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A REVIEW ON HYPERSONIC AIRCRAFT

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ABSTRACT

The ultimate objective of making the world smaller place and being able to fly to any point in just couple of hours which can be possible with "hypersonic aircraft". This is aircraft moves with 7 times more than the speed of the sound i.e. (7 Mach). This aircraft uses air breathing type supersonic ramjet (scramjet) engine. having speed near about 7700 km/hr. nasa's x-43 (hyper-x) is one of the hypersonic aircraft, which is construct with title based thermal protection system, carbon-carbon composites and high temperature resistance metal with gaseous hydrogen fuel in engine. This aircraft is carried out by booster rocket up to its test altitude of 100000 ft. where it separates from the booster and files under pre-programmed control system.

Keywords: Booster rocket, Hydrogen fuel, Supersonic ramjet, Thermal protection.

I. INTRODUCTION

Emerging hypersonic air breathing propulsion systems offer the potential to enable new classes of flight vehicles that allow rapid response at long range, more Manoeuvrable flight, better survivability, and routine and assured access to space. Historically, rocket boosters have been used to propel hypersonic vehicles (i.e., those flying faster than 5 times the local speed of sound) for applications such as space launch, long-range ballistic flight, and air-defence interceptor missiles. Air breathing propulsion systems currently under development will provide a means for sustained and accelerating flight within the atmosphere at hypersonic speeds. Potential mission areas include long-range cruise missiles for attack of time-sensitive targets, flexible high-altitude atmospheric interceptors, responsive hypersonic aircraft for global payload delivery, and reusable launch vehicles for efficient space access. Although hypersonic air breathing propulsion systems have been investigated for the past 40 years without development of an operational system, significant technology advancements have been realized recently, and the development of operational hypersonic systems appears to be within our grasp. In particular, the technology to support a baseline hypersonic propulsion system exists that will allow operation at speeds up to M ach 6 with conventional liquid hydrocarbon fuels.[1]

II. HISTORY

During World War II, a tremendous amount of time and effort were put into researching high-speed jet- and rocket-powered aircraft, predominantly by the Germans. After the war, the US and UK took in several German scientists and military technologies through Operation Paperclip to begin putting more emphasis on their own weapons development, including jet engines. The Bell X-1 attained supersonic flight in 1947 and, by the early 1960s, rapid progress towards faster aircraft suggested that operational aircraft would be flying at "hypersonic" speeds within a few years. Except for specialized rocket research vehicles like the North American X-15 and other rocket-powered spacecraft, aircraft top speeds have remained level, generally in the range of Mach 1 to Mach 3.

In the 1950s and 1960s a variety of experimental scramjet engines were built and ground tested in the US and the UK. In 1964, Dr. Frederick S. Billig and Dr. Gordon L. Dugger submitted a patent application for a supersonic combustion ramjet based on Billig's Ph.D. thesis. This patent was issued in 1981 following the removal of an order of secrecy. In 1981 tests were made in Australia under the guidance of Professor Ray Stalker in the T3 ground test facility at ANU.

The first successful flight test of a Scramjet was performed by Russia in 1991. It was an axisymmetric hydrogen-fuelled dual-mode scramjet developed by Central Institute of Aviation Motors (CIAM), Moscow in the late 1970s. The scramjet flight was flown captive-carry atop the SA-5 surface-to-air missile that included an experiment flight support unit known as the "Hypersonic Flying Laboratory" (HFL), "Kholod".[2] Then from 1992 to 1998 an additional 6 flight tests of the axisymmetric high-speed scramjet-demonstrator were conducted by CIAM together with France and then with NASA, USA.[3] Maximum flight velocity greater than Mach 6.4 was achieved and Scramjet operation during 77 seconds was demonstrated. These flight test series also provided insight into autonomous hypersonic flight controls.

Fig.1 NASA X-43with scramjet attached to the underside

In the 2000s, significant progress was made in the development of hypersonic technology, particularly in the field of scramjet engines.The HyShot project demonstrated scramjet combustion on July 30, 2002. The scramjet engine worked effectively and demonstrated supersonic combustion in action. However, the engine was not designed to provide thrust to propel a craft. It was designed more or less as a technology demonstrator.

A joint British and Australian team from UK defence company QinetiQ and the University of Queensland were the first group to demonstrate a scramjet working in an atmospheric test. US efforts are probably the best funded, and the Hyper-X team claimed the first flight of a thrust-producing scramjet-powered vehicle with full aerodynamic manoeuvring surfaces in 2004 with the X-43A. On Friday, June 15, 2007, the US Defence Advanced Research Project Agency (DARPA), in cooperation with the Australian Defence Science and Technology Organisation (DSTO), announced a successful scramjet flight at Mach 10 using rocket engines to boost the test vehicle to hypersonic speeds. A series of scramjet ground tests was completed at NASA Langley Arc-Heated Scramjet Test Facility (AHSTF) at simulated Mach 8 flight conditions. These experiments were used to support HI Fire flight 2.

On May 22, 2009, Woomera hosted the first successful test flight of a hypersonic aircraft in HIFiRE. The launch was one of 10 planned test flights. The series of up to 10 planned hypersonic flight experiments is part of a joint research program between the Defence Science and Technology Organisation and the US Air Force, designated as the Hypersonic International Flight Research Experimentation (HIFiRE).[4] HIFiRE is investigating hypersonics technology (the study of flight exceeding five times the speed of sound) and its application to advanced scramjet-powered space launch vehicles — the objective is to support the new Boeing X-51 scramjet demonstrator while also building a strong base of flight test data for quick-reaction space launch development and hypersonic "quick-strike" weapons.

On May 27, 2010, NASA and the United States Air Force successfully flew the X-51A Waverider for approximately 200 seconds at Mach 5, setting a new world record hypersonic airspeed. The Waverider flew autonomously before losing acceleration for an unknown reason and destroying itself as planned. The test was declared a success. The X-51A was carried aboard a B-52, accelerated to Mach 4.5 via a solid rocket booster, and then ignited the Pratt & Whitney Rocketdyne scramjet engine to reach Mach 5 at 70,000 feet. However, a second flight June 13, 2011 was ended prematurely when the engine lit briefly on ethylene but failed to transition to its primary JP7 fuel, failing to reach full power.

On 16 November 2010, Australian scientists successfully demonstrated that the high-speed flow in a naturally non-burning scramjet engine can be ignited using a pulsed laser source. A further X-51A Waverider test failed on August 15, 2012. The attempt to fly the Scramjet, carried by a B-52 for a prolonged period at Mach 6 was cut short when, only 15 seconds into the unmanned flight, the X-51A craft lost control and broke apart, falling into the Pacific Ocean north-west of Los Angeles. The cause of the failure was blamed on a faulty control fin. In May 2013 an unmanned X-51A WaveRider reached 4828 km/h (Mach 5.1) during a three-minute flight under scramjet power. The WaveRider was dropped at 50,000 feet from a B-52 bomber, and then accelerated to Mach 4.8 by a solid rocket booster which then separated before the WaveRider's scramjet engine came into effect.

III. WORKING

The booster rocket carries X-43A up its altitude of 1,00,000ft where the X-43A vehicle separates from the booster and flies under the power and control of its own built-in engineer and pre-programmed control system.

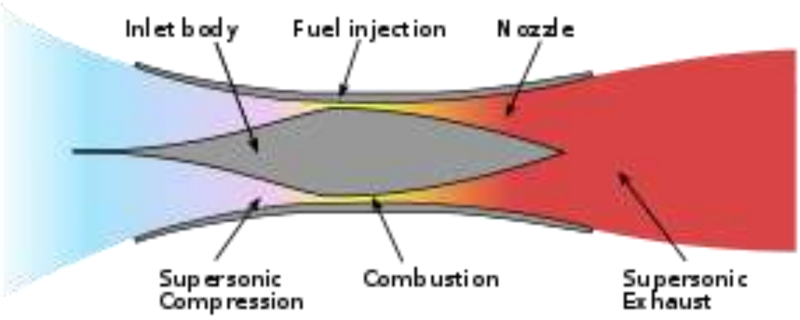

Fig.2 Scramjet engine

The X-43A vehicle separates from the booster rocket by the activation of two small pistons. Immediately after separation, the X-43A engine operates for just over ten seconds demonstrating forward thrust in flight. When the engine test is completed the vehicle is programmed to go into a high-speed glide which provides six minutes of aerodynamic data at hypersonic speed. The X-43A continues to a pre-programmed mission completion point in the Weapon's Division Sea Range managed by the Naval Air Warfare center and situated in the pacific off the southern coast of California. NASA Dryden Flight Research Centre at Edwards, California is responsible for the manufacture and flight of three unpiloted X-43A research vehicles and also for the manufacture of the expendable booster rockets for the launch of the X-43A vehicles. The fight data is used evaluate the performance of the X-43A vehicles at speed of Mach 7 and Mach 10, and demonstrate the use of the air breathing engines. The flight from NASA Dryden continues over the pacific Missile Test Range and returns to Dryden.[5]

- **Rundown of how the X-43A test flights work**

1. The X-43A is attached to Pegasus booster rocket.
2. The X-43A and booster rockets are carried up to about 20,000ft (6,096m) by a customized B-52 aircraft.
3. The B-52 releases the launch vehicle.
4. The booster rocket accelerates to a speed of somewhere between Mach 5 or faster and flies to an altitude of about 1,00,000 feet (30,480 m).
5. The X-43A separates from the booster rocket and flies under its own power and pre-programmed control.
6. The X-43A flies over the ocean for a few minutes before splashing down.

IV. MATERIALS FOR HYPERSONIC AIRCRAFT

- **Ceramics (High Temp 2000-3000 degree F)**

Ceramic offers a high temperature range. However, ceramics are not very strong. To compensate for their lack of strength ceramics are usually combined some other material to form a ceramic composite. You can find these ceramic composite lused in combustor and nozzle components.

- **Composites (All temperature)**

Composite materials offer great advantages over metals and ceramics. Not only are composite able to withstand very high temperature, they can also be lightweight.There are three main types of composites materials: polymer-matrix, metal-matrix, ceramic-matrix.

1. Polymer Matrix Composites (PMC)

Polymer materials tend to degrade when exposed to elevated temperatures. ,ost PMCs operate at temperature below 570 degree F.

2. Metallic Matrix Composites (MMC)

Offer not only very high temperature limits, but also increased toughness and strength against ductility. These MMCs are often used on the skin of a hypersonic aircraft.

3. Ceramic Matrix Composites (CMC)

Allow for higher temperature inside the jet engine thus creating greater combustion efficiency (i.e. the higher the temperature, the move completely the fuel bums which leads to increased fuel efficiency and lower emissions.) CMCs major downfall is their brittleness.[6]

V. CONCLUSION

As SCRAMJET is required high compression for this it is powered by some external supply, for that it is attached with other airplane up to some height and releases. Scramjet can’t start at rest. Considering this concept in future scramjet will use Mach 10-15. Due to this property it is used in Military operations.

In Hypersonic Aircraft dual mode engine that is Ramjet both are used. Hence it is very advantageous to use in Military applications. Also it is very good achievement for our scientist, for NASA people this research is measure success for their knowledge. Hence in today’s competitive world the challenge comes in front of man is

"Need for speed-most wanted" so aircraft using this type of jet engine could dramatically reduce the time it takes to travel from one place to another, potentially putting any place on Earth within a 90 minute flight.

REFERENCES

[1] David M. Van Wie, Stephen M. D'Alessio, and Michael E. White. "Hypersonic Airbreathing P ropulsion"

[2] Roudakov, A.S., Y. Schickhman, V. Semenov, Ph. Novelli, and O. Fourt, "Flight Testing an Axisymmetric Scramjet: Russian Recent Advances,"

[3] A.Roudakov, V.Semenov, V.Kopchenov, J.Hicks "Future Flight Test Plans of an Axisymmetric Hydrogen-Fueled Scramjet Engine on the Hypersonic Flying Laboratory"

[4] Cabell, Karen; Hass, Neal; Storch, Andrea; Gruber, Mark. "HIFiRE Direct-Connect Rig (HDCR) Phase I Scramjet Test Results from the NASA Langley Arc-Heated Scramjet Test Facility".

[5] Heiser, William H., David T. Pratt, Daniel H. Daley, and Unmeel B. Mehta. Hypersonic Airbreathing Propulsion.

[6] "Materials and Structures for Future Aircraft" paper no:-06 A2.01-9674 published by Avant Analysis Technology, 39 Hickory circle, Ithaca, NY 14850-9610(607)2\77-4648