THE FUTURE OF RAMJET AND SCRAMJET ENGINES IN COMMERCIAL OPERATIONS

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Abstract- Ramjet engines are a type of advanced air-breathing jet engines where ignition starts at supersonic speeds only. This means the aircraft cannot operate at lower speeds and needs assist take-off operations to fly efficiently. Scramjet is a supersonic combustion ramjet, an even advanced variant where both ignition and combustion occurs at supersonic speeds. Ramjet and scramjets are very efficient at supersonic and hypersonic speeds respectively. However only secretive military projects such as the fifth generation stealth multirole fighters or prototypes such as NASA X-43 are the only operational hypervelocity aircrafts currently. But there is a lot of potential and room to accommodate the use of ramjet and scramjet engines for commercial and civilian aircraft transport. This paper deals with the possible ways of commercializing a ramjet engine for civilian jet transport. It also mentions the ways of modifying a ramjet engine to handle commercial operations i.e. manufacturing a commercial variant of the military ramjet engines and prototypes. The paper also includes theoretical explanations for the same and an analysis of how could an operational supersonic or hypersonic aircraft engine model will look like in a commercial variant.

I. INTRODUCTION

A ramjet is an advanced air breathing jet engine which is usually associated with supersonic transport and they are also a type of rocket propulsion. This is because rockets travel at speedsexceedingMach 2to reach their targets. Ramjet can also be used for military applications such as missiles and nuclear war heads. Ramjets start at supersonic speeds only, so as a result they cannot be started at zero velocity and cannot produce thrust as there is a lack of airspeed. Hence Assisted take off flights or rockets are needed to tow or accelerate it to a point from which it starts producing thrust. Thus this makes ramjet engine to be highly efficient at supersonic speeds as it can accelerate to speeds of about Mach 6.

The ramjet was first flight tested in 1948 by the US Armed forces as a prototype fordevising air to air missiles. Subsequent progress in Ramjet technologies have been limited to Military aircrafts and prototypes. Ramjet has revolutionized Rocket Propulsion and Missile Technology over the years. The Erstwhile soviet union in fact experimented with ramjet technology to develop ICBM's or Intercontinental ballistic missiles. Liquid fuel based rockets and Propulsion system projects took off with ramjet engines, but were never completed and many projects got cancelled. Since the early 2000's Ramjet Technology has grown by leaps and bounds but still remain confined to military use.

On the other hand the Scramjet or the Supersonic Combustion Ramjet is a further sophisticated variant and is efficient at hypersonic speeds, usually upwards of Mach 7. The Germans were the pioneers in introducing this high speed machines for purpose of war . The cold war era saw Russia ground testing scramjet propulsion for a hypersonic Technology Demonstration . After the cold war , the advent of Nasa venturing into atmospheric hypersonic flights emerged with the scramjet vehicle known as X-43 A. Further studies continue in the area of hypersonic Flights but they remain limited to military fields.

The Advent of the first spaceport in the USA triggered an interest for upper stratospheric flights which is at an altitude of 80kms from sea level to showcase sub-orbital flights to fliers and enthusiasts. These flights have been planned to incorporate hypersonic technology in them. Also plans have been unveiled for a new supersonic transport promising to be faster and better than Concorde. For these Proposals A commercial variant of ramjet and scramjet powered aircrafts can fulfill all requirements and specifications needed for such flights . A commercial variant of the X-43 A in the future can revolutionize air travel so much that a 16000 km trip distance can be covered in less than 8 hours for ramjet engine powered aircrafts and less than 5 hours for scramjet powered aircrafts . For Comparison , the top speed of a commercial airliner powered by a turbofan engine can be up to 1.2 Mach , whereas the top speed for a ramjet aircraft is about 6-7 Mach and the top speed for a scramjet aircraft is 15 Mach.



Fig 1 – an illustration of the x-43 a , the scramjet engine is visible below the belly Of the fuselage, source – google images

II. WORKING OF RAMJET AND SCRAMJET ENGINES

A Ramjet's Interior is made up of few parts and includes a compressor , a combustion chamber and an exhaust nozzle. Unlike normal jet engines as stated above , a ramjet cannot start functioning at zero thrust . So once the aircraft reaches supersonic speed ,the air which enters the ramjet through the inlet, is compressed by the compressor as the pressure builds up in the ramjet tube . As pressure builds up , the temperature inside the engine tube also rises exponentially($\Delta T = Q/mc_p$) with a lot of hot gases trying to escape in all directions but are obstructed by the walls of the ramjet in the Combustion Chamber. The air which is meanwhile compressed along with the fuel slows down as the pressure inside the tube and the ambient pressure stabilizes at a equal level and is passed into the combustion chamber . The temperature further increases and the compressed air along with the hot gases are trying to escape but the walls of the ramjet prevents any expansion of the air and hot gases and hence pressure causes the air and the hot gases to rapidly exit the ramjet through the Exhaust .

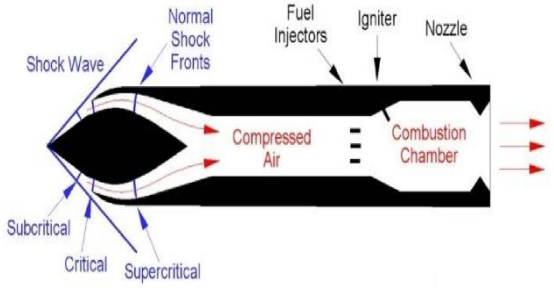


Fig 2 – a schematic representation of the working of a ramjet engine, source – google images

The above diagram shows how the thrust is maximized in a ramjet . Air which is propagating inside the ramjet is faster than the speed of sound , hence shockwaves are produced . The shockwave is present along the nozzle of the ramjet engine and since the shockwave position is perpendicular to that of the Ramjet tube , it is called as Normal shock wave . The air meanwhile , is compressed and mixed with the fuel received from the fuel injectors and the speed is slowed down. The Gases and the air try to escape the combustion chamber exit at a higher speed compared to the speed of the air entering the inlet . This means Greater thrust and a higher acceleration for the ramjet to higher speeds . Typically a Ramjet can attain 6.5 Mach through the above mentioned process. Scramjets have a very similar working to that of the ramjet except the fact that combustion also takes place in supersonic speed . This means that the air being compressed does not slow down as it enters the combustion chamber and exits the exhaust tube producing far greater thrust and giving greater speed compared to ramjet.

III. RAMJET ENGINES FOR COMMERCIAL USE AND RESULTS

A Commercial aircraft can be fitted with a ramjet engine in addition to the turbofan engines equipped with afterburners , which can be used as assisted take off engines . Once the aircraft reaches supersonic speed , the ramjet engine ignition will start and can be used for sub-orbital commercial flights. We propose a funnel shaped ramjet engine design where the inlet functions as the smaller end and the exhaust behaves like the larger end of a funnel . The idea of a funnel shaped design is that if fluids flow through the smaller end it will come out in a greater speed from the larger end . This enables higher thrust and acceleration for the engines as drag problems become negligible due to the exponential thrust force. The front intake tube is designed to accommodate maximum amount of incoming slow moving air . The pressure rise and pressure drop is dependent on the interaction between the compressor and the mostly closed combustion chamber. The closed in combustion chamber is designed so as to prevent expansion of hot gases and the compressed air and also for rapid exit of gases through the exhaust as mentioned earlier. The below figure shows a simple Catia structural outline of a funnel shaped ramjet engine. The five parallelograms indicate the parts of the ramjet as follows 1) Intake 2) Compressor 3) Fuel injector and ramjet tube 4) Combustion Chamber and 5) Nozzle and Exhaust.

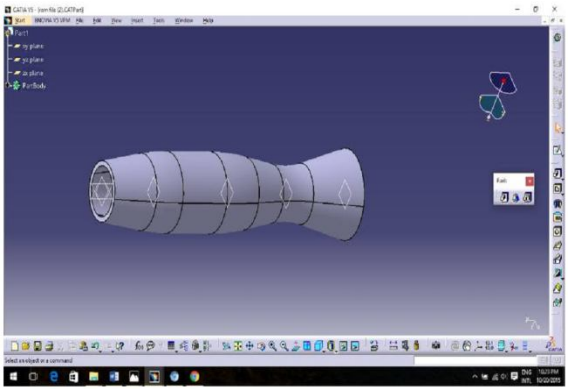


Fig 3 – catia structural overview of a ramjet engine

The same engine model can be incorporated in a scramjet powered aircraft by modifying the design of the combustion chamber.

CONCLUSION

With the advent in the opening up of commercial spaceports , supersonic transport and Interstellar travel which looks into faster and efficient engine models , commercialization of ramjet and scramjet engines could be the solution. Assisted take offs for a

ramjet engine actually solves one more problem apart from taking a ramjet engine to supersonic speed and that is decreases energy and fuel loss during consumption and increases efficiency and aircraft optimum performance . A ramjet can fly passengers up to the altitude of 90 kms from the sea level. This can open up a new commercial spaceline industry which could be beneficial to the airline industry. With better designs and commercialization , the ramjet and scramjet engines holds the key to the future of supersonic and hypersonic aircrafts .

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