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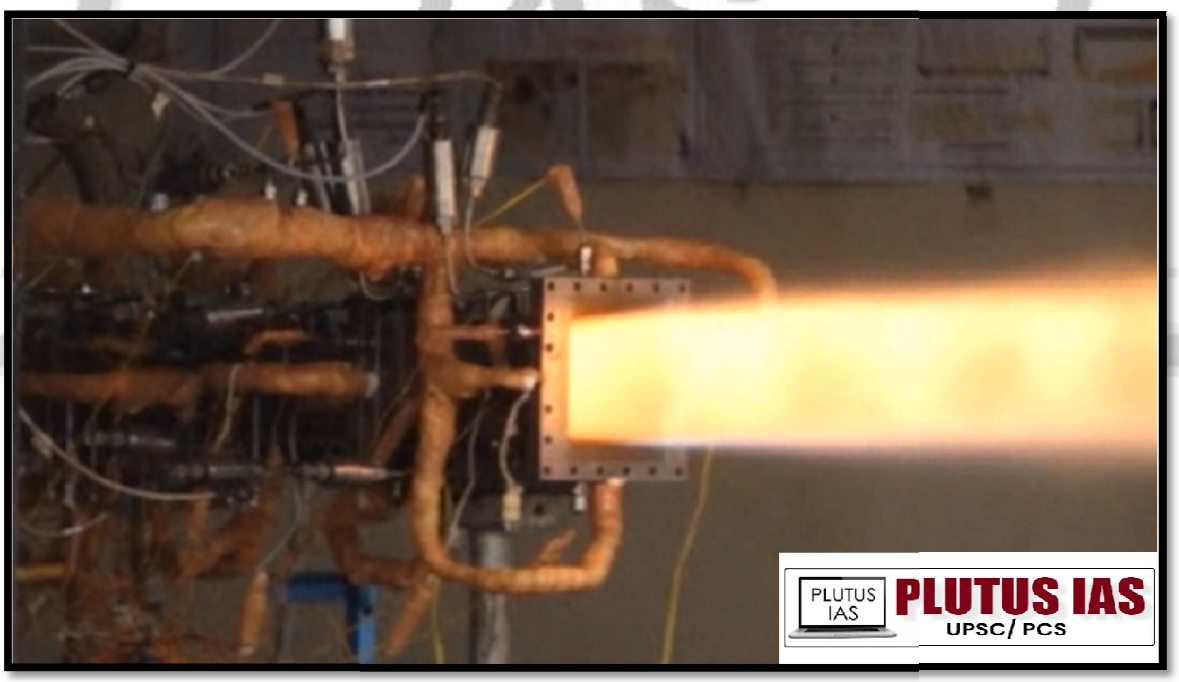
SCRAMJET HYPERSONIC MISSILE TECHNOLOGY

WHY IN THE NEWS?

India's Defence Research and Development Organisation (DRDO) has achieved a major milestone in hypersonic technology with the successful ground test of an active cooled scramjet combustor. The test, which demonstrated stable combustion for 120 seconds, marks a crucial step in developing long-duration scramjet-powered hypersonic vehicles. This achievement places India at the forefront of advanced defence technology, positioning it to build next-generation hypersonic missiles that can travel at speeds above Mach 5. Scramjet technology, the key to these vehicles, allows for sustained combustion at supersonic speeds without moving parts, making it a highly efficient propulsion system.



WHAT IS HYPERSONIC MISSILE TECHNOLOGY?

Hypersonic Missile Technology refers to weapons capable of travelling at speeds greater than Mach 5 (more than five times the speed of sound). These missiles are faster, more manoeuvrable, and harder to intercept than traditional missiles, making them a significant advancement in military technology.

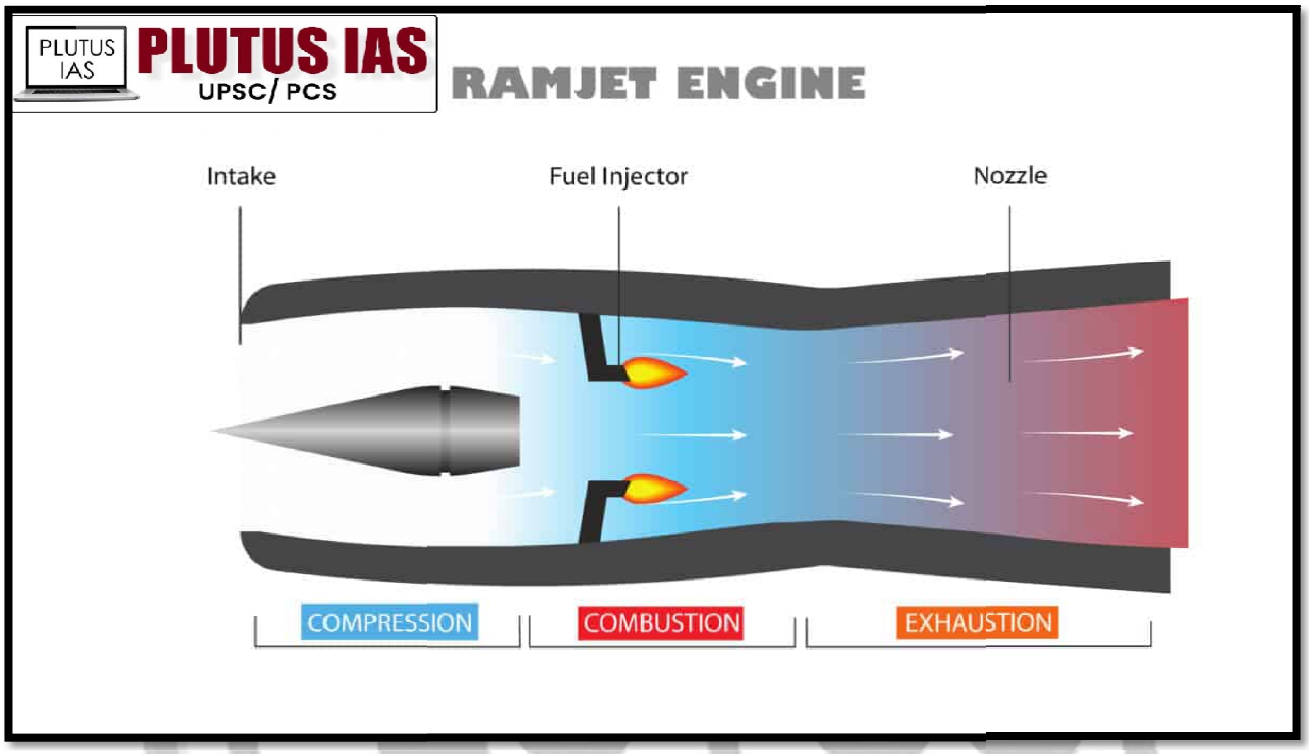
Types of Hypersonic Missiles:

1. Hypersonic Cruise Missiles (HCMs): Powered by scramjets, these missiles maintain hypersonic speeds throughout their flight.

2. Hypersonic Glide Vehicles (HGVs): Launched by rockets into space, they glide back to Earth at hypersonic speeds, capable of altering their trajectory.

SCRAMJET VS RAMJET VS TURBINE

Feature	Scramjet	Ramjet	Turbine
Speed Range	Hypersonic (Mach 5 and above)	Supersonic (Mach 2 to Mach 5)	Subsonic to Supersonic (Mach 0.3 to Mach 3)
Operation Principle	Air-breathing with supersonic combustion	Air-breathing with subsonic combustion	Air-breathing with compression and combustion
Components	Inlet, Combustor, Diverging Nozzle	Inlet, Combustor, Diverging Nozzle	Compressor, Combustor, Turbine, Nozzle
Air Compression	Uses shock waves for compression at hypersonic speeds	Uses forward motion to compress air	Uses rotating blades (compressor) for air compression
Efficiency	High efficiency at hypersonic speeds	High efficiency at supersonic speeds	High efficiency at subsonic to supersonic speeds
Thrust Generation	By accelerating heated air at hypersonic speeds	By accelerating heated air at supersonic speeds	By expanding air through turbines for thrust
Moving Parts	None (no moving parts)	None (no moving parts)	Yes (rotating blades in compressor and turbine)
Fuel Type	Typically, hydrogen or hydrocarbon-based	Typically, hydrogen or hydrocarbon-based	Typically, jet fuel (e.g., kerosene)
Operational Altitude	Typically above 100 km (high-altitude)	Typically in the atmosphere (up to ~30 km)	Operates at lower altitudes (up to ~12 km)
Applications	Hypersonic flight, future space exploration, military missiles	Supersonic flight (e.g., missiles, supersonic aircraft)	Commercial jets, military jets, helicopters
Complexity	Very high (advanced engineering for high speeds)	Moderate (simpler design compared to turbines)	Moderate to high (advanced systems for jet propulsion)
Heat Management	Very high (extreme heat at hypersonic speeds)	High (but less extreme than scramjets)	Moderate (operates at lower temperatures)



SCRAMJET ENGINE MECHANISM OF WORKING:

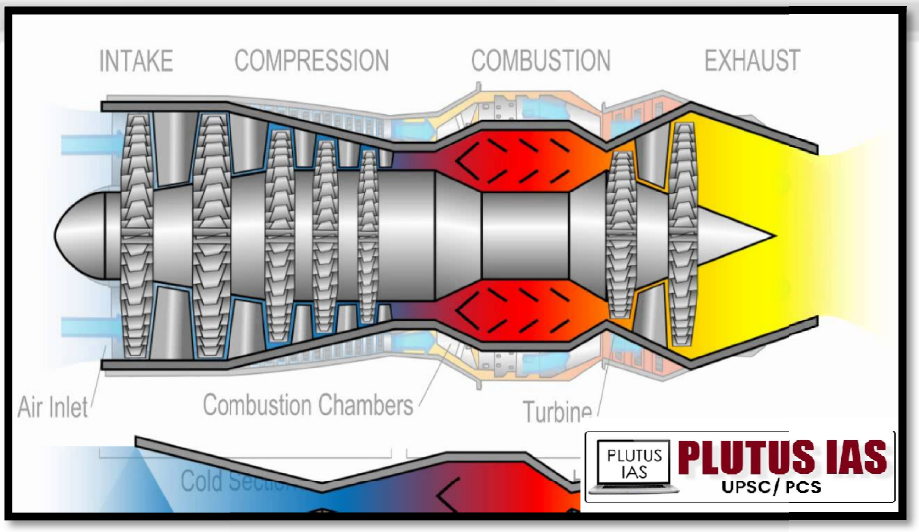
1. Air Intake: At hypersonic speeds (Mach 5+), the air is taken in without slowing down, compressed by the vehicle's high velocity through the intake.

2. Compression: Air is compressed by the intake shape, increasing pressure and temperature while remaining supersonic throughout the process.

3. Combustion: Fuel (like hydrogen) is injected into the supersonic airflow in the combustion chamber. Combustion occurs almost instantly due to the high pressure and temperature.

4. Thrust Generation: Post-combustion, hot gases expand and accelerate through a divergent nozzle, creating thrust to propel the vehicle forward.

5. No Moving Parts: Unlike traditional jet engines, scramjets have no rotating components. They rely solely on vehicle speed for compression, making them lighter but requiring higher operational speeds.



APPLICATION OF SCRAMJET ENGINE:

1. Hypersonic Aircraft: Enables vehicles to fly at Mach 5+ speeds, reducing global travel times by travelling through the upper atmosphere.

2. Hypersonic Missiles: Powers missiles that are faster and harder to intercept than conventional ones, with longer range and speed.

3. Space Launch Vehicles: Used to reduce fuel needs by utilizing atmospheric air as an oxidizer, making space launches more efficient and cost-effective.

4. Spaceplanes and Reusable Spacecraft: Key to developing spaceplanes that can launch like aeroplanes and transition to rocket propulsion for space access, enabling reusable spacecraft.

5. High-Speed Interceptors: Develop interceptors capable of countering hypersonic threats with extreme speed.

6. Scientific Research & Space Exploration: Enables quick access to the upper atmosphere for research on air composition, environmental conditions, and more.

CONCLUSION

India's successful test of the actively cooled scramjet combustor marks a key milestone in hypersonic technology, placing the country at the forefront of defence innovation. This achievement paves the way for next-gen hypersonic missiles capable of exceeding Mach 5 speeds, making them faster, more manoeuvrable, and harder to intercept. Scramjet technology, which enables supersonic combustion without moving parts, is highly efficient and essential for high-speed flight and long-duration missions. Its applications extend beyond defence to include hypersonic aircraft, space exploration, and cost-effective space launches. By using atmospheric oxygen, scramjets also reduce fuel needs, potentially revolutionizing space access.

PRELIMS QUESTION:

Q. With reference to Scramjet Engine technology, consider the following statements:

1. Scramjet engines are capable of operating at hypersonic speeds (Mach 5 and above).
2. Scramjets rely on rotating parts like turbines and compressors for air compression.
3. The combustion process in a scramjet engine occurs at supersonic speeds without any moving parts.

How many of the above-given statements are correct?

A. Only one
B. Only two
C. All three
D. None

Answer: A

MAINS QUESTION:

Q. Discuss the working principle and applications of scramjet engines in hypersonic technologies. How does India's successful testing of an actively cooled scramjet combustor contribute to the development of advanced defence technologies? (250 words, 15 marks)

Ritik singh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