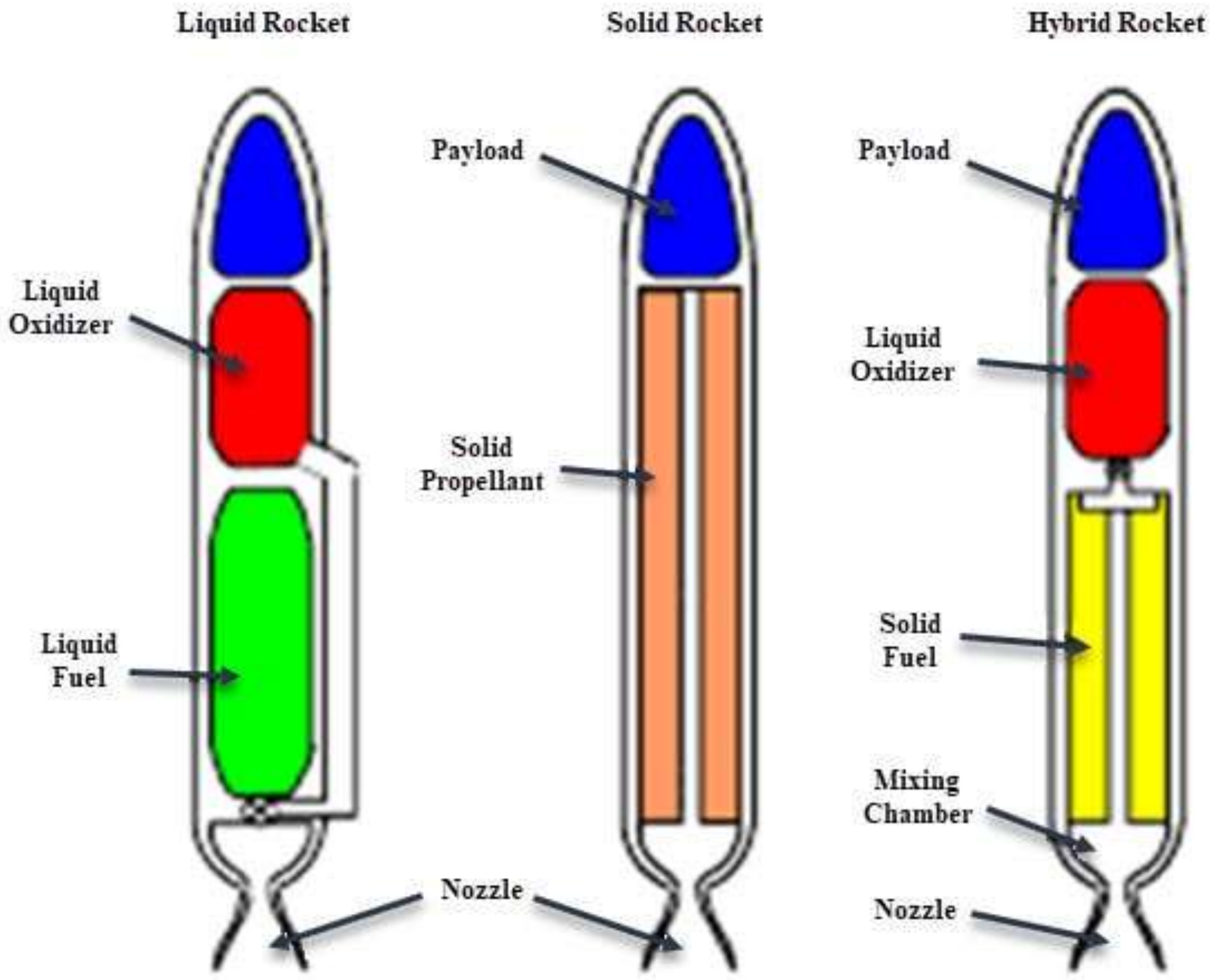
Rocket propulsion is a method of generating thrust by expelling high-speed exhaust gases, based on **Newton's Third Law of Motion** (action-reaction). Unlike air-breathing engines, rockets carry both fuel and an oxidizer, allowing them to operate in space where there is no atmospheric oxygen.

1. Principles of Rocket Propulsion

- **Thrust Equation**: $F = \dot{m}v_e + (P_e - P_a)A_e$
  - $\dot{m}$ = mass flow rate of exhaust
  - v_e = exhaust velocity
  - P_e = exit pressure
  - P_a = ambient pressure
  - A_e = exhaust area
- **Specific Impulse (Isp)**: A measure of efficiency, given by:

$$I_{sp} = \frac{F}{\dot{m}g_0}$$

  - Higher Isp means better efficiency (e.g., liquid hydrogen has high Isp).



Common Use: Spacecraft, high-speed experimental aircraft
Example: SpaceX Falcon 9, X-15
Advantages: Operates in space, extremely high speeds
Challenges: High fuel consumption, costly

THANK YOU!