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Zero Emission Hyper Sonic Transport: The Next Generation of Transportation

Imagine travelling from London to Tokyo is less than two and a half hours while having minimal impact on the environment. It may seem impossible, yet it may be a reality in the near future. Zero Emission Hyper Sonic Transport, or ZEHST, is an environment-friendly hypersonic passenger airliner with speed capabilities of four times the speed of sound. The engines are powered by clean burning biofuel and hydrogen. The ZEHST will usher in a new era of blazing fast transportation without damaging the environment.

Introduction

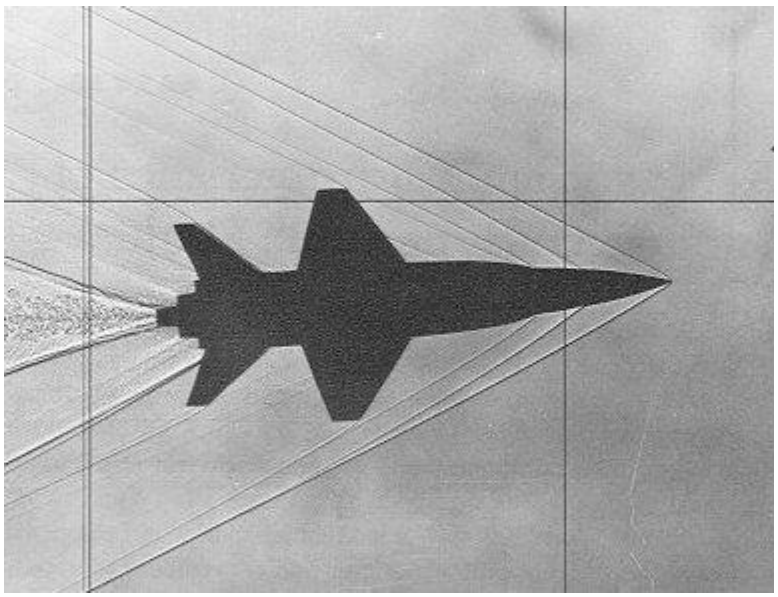
The early twentieth century brought us commercial aircraft for the first time. People could soar across the air and travel from one corner of the globe to another in a fraction of the time it would have taken before. As technology progressed, the first supersonic airliner, the Concorde, was introduced. The elite few who experienced travelling on the Concorde broke the sound barrier while travelling from New York to London in a little more than three hours; however, the Concorde was shut down in 2003 because it was economically unviable [1]. Currently, travel time is limited to the speeds of standard aircraft or other slower modes of transportation, as there are no supersonic airliners in the market, but Airbus Group’s Zero Emission Hyper Sonic Transport, or ZEHST, will soon usher in next generation of airliners by providing speeds five times faster than current passenger aircraft. The conceptual drawing of the ZEHST is shown in Figure 1 below. The ZEHST will provide a cruise speed of Mach 4 (four times the speed of sound) or about 3000 mph [2]. With this kind of speed, the ZEHST can travel from London to Tokyo in less than two and a half hours! Additionally, the ZEHST will have zero environmental impact, utilizing biofuel from seaweed and cryogenic, meaning cool and liquid, hydrogen [2]. Combining unparalleled speed and environment-friendly technology, the ZEHST will pave the future of transportation.

http://wowozine.com/wp-content/uploads/2012/02/%C2%A9-EADS-ZEHST1.jpg

Figure 1. Zero Emission Hyper Sonic Transport.

Why Are Current Aircraft Not Supersonic?

Before looking into how the ZEHST can fly so fast, it is important to first see how flying supersonic, speeds faster than speed of sound, affect drag on an aircraft. Drag increases dramatically when the speed of the aircraft reaches the speed of sound. When the aircraft approaches the speed of sound, shockwaves start to form. These shockwaves are nature's response to slow down the aircraft; the air travels so fast that it cannot travel upstream and therefore compresses, builds up pressure, and creates a big shock [3]. A visual representation of shockwaves are shown in Figure 2. Since shockwaves create a significant amount of drag, more powerful engines and fuel are required. This inherently makes supersonic vehicles more expensive to fly, which is why current aircrafts are not supersonic.



http://history.nasa.gov/SP-60/ch-5.html

Figure 2. Shock waves on an aircraft travelling at Mach 3.5.

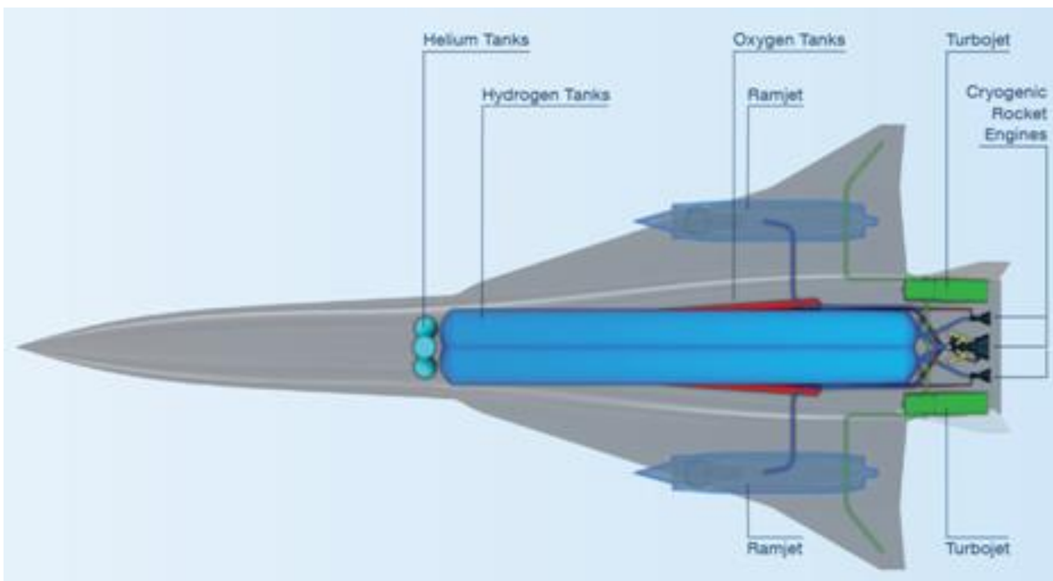
Since flying supersonic creates shockwaves, it is important to recognize the word 'Mach' with a number after, which gauges supersonic speeds. A Mach number refers to the ratio of the speed of the aircraft to the speed of sound. For example, Mach 1 is the speed of sound and Mach 2 is twice the speed of sound. Mach number is a convention when measuring speeds of supersonic aircraft.

Flying at Mach numbers over one can pose many challenges. In addition to requiring more powerful engines, the fast air surrounding the aircraft leads to intense friction between the air molecules, leading to high temperatures and high stresses on the plane, which call for stronger materials and complex designs. The solutions to the problems caused by supersonic speeds add weight to the aircraft, making it more expensive and inefficient. Another problem with shockwaves is that it generates a loud thunderous boom which can be uncomfortable for people on the ground. Due to this noise problem, supersonic aircrafts are not allowed to fly over many countries [4].

Despite the problems and challenges with supersonic aircraft, the lack of a supersonic airliners and the limited speed of current transports creates a demand for a faster mode of transportation. Although the Concorde was economically unviable, new technologies can reduce cost to overcome financial burden and be profitable for airline companies.

Reaching Hypersonic Speed

Although attaining supersonic and even faster hypersonic speeds is difficult due to the increase in drag, it is possible. The ZEHST will be travelling from rest to a cruise speed of Mach 4. To fly at such speeds, powerful engines are required. However, every engine is designed to be efficient at different speeds; therefore one type of engine is not enough. The ZHEST uses three sets of engine for different speeds: turbojet, booster rocket, and ramjet. The turbojet will accelerate the ZEHST to Mach 0.8. The booster rocket will then bring the aircraft to Mach 2.5, and the ramjet will bring it to a cruise speed of Mach 4. Figure 3 shows the engine configuration of the ZEHST.



http://www.airbus-group.com/dms/airbusgroup/int/en/press/documents/Dossiers/Downloads/EADS-Brochure_ZEHST_English.pdf

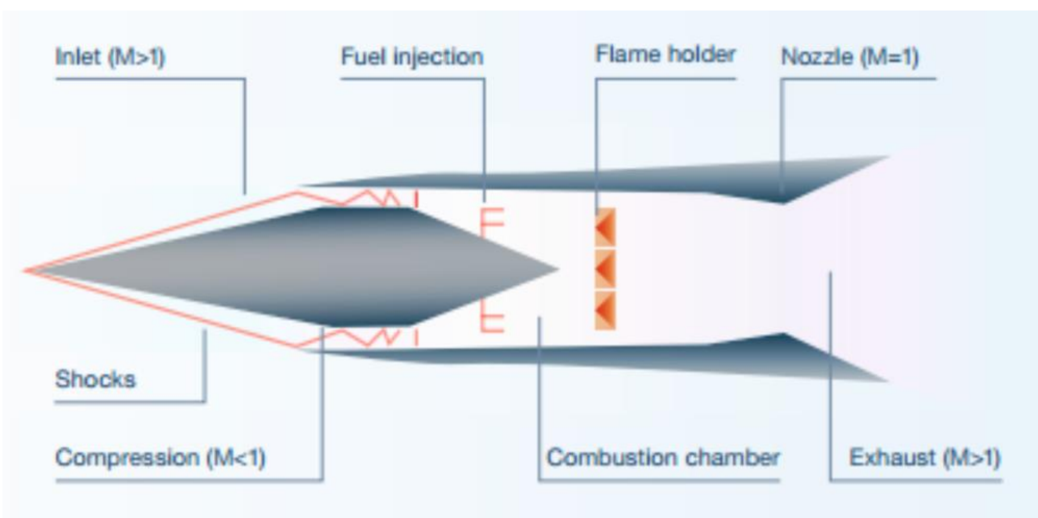
Figure 3. Engine Configuration of ZEHST.

In addition to the engine configuration of the ZEHST shown in Figure 3, design characteristics of it are also shown. Because of the high drag from supersonic speeds, the ZHEST requires a narrow fuselage and a small swept-back wing. These physical features are similar to all supersonic jets and not exclusive to the ZHEST. However, the cryogenic rocket engines and ramjet engines require great amounts of fuel to fly at supersonic speeds, explaining why the hydrogen tanks, the main source of fuel, take up a majority of the volume. Although design characteristics and engine configuration are meaningful, it is important to see the transitions of the different engines to reach Mach 4.

A turbojet engine is the same kind of engine used in most passenger airliners, which compresses the air and ignites the fuel to generate thrust. It is only efficient at speeds less than Mach 1 because the compressed air must be slowed down to about Mach 0.5 [5]. When the ZHEST reaches a speed of about Mach 0.8, or 600 mph, the booster rockets are activated.

A booster rocket is similar to what rockets use to launch. The cryogenic hydrogen acts as the fuel and the cryogenic oxygen acts as an oxidizer which helps the hydrogen burn [5]. The hydrogen combusts and goes through a nozzle, generating high thrust. The booster rockets will produce enough thrust to accelerate the ZEHST to about Mach 2.5, or 1900 mph [5].

After reaching Mach 2.5, the ramjets are activated to propel the ZEHST to a cruise speed of Mach 4, or 3000mph [5]. A ramjet engine is only used in supersonic and hypersonic flights; it get its name because it rams the air into the combustion chamber. “A ramjet can only produce sufficient thrust if the aircraft is moving at supersonic speeds greater than Mach 2” [5], which is why booster rockets are needed to reach such speeds. The ramjet engines “have no rotating parts and use surrounding air for combustion of the fuel” [5]. Because of its relatively simple design shown in Figure 4, it will be cheaper to manufacture than other complex engines. One great advantage of ramjets are that “the consumption is relatively low, which makes it optimized for long-range flights while providing hypersonic speeds” [5]. Although ramjets provide significant speeds, many may think that the high speed would result in an uncomfortable ride; however, “ZEHST passengers would only feel mild acceleration forces” creating a ‘normal’ flight experience [2].



http://www.airbus-group.com/dms/airbusgroup/int/en/press/documents/Dossiers/Downloads/EADS-Brochure_ZEHST_English.pdf

Figure 4. Ramjet Fundamentals.

Zero Emission Technology

With an aircraft of such high speed capabilities, a tremendous amount of fuel will be consumed. Currently, there is a great concern for the environmental effects of carbon emission. Using standard jet fuel or rocket fuel would have a detrimental impact on the environment and the ozone layer. The zero emission technology is a necessity for an aircraft like the ZEHST because it has a cruise altitude of up to 32 km, or 100,000 feet [2]; flying at higher altitudes increases the impact of carbon emissions on the ozone layer. The goal of the ZEHST is to create zero carbon emissions to the environment, hence its name. The three types of engines will use different means of fuel. The turbojet engines will be fueled by a seaweed based biofuel. The booster rocket engines and the ramjets will be hydrogen powered. Using these methods of fuel the ZEHST will practically have zero emissions to the environment [5].

Biofuel usage “mitigates the effect of greenhouse gases” [6]. The biofuel the ZEHST utilizes is bioethanol, which is produced from raw plants. Using ethanol, a clean burning fuel, as a power source for engines has proved to be viable in other transportation vehicles [6]. Ethanol can be most effectively produced from major crops such as wheat, rice, corn, and potato. [7] However, using crops as a fuel source endangers the price of food. To avoid market competition with food, seaweed can be used to produce ethanol [7]. Since the oceans make up 70% of Earth’s surface area, farming and harvesting seaweed is viable. Studies show that seaweed can competitively yield as much ethanol as major crops [7]. Using ethanol from seaweed to power the turbojet engines, the ZEHST will have a sustainable, clean source of fuel to power its turbojet engines.

The rocket booster and ramjet engine use cryogenic hydrogen as fuel, with cryogenic oxygen as an oxidizer [5]. The hydrogen and oxygen go through a chemical reaction and ignite to provide thrust for the rocket booster and ramjet. Since this reaction is carbon-free, there is zero emission of greenhouse gases. Combining the use of bioethanol and cryogenic hydrogen, the ZEHST will minimally impact the environment.

Conclusion

The ZEHST brings in the speed capabilities that has yet to exist commercially and at the same time uses sustainable and clean fuel resources. However, with such new and advanced technology, it will take a great deal of research, development, and more technological advances for the ZEHST to be commercially viable. The time-frame for the ZEHST is “around 2050, but a small scale demonstrator could be a reality by 2020” [8]. It may be a long time for the ZEHST to surface commercially, but imagine being able to travel from New York to Tokyo is less than two and a half hours! The ZEHST exemplifies the future of transportation: environment friendliness and unparalleled speed. Vehicles like the environment-friendly, blazing fast ZEHST may be the norm in the near future.

References

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