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TODAY'S IMPORTANT CURRENT AFFAIRS
UPSC MAINS

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SEMI CRYOGENIC ENGINE

Source: The post is based on the article published in **"The Hindu"** on **28.04.2025**.

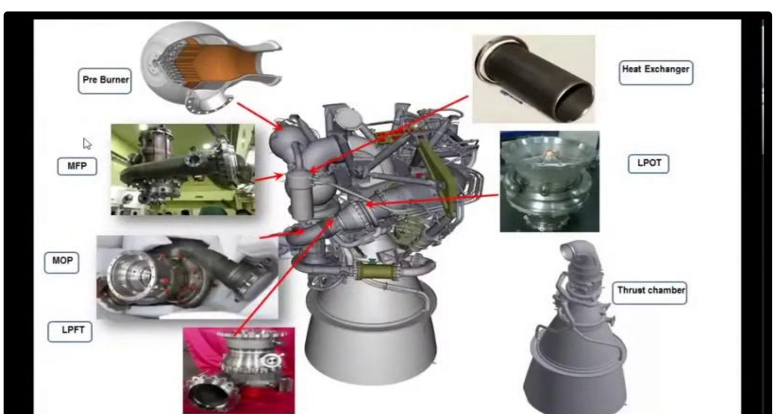
In News:ISRO 's second short hot test of semicryogenic engine a success.

The test was conducted at ISRO Propulsion Complex (IPRC), **Mahendragiri, Tamil Nadu**.The latest test lasted about **3.5 seconds**.It involved the **Engine Power Head Test Article, which includes all engine systems except the thrust chambe**r.Critical subsystems tested included low-pressure and high-pressure turbo pumps, pre-burner, and control systems.The test validated the engine start-up sequence and provided crucial data to finalize the operational sequencing of the full engine.

Syllabus: ***Mains – GS III (SCIENCE AND TECHNOLOGY- CRYOGENIC ENGINE)***

Short duration hot test

A short duration hot test of a semicryogenic engine is a brief, controlled firing of the engine at high temperature and pressure to validate its start-up sequence and subsystem performance without running the full engine for long periods



Semi cryogenic engine

A semi-cryogenic engine is a type of rocket engine that uses a **cryogenic oxidizer (usually liquid oxygen, LOX) and a hydrocarbon-based fuel** (typically refined kerosene, RP-1) instead of liquid hydrogen. This combination offers a balance between high performance and simpler, safer handling compared to full cryogenic engines.

Key Components

- **Thrust Chambe**r: Where fuel and oxidizer mix and combust to produce thrust.
- **Gas Generator or Pre-burne**r: Burns a small amount of fuel and oxidizer to generate hot gases that drive the turbopumps.
- **Turbopumps**: High-speed pumps powered by the gas generator to feed the fuel and oxidizer into the thrust chamber at high pressure.
- **Control Components:** Valves, sensors, and programmable logic controllers to regulate flow and ensure safe operation.
- **Ignition System**: Initiates combustion, often using special pyrophoric chemicals (e.g., Triethyl Aluminide and Triethyl Boron) for reliable ignition.
- **Feed System**: Includes tanks, pipes, and valves for storing and delivering LOX and kerosene to the engine.

Working Principle of a Semi-Cryogenic Engine

A semi-cryogenic engine operates by burning a cryogenic oxidizer (usually liquid oxygen, LOX) with a hydrocarbon fuel (such as refined kerosene, RP-1) to produce thrust, following **Newton's third law**: for every action, there is an equal and opposite reaction.

How It Works

- **Propellant Feed:** LOX (stored at very low temperatures) and kerosene (stored at ambient temperature) are pumped from their respective tanks into the combustion chamber using turbopumps.
- **Combustion**: The propellants are injected and mixed in the combustion chamber, where they are ignited. The chemical reaction produces high-pressure, high-temperature gases.
- **Thrust Generation:** These gases expand rapidly and are expelled at high speed through a nozzle, generating thrust that propels the rocket in the opposite direction.
- **Cycle Type:** Many semi-cryogenic engines use the staged combustion cycle, where a portion of the propellants is burned in a preburner to drive the turbopumps before entering the main combustion chamber, increasing efficiency and thrust.

Significance:

❖ Semi-cryogenic engines represent a major **advancement in rocket propulsio**n, enabling countries like India to launch heavier payloads into space and compete globally in satellite launches and deep space missions.

❖ They are crucial for **powering the first stages of heavy-lift launch vehicles**, such as ISRO's LVM3, increasing payload capacity for geostationary and interplanetary missions.

❖ Relevance to India's Upcoming Missions.**Gaganyaan Program**.The technology supports ambitions for **human spaceflight** and more complex scientific missions, as it allows rockets to carry the equipment and supplies needed for astronauts and advanced probes.

Advantages:

❖ **Higher Thrust and Payload:** Delivers more power than older engines, allowing rockets to lift heavier payloads into higher orbits.

❖ **Cost-Effectiveness:** Kerosene is cheaper and easier to store than liquid hydrogen, reducing operational costs.

❖ **Operational Simplicity:** Kerosene can be stored at normal temperatures, simplifying logistics compared to handling cryogenic hydrogen.

❖ **Compact Storage:** Kerosene's higher density means more propellant can be stored in a given volume, enabling longer missions or more powerful launches.

❖ **Environmental Friendliness**: The LOX-kerosene combination is less toxic and more environmentally friendly than some traditional propellants.

❖ **Global Adoption:** Used by leading space agencies (Russia, USA, China, Japan) for reliable and efficient launch operations, validating its effectiveness.

In summary, semi-cryogenic engines are **essential for next-generation space missions** due to their high thrust, efficiency, cost savings, and operational advantages, making them a cornerstone for future space exploration and satellite deployment.