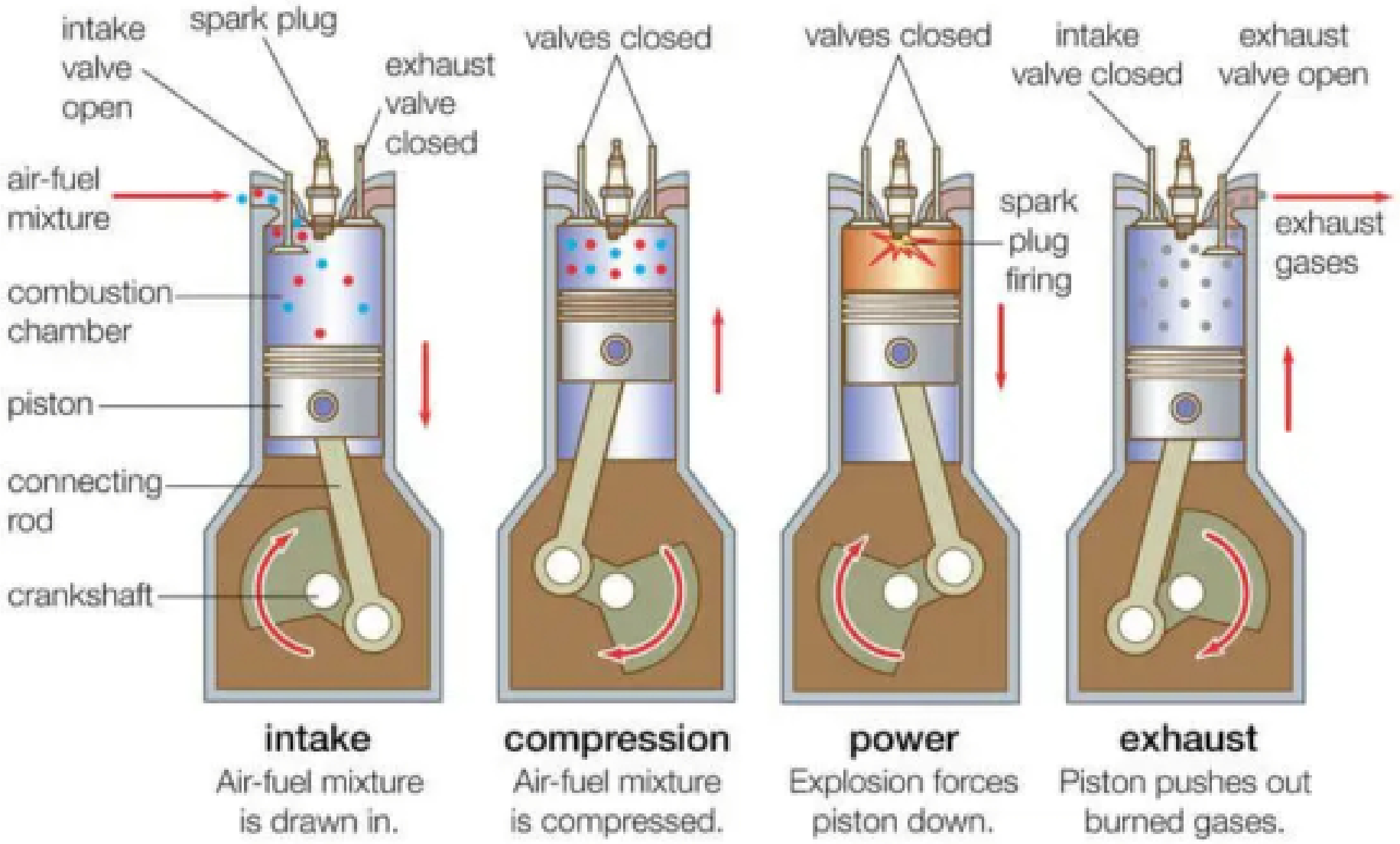
Propulsion

4 stroke piston engine



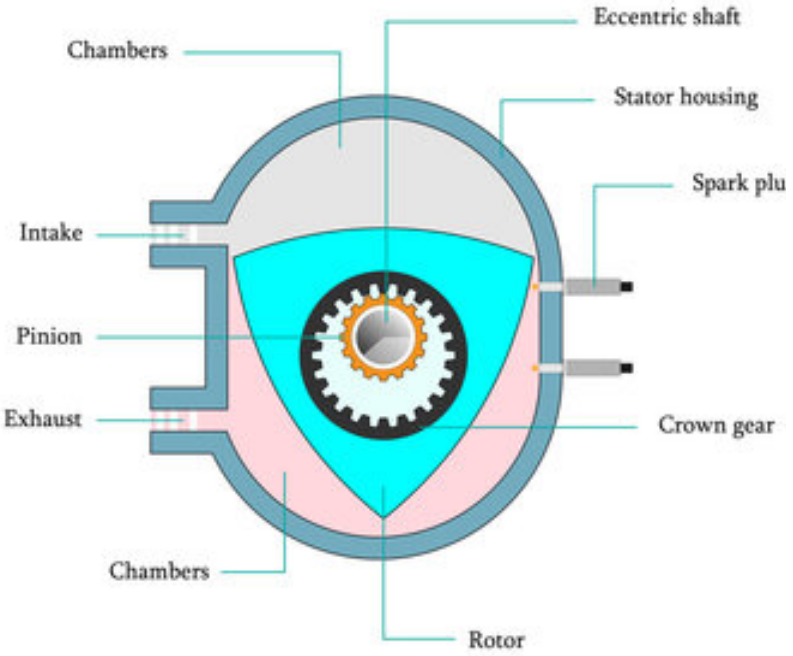
Construction

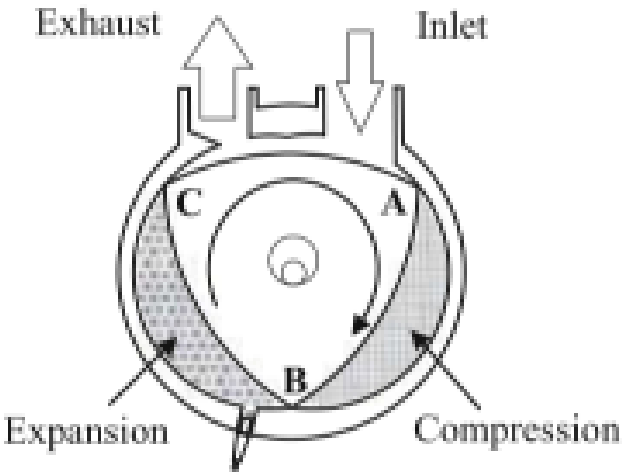
- Four-stroke engines consist of the following parts:
- **Cylinder**: It is the heart of the engine. The piston reciprocates in the cylinder.
- **Cylinder head:** It is the top cover of the cylinder, towards TDC, which is called the cylinder head.
- **Piston**: It is the reciprocating member of the engine. It reciprocates in the cylinder.
- **Piston rings**: Two or three piston rings are provided on the piston. It seals the gap between the cylinder liner and piston.
- **Crank**: It is a rotating member. It makes a circular motion inside the crankcase.
- **Crankcase**: It is the housing of crank and other engine parts. It is also used as the sump of lubricating oil.
- **Connecting rod**: It is used to convert the reciprocating motion of the piston to rotary motion of the crankshaft.
- **Crankshaft**: It is the rotating member, which connects the crank.
- **Cooling fins or Water jackets:** It is used for cooling purposes.
- **Cam and Camshaft:** It is provided to operate the opening and closing of the Inlet and Exhaust valve and also operate the fuel injection pump in the Diesel engine.
- **Inlet valve:** This valve controlled the admission of charge or air inside the engine cylinder.
- **Exhaust valve**: This valve controls the removal of burnt gas after combustion.
- **Intake manifold**: This is a passage that carries the fresh charge or air.
- **Exhaust manifold**: This a passage through which the exhaust gas goes out of the engine cylinder.
- **Spark plug**: It is used in a Petrol engine or SI engine to ignite the fuel.
- **Fuel injector**: It is used in a Diesel engine or CI engine to sprayed the fuel inside the engine cylinder.
- **Carburetor**: It is used in a Petrol engine to mix the air-fuel properly.

Working

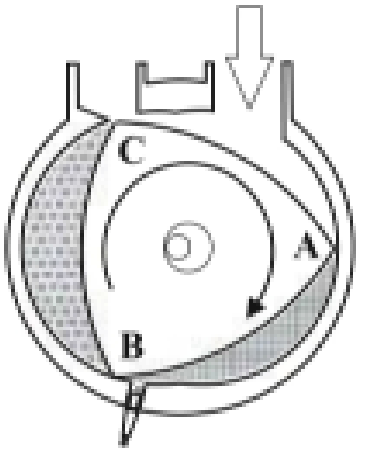
- A four-stroke engine delivers one power stroke for every two cycles of the piston (or four-piston strokes). Intake stroke: The piston moves downward to the bottom; this increases the volume to allow a fuel-air mixture to enter the chamber.
- Compression stroke: The intake valve is closed, and the piston moves up the chamber to the top. This compresses the fuel-air mixture. At the end of this stroke, a spark plug provides the compressed fuel with the activation energy required to begin combustion.
- Power Stroke: As the fuel reaches the end of its combustion, the heat released from combusting hydrocarbons increases the pressure which causes the gas to push down on the piston and create the power output.
- Exhaust stroke: As the piston reaches the bottom, the exhaust valve opens. The remaining exhaust gas is pushed out by the piston as it moves back upwards.

Rotary engine

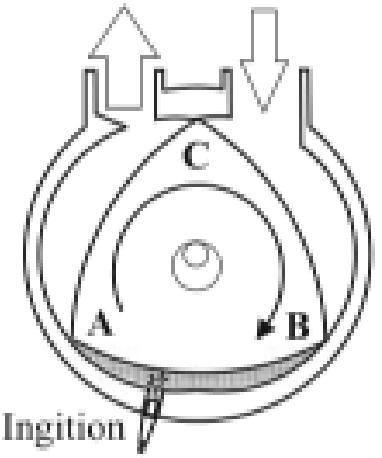




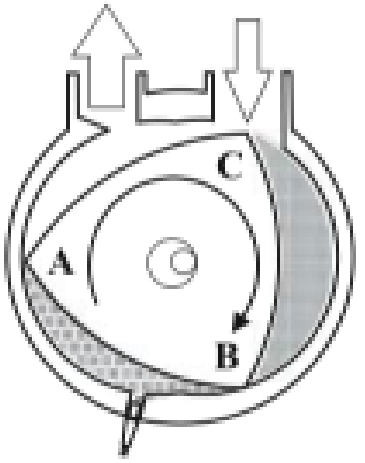
I



II



III

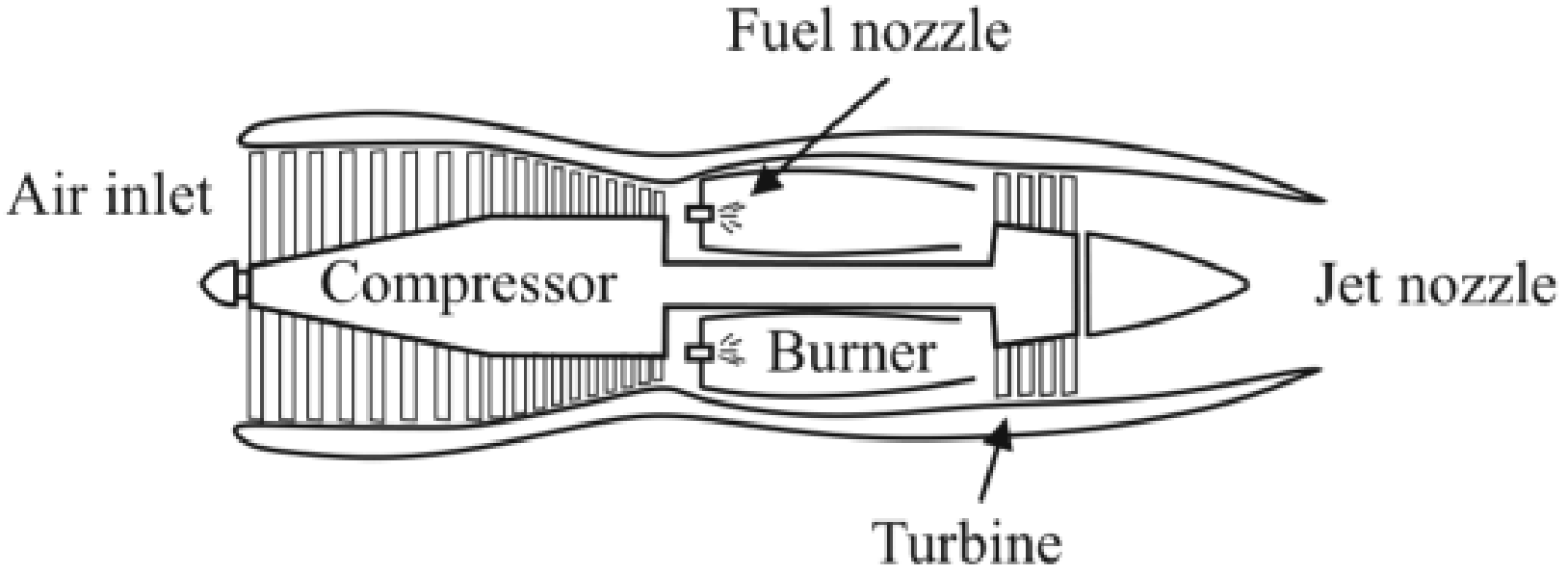


IV

- The principle of operation of the rotary engine is based on the rotation of a three-sided geometrical shape within a two-lobe geometrical stator. The rotor revolves within this stator such that its three apices make continuous contact with the stator. The stator is an epitrochoid curve based on the path of a point on the radius of a circle that rolls on the outside of a fixed circle.
- Each face of the rotor completes a four-cycle process identical to the four-cycle engine:intake, compression, combustion, and exhaust.
- The cycle takes place during one rotation of the rotor, so one can consider a single bank rotary engine as a three-cylinder engine. As we shall see there is no reciprocating motion, so vibration can be very low. The end of the rotor is usually provided with an internal gear, concentric with its center, that rotates around a smaller fixed pinion gear mounted on the side cover of the casing

- In diagram I, the exhaust and inlet ports are shown to be open, just ending one cycle of exhaust and starting input of a fresh fuel–air mixture to the segment adjacent to side C–A, while the mixture previously drawn into the segment adjacent to side A–B is starting to be compressed. This process continues in diagram II. In diagram III, the mixture adjacent to side A–B has reached its maximum compression and is ignited by a spark. At the same time, the segment adjacent to side B–C, which has been expanding and driving the rotor, is opened to the exhaust port.
- The burning mixture in the segment adjacent to side A–B now expands and drives the rotor, while the fresh mixture that has been drawn into the segment adjacent to side C–A begins tobe compressed, and the combustion products in the segment adjacent to side B–C are expelled through the exhaust port and replaced by a fresh fuel–air mixture entering through the inlet port.
- Thus, in one revolution three, four-cycle Otto cycles have been completed, one in each segment

The Gas Turbine Engine



Air inlet: The air inlet duct must provide clean and unrestricted airflow to the engine. Clean and undisturbed inlet airflow extends engine life by preventing erosion, corrosion, and foreign object damage (FOD).

Compressor: The compressor is responsible for providing the turbine with all the air it needs in an efficient manner. In addition, it must supply this air at high static pressures.In an axial flow compressor, each stage incrementally boosts the pressure from the previous stage. A single stage of compression consists of a set of rotor blades attached to a rotating disk, followed by stator vanes attached to a stationary ring. The flow area between the compressor blades is slightly divergent.

Combustion chamber :combustion section has the difficult task of controlling the burning of large amounts of fuel and air. It must release the heat in a manner that the air is expanded and accelerated to give a smooth and stable stream of uniformly-heated gas at all starting and operating conditions.Maximum combustion section outlet temperature (turbine inlet temperature) in this engine is about 1070 degree Celsius.

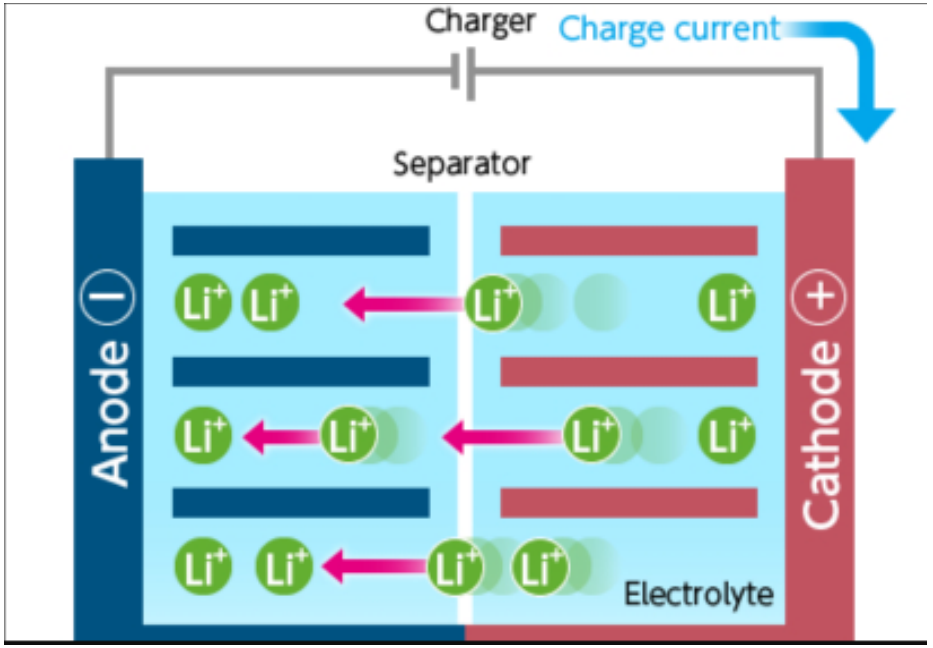
Turbine :The turbine converts the gaseous energy of the air/burned fuel mixture out of the combustor into mechanical energy to drive the compressor, driven accessories, and, through a reduction gear, the propeller. The turbine converts gaseous energy into mechanical energy by expanding the hot, high-pressure gases to a lower temperature and pressure

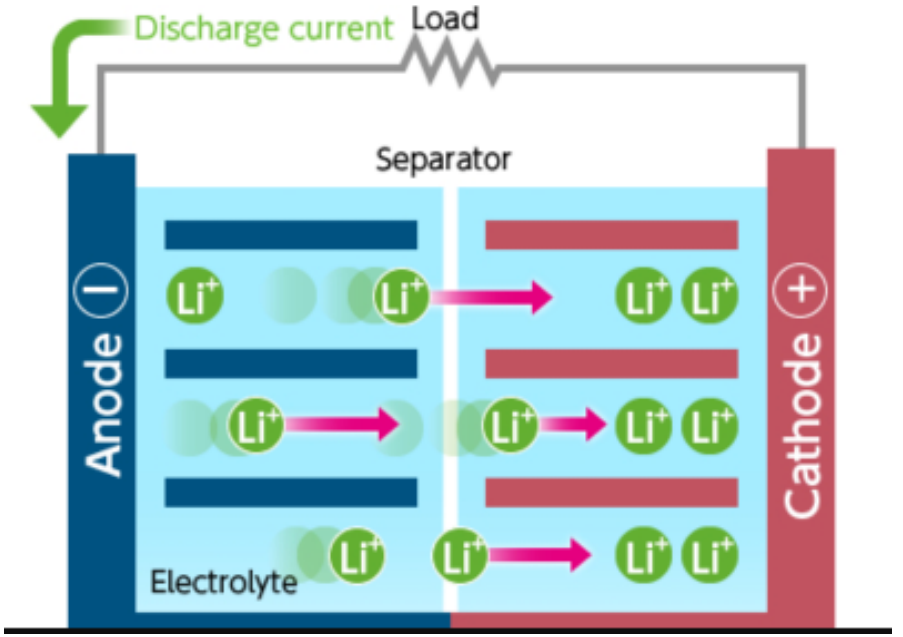
Nozzle: It is a device that is used to accelerate the hot gas from the turbine.it expands the gas to higher velocity and generates a jet thrust. It is found at the rear of the engine.

Fan : The turbojet engine fitted with fan at the front end of engine is called as turbofan engine.The rotation of fan pushes a incoming air rearward resulting in forward Fan thrust. This design is not suitable for supersonic flight.

Turbofan thrust = Fan thrust +Jet thrust

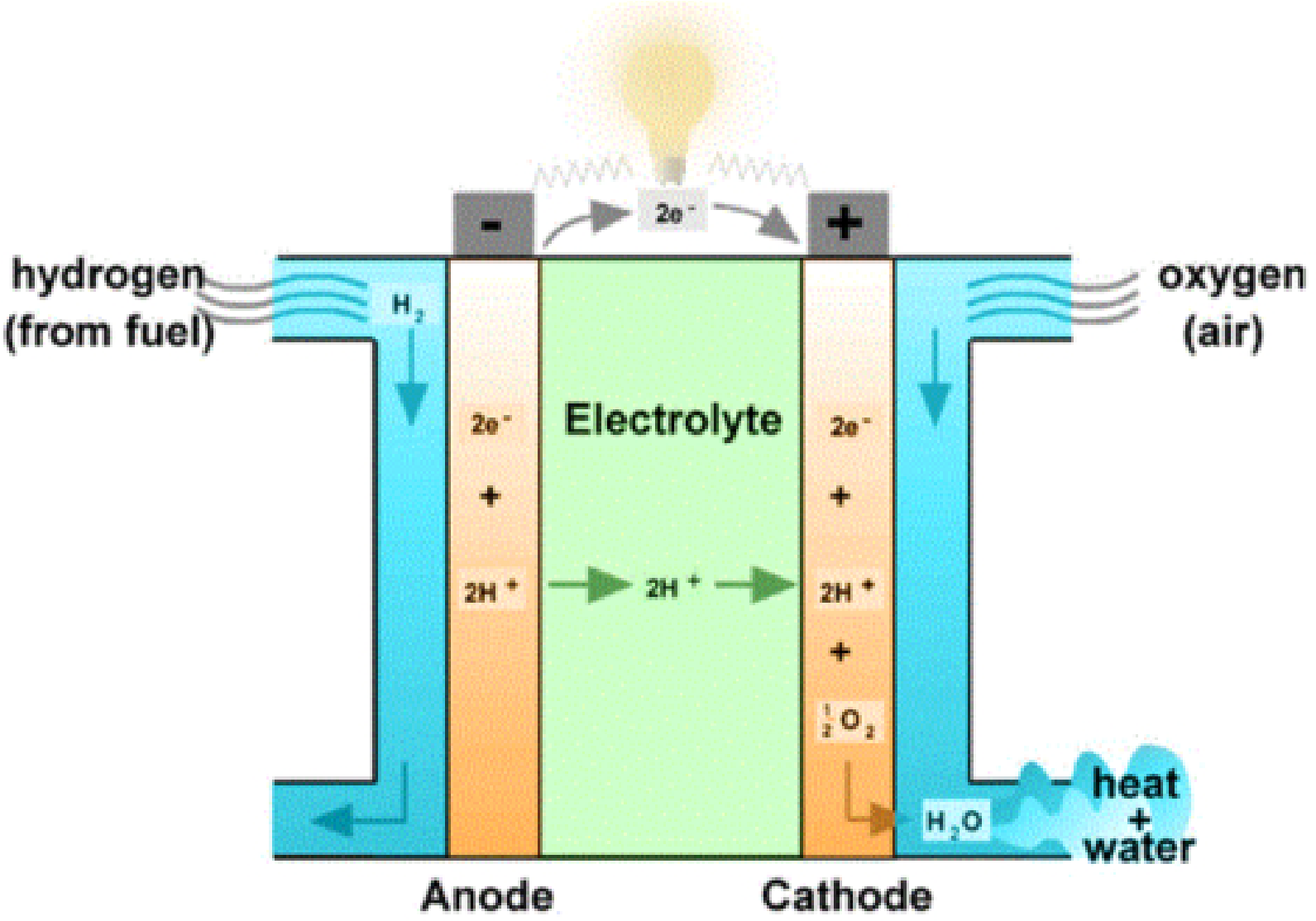
Lithium ion battery





- The rechargeable lithium-ion battery is made of one or more power-generating compartments called cells. Each cell has essentially three components.- positive electrode, negative electrode and electrolyte.
- A positive electrode connects to the battery's positive or + terminal. A negative electrode connects to the negative or − terminal. And a chemical called an electrolyte in between them.
- The positive electrode is typically made from a chemical compound called lithium-cobalt oxide ($LiCoO_2$) or lithium iron phosphate ($LiFePO_4$). The negative electrode is generally made from carbon (graphite). The electrolyte varies from one type of battery to another.
- The electrolyte carries positively charged lithium ions from the anode to the cathode.The movement of the lithium ions creates free electrons in the anode which creates a charge at the positive current collector. The electrical current then flows from the current collector through a device being powered (cell phone, computer, etc.) to the negative current collector. The separator blocks the flow of electrons inside the battery.
- While the battery is discharging and providing an electric current, the anode releases lithium ions to the cathode, generating a flow of electrons from one side to the other. When plugging in the device, the opposite reaction happens, the cathode releases lithium ions and anode receives them. This is how the Lithium-ion battery works

Fuel cells


hydrogen
(from fuel)
oxygen
(air)
-
+
2e⁻
H₂
2e⁻
+
2H⁺
Electrolyte
2H⁺
2e⁻
+
2H⁺
+
½O₂
H₂O
heat
+
water
Anode
Cathode

- In fuel cell the chemical energy is converted into electrical energy in a reaction that eliminates the combustion of the fuel.
- Fuel cells allow the direct conversion of energy stored in a fuel into electricity.
- Instead of combining the hydrogen with oxygen from the air, the fuel cell uses a catalyst to facilitate the ionization of the hydrogen at the anode, creating positively charged hydrogen ions and free electrons. It then uses an electrolyte to pass the hydrogen ions to a cathode that is in contact with oxygen gas. This gives the anode a positive charge and creates a voltage potential between the cathode and anode that drives the free electrons through an external circuit. When the electrons get to the cathode, they combine with the oxygen atoms to form water molecules.
- The choice of the electrolyte is very important. Some of the electrolytes that work well in fuel cells need to operate at temperatures as high as 1,000 C. This clearly requires signif i cant packaging to insulate the cell from its surroundings. For use in a UAS, the more attractive electrolytes are solid organic polymers and solutions of potassium hydroxide in a “matrix.”
- In this context, one could think of the matrix as a layer of some absorbing material that can be permeated by the liquid electrolyte and avoids the issues related to an unrestrained liquid electrolyte.
- A fuel cell is not a battery and cannot directly be “recharged.” However, if it uses hydrogen as a fuel, the resulting water can be saved and electrolyzed to turn it back into oxygen and hydrogen gas. This makes a fuel cell an attractive way to store and recover energy on an electrically propelled UAV that uses solar cells to provide power during the day but must store energy to remain aloft at night