Source : www.thehindu.com Date : 2020-09-13

SCIENCE BEHIND AIR-BREATHING SCRAMJET ENGINE

Relevant for: Science & Technology | Topic: Space Technology & related matters

Major feat: The cruise vehicle was flown at a hypersonic speed of Mach six for 20 seconds. | Photo Credit: PTI

The Defence Research and Development Organisation (DRDO) performed a major technological feat on September 7 when it flew a cruise vehicle at a hypersonic speed of Mach six for 20 seconds. The DRDO called the cruise vehicle Hypersonic Technology Demonstrator Vehicle (HSTDV). The centrepiece of the HSTDV was the indigenously developed air-breathing scramjet engine, which formed the HSTDV's propulsion system. If the mission's aim was to prove this air-breathing scramjet engine in flight, it was achieved.

The critical technologies developed for the HSTDV mission were the scramjet engine and its ignition, sustaining the ignition, ethylene fuel, generation of maximum energy from the engine, development of materials to take care of the high temperatures that occurred due to air friction on the leading edges of the cruiser's wings, tail surface and nose tip, and controlling the HSTDV with minimum drag and maximum thrust.

In an air-breathing scramjet engine, air from the atmosphere is rammed into the engine's combustion chamber at a supersonic speed of more than Mach two. In the chamber, the air mixes with the fuel to ignite a supersonic combustion but the cruiser's flight will be at a hypersonic speed of Mach six to seven. So it is called supersonic combustion ramjet or Scramjet.

On the D-day, a launch vehicle, which was derived from Agni 1 missile, rose from its launch pad in Odisha, carrying the HSTDV. The Agni 1 booster climbed to a height of 30 km in 12 seconds at a speed of Mach 5.6. The launch vehicle's control systems were made rugged enough to take care of its ascent through the atmosphere when it would experience heavy loads. When the launch vehicle reached an altitude of 30 km, the air intake ducts in the scramjet engine opened just before the launch vehicle separated smoothly from the HSTDV. At 30 km altitude, the cruise vehicle's nose cone split in two and fell off. Besides, the heat shield covering the cruiser was jettisoned. All these events took place in micro seconds as planned.

Air from the atmosphere was then rammed into the scramjet engine's combustion chamber at a supersonic speed. The air mixed with the atomised fuel, the fuel was ignited and the scramjet engine revved into action. The HSTDV flew for the next 20 seconds at a hypersonic speed of Mach six and fell 40 km away in the Bay of Bengal. The mission was a success.

Dr. Avinash Chander, former Director General, DRDO, said: "The fuel should be ignited in milliseconds. Not many countries were able to do it at the first instance... Energy generation should be maximum and drag should be minimum." The ignition should be sustained for the duration set for the flight. The entire HSTDV should be controlled but with maximum thrust.

Dr. R.K. Sharma, former Project Director, HSTDV, said lighting the fuel with the air coming in from the atmosphere at a supersonic speed was akin "to lighting a match-stick in a hurricane". DRDO developed special materials to take care of the cruise vehicle's nose-tip, tail and the wings' leading edges which were impacted by very high temperatures due to air friction. Higher the vehicle's velocity, much higher the temperature.

Dr. G. Satheesh Reddy, DRDO Chairman, said India mastering the scramjet engine technology

“will pave the way for developing many more critical technologies, materials and particularly hypersonic vehicles”.

The DRDO’s missile complex in Hyderabad, comprising the Defence Research and Development Laboratory (DRDL), the Research Centre, Imarat (RCI), and the Advanced Systems' Laboratory (ASL) developed all the technologies needed for the mission.

Mastering the air-breathing scramjet technology will lead to the development of hypersonic missiles, faster civilian air transportation and facilities for putting satellites into orbit at a low cost.

health and well-being, our lives, and livelihoods. As a subscriber, you are not only a beneficiary of our work but also its enabler.

We also reiterate here the promise that our team of reporters, copy editors, fact-checkers, designers, and photographers will deliver quality journalism that stays away from vested interest and political propaganda.

Suresh Nambath

END