SCRAMJET TEST: SCIENCE & TECHNOLOGY

NEWS: DRDO makes headway in hypersonic technology

WHAT'S IN THE NEWS?

DRDO's successful 1000-second test of an active-cooled scramjet combustor marks a major leap in India's hypersonic propulsion capabilities, enabling the development of advanced air-breathing missile systems. Scramjets operate at speeds beyond Mach 5 using atmospheric oxygen, offering efficiency and extended range for future hypersonic weapons.

Context: DRDL Scramjet Test

- The **Defence Research and Development Laboratory (DRDL)**, a unit under **DRDO**, successfully conducted **ground testing** of an **Active-Cooled Scramjet Subscale Combustor**.
- The combustor operated **for over 1000 seconds**, marking a major milestone in the development of **hypersonic propulsion systems** in India.
- This development represents a significant advancement toward **indigenously built hypersonic weapons**.

What is Hypersonic Propulsion Technology?

- Hypersonic propulsion refers to technologies enabling vehicles to travel at **Mach 5 or above**, i.e., **five times the speed of sound (~6125 km/h or higher)**.
- It is crucial for **next-generation aerospace and defence applications**, particularly in developing **hypersonic cruise missiles**, glide vehicles, and reusable launch systems.
- Hypersonic systems promise **unmatched speed, manoeuvrability, and penetration capabilities**, making them difficult to intercept by conventional missile defence systems.

Mach Number (M)

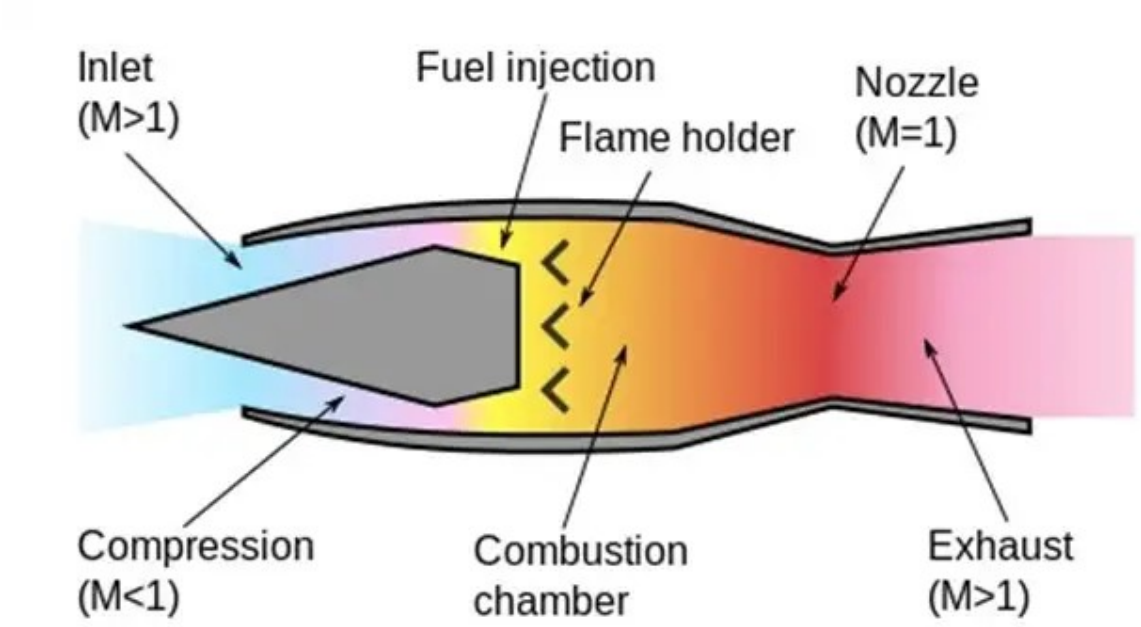
- It is the ratio of speed of object and speed of sound.
  - **Subsonic:** M < 1
  - **Transonic**: M = 0 (Speed of an object is equal to the speed of sound)
  - **Supersonic:** 1 < M < 3
  - **High Supersonic:** 3 < M < 5
  - **Hypersonic**: M > 5
- The **Space Shuttle** re-enters the atmosphere at **high hypersonic speeds (M ~ 25).**

Key Features of Hypersonic Propulsion Technology

- **Air-Breathing Engines**: Unlike traditional rocket engines that carry onboard oxidizers, hypersonic vehicles **use atmospheric oxygen** for combustion.
- This results in **lighter designs and greater fuel efficiency**, especially useful for **long-range, high-speed cruise flight**.
- The most advanced form of air-breathing propulsion for hypersonic speeds is the **Scramjet Engine**.

Scramjet (Supersonic Combustion Ramjet) Engine

- A **Scramjet engine** allows combustion to occur **while the airflow remains supersonic** throughout the engine.
- It is an **air-breathing jet engine** that operates at hypersonic speeds (Mach 5 and above), where **supersonic airflow is not decelerated to subsonic** before combustion.
- **Working Principle**:
    - The forward motion of the vehicle **compresses incoming air**.
    - Fuel is injected and combusted in this high-speed airflow without the need for **rotating parts like compressors or turbines**.
- **Comparison with Ramjet**:
    - Ramjet: Slows incoming air to **subsonic speeds** before combustion.
    - Scramjet: Maintains **supersonic airflow throughout**, allowing for **much higher speed operation**.



India's Position in Global Scramjet Development

- India became the **fourth country** after the **USA, Russia, and China** to **demonstrate flight testing of a Scramjet engine**, reflecting its growing capabilities in high-end aerospace defence technologies.
- The **Hypersonic Technology Demonstrator Vehicle (HSTDV)** project by DRDO has been a key program in this field.
- The current long-duration test further consolidates India's standing among a **select group of hypersonic-capable nations**.

Significance of the Scramjet Engine Test (2024–25)

- **Validation of Long-Duration Supersonic Combustion**:
    - The recent test builds upon the **January 2024 test (120 seconds)** and validates the combustor's ability to **sustain efficient combustion at hypersonic speeds**.
    - Testing over **1000 seconds** marks a crucial transition from short bursts to **long operational stability**, essential for real-world applications.
- **Step Towards Hypersonic Missile Development**:
    - Scramjet engines enable **extended-range air-breathing cruise missiles** that are faster, lighter, and more cost-effective than rocket-based systems.
    - They also enable **stealthier and low-altitude penetration**, reducing radar detection and interception chances.

    - A successful ground test is a precursor to **full-scale flight testing**, eventually leading to deployment-ready **hypersonic cruise missiles**.

- **Strategic and Tactical Edge**:
    - Hypersonic missiles are seen as a **game-changer in future warfare**, capable of precision strikes within minutes.
    - India's successful tests indicate **indigenous capabilities**, reducing dependency on foreign propulsion technologies and enhancing **strategic deterrence**.

Conclusion

- DRDL's successful scramjet combustor test marks a **critical step in India's hypersonic roadmap**, demonstrating sustained supersonic combustion capability.
- This paves the way for **advanced hypersonic weapon systems**, showcasing India's growing prowess in cutting-edge defence technologies and contributing to **strategic autonomy**.

Source: **https://www.thehindu.com/sci-tech/science/drdo-achieves-major-breakthrough-in-hypersonic-weapon-technology/article69492050.ece**