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# IMPROVEMENT IN DESIGN OF ENGINES TO REDUCE EMISSIONS IN AIRCARFT AND INCREASE FUEL EFFICIENCY

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## Abstract

*The aviation industry in today's world is growing constantly and it is at its peak. This increases the demand for fuel and also results in more pollution by the emission of gases like CO2 and NO2. The scientist and engineers are working to increase fuel efficiency of aircraft engines thereby reducing the emissions of the greenhouse gases responsible for ozone layer depletion.*

*In this paper there is an investigation about different challenges to increase the fuel efficiency in aircraft engines. It also highlights about different alternative fuels for increasing fuel efficiency thereby keeping in mind pollution norms.*

***Keywords:*** *electric propulsion, bio fuel, greenhouse gases, fuel cell, future aircraft*

## Introduction

The efficiency of an engine i.e. a thermal engine is the relation of the total energy stored in a carrier (fuel) with the amount of energy required to execute useful work. A fuel-efficient engine is which makes the maximum use of the fuel provided to perform work. In theory, the maximum efficiency that could be achieved by a combustion engine (according to Carnot) is limited to 64%. However, in real life, this efficiency is reduced to a maximum of 50% where this 50% efficiency is achieved by formula race cars for example, Mercedes' Formula 1 engine recently broke the 50% thermal efficiency barrier for the first time. The petrol engines we are sing are having an average efficiency of 30% max in ideal conditions and the diesel engines which we use have an efficiency of 30% roughly and could be achieved to 41% in ideal conditions. Most of the energy is wasted in air drag, friction and heat radiation.

The world is facing a petroleum crisis and thus demands an engine which is both fuel and cost efficient and could also be used in our day to day commuting. One kilogram of fuel consumes fifteen kilograms of air to burn and produce about three kilograms of Carbon Dioxide, significant amount of energy is also required to pump the fuel in and out of the engine. This carbon dioxide produced contributes to the world annual production of 31 billion tons of Carbon Dioxide. This CO2 is a major greenhouse gas which results in major climatic changes. Thus, one additional goal of the modern day engineers is to make engines that also minimize pollutant emission and allow the usage of different fuels in transportation systems.

The problem faced today in that even if a new engine is made, it should be able to run on the current fuels available or if a new fuel is synthesized it should be compatible with the current engines. The acceptance by the consumer is also important. The current development in the automobile industries like down sized engines and the use of increased pressure in fuel injection must work with the existing fuels.

This study is intended to fine a possible solution for increasing the efficiency of aircraft engines or finding cost effective fuels or fuel replacements. The development of these engines is not centered only to the daily use aircraft like airbusA380 and jumbo jets but also to the heavy fighter aircrafts used in the international security.

**Literary Survey**

[1]-The research shows that at the present time, a "drop in" jet fuel replacement, i.e. a proper mixture of kerosene and synthetic fuel, in a proper composition would be a viable substitute in the aircrafts of now and near future. Synthetic jet fuels manufactured using Fischer-Tropsch process are very alike to standard jet fuels but contain almost zero sulphur and aromatics, which results in lower particulate emissions. Since, synthetic fuels have already been in use for sometimes at Johannesburg airport, it would be easy to adjunct the jet fuels of today with synthetically derived fuels. On the other hand, a combination of synthetic and bio- fuels is also a possible midterm solution. On using pure bio-fuels we face major challenges like their proclivity to solidify at standard cruising conditions, inferior high temperature thermal constancy etc. Therefore, these issues need to be addressed to make their future use possible. In spite of these problems the advantages of using bio-fuels are their environmentally balanced CO2 impact and their potential to become a sustainable fuel. Solutions that would be successful for a longer period need to effectively minimize the release of greenhouse gases, hence, need alternate fuels with almost negligible carbon content, the examples of these are liquid Hydrogen and Methane. The drawback of using these cryogenic fuels is that major modifications are needed in the combustor and fuel system components of the aircraft. Moreover, a heat exchanger would be required for vaporizing the fuel before combustion and hence, compromises must be made with the airframe design. The hefty insulated fuel tank would decrease the aircraft's energy efficiency in short- ranged flights. [2]-This research shows the advances of the modern world towards the "More Electric Aircrafts" (MEA), giving more focus on the flight controls. The aircrafts of today are a mixture of electrical, mechanical, pneumatic and hydraulic systems which are the products of decades of evolution. In the standard architecture of aircrafts, engines convert fuel into power, maximum part of which is utilized for propulsion and the remaining for the other components. With the passing decades each system has become more composite reducing the efficiency of the aircraft by their interactions. An all-electric aircraft is one in which every form of power consumption is electrical in nature. It is believed that an all-electric system has more potential in future aircraft use than the conventional aircrafts, both in terms of efficiency and environmental impact. There are various steps taken towards MEA, first being, the removal of present hydraulic and air engines and increasing its capability of generating electrical power. This needs lots of changes in fault protection techniques, network techniques and generation of electricity. The second being the substitution of hydraulic mechanism for electromechanical mechanism, reduction in weight and reducing production and maintenance expenditure, MEA lays stress on the usage of electrical energy to advance the performance and life of the aircrafts. [3]-The present-day range of aircrafts which are jet powered face a very important challenge, which is the reduction of CO2 and CO and NO2 emissions while as increasing the efficiency of aircraft. Since the emission of unburned hydrocarbon and carbon monoxide (CO) are thus far very low and these pollutants are continuously controlled as expected when engine pressure and temperature ratios are elevated, it is very important to change the engine design which will help to reduce the NO2 emission which in turn will increase the fuel efficiency. One way to reduce fuel efficiency and reduce NO2 is that we can use the concept of staged combustion, splitting the loading of fuel among the several fuel and air phases which controls the localized fuel to air ratio to reduce the NO2

production rate as the power is elevated. The pilot section should be at a position which is near the centreline of the engine and the main section should be outboard and should be towards the downstream of the pilot section. The benefit of using this type of system is that it eradicates the combustor receptiveness to blow out. [4]-Fuel-cooled thermal management consists of breaking of large hydrocarbon molecules into simpler and smaller alkenes, this process is endothermic and improvement of hydrocarbon fuels. It is a way for cycle improvements and pollution emission control in gas turbine engine applications. This technology is based upon the standard multi-component hydrocarbon fuel for improvement in fuel cooled thermal management. It involves the improvement of endothermic potential of JP-7 and JP-8+100. It is demonstrated with the help of bunch scale test rig working under flow conditions and passage geometers mimetic of practical heat exchangers for aircraft and missile technology applications. Full scale sector rig tests are performed in order to define the combustion and emission of supercritical jet fuel. It is also used to ensure safety and working of the fuel systems, including a fuel air heat exchanger. [5]-Fuel efficiency of a turbofan engines can greatly be increased by decreasing its weight and size and also by decreasing the engines specific fuel consumption. By reducing the weight of the engine, it results in decreasing aircraft maximum take of weight which can further reduce aircraft lift to drag ratio. By bringing down the engine size mainly, the nascle radius and length of the engine results in lesser thrust requirement of the engine specific fuel consumption can decrease the fuel consumption. We can reduce engine specific fuel consumption by increasing the ability to push forward or we can say it propulsion and thermal efficiency. By using the modern computational fluid dynamics abet 3D-blade designs, it is already quite aggressive and therefore we can take a limited advantage in fuel efficiency. By improving component efficiencies and reducing other losses like duct pressure losses and the cooling flows losses, it is also a way to improve the specific fuel consumption. [6]-This research shows NASA’s response to the increasing demand and care about the environment. Subsonic fixed wing project of NASA recognizes four problems which are exhibited in air travel. These problems include emissions, noise and fuel burn of aircraft and span area in design of aircraft. NASA has been exploring one of the propulsions and vehicle concepts for year 2020 that is a synergistic combustion of a distributed propulsion system and a hybrid-wing-body airframe. NASA has already taken some steps like in 2006 NASA financed a one-year research or study which was focused on benefits of distributed propulsion, body or airframe design to increase efficiency and done some operation on aircrafts from some local airports. To develop a silent aircraft, MIT Institute in Cambridge have developed a conceptual design known as SAX-40 which was further worked on by NASA and Boeing. [7]- The design and construction of an aircraft which would be powered by fuel cell and will be unmanned like drones. Many researchers and scientists have developed aircrafts which are powered by fuel cell to show possibilities of using fuel cells as new source of energy and power. For existing batteries as a replacement fuel cell system are combined generators using hydrogen. In past first fuel cell was developed by AeroVironment in 2005 which used hydrogen in liquified from. Aircrafts using fuel cell of current generation is classified on the basis of methods to store hydrogen and fuel cell types. For development of an aircraft using fuel cell, some of these things should be kept in mind. Fuel cell systems should be starting fast and recharge of fuel should be convenient. Fuel cell components should be more reliable and should have less weight. Test of performance of aircrafts using fuel cell should be done in harsh conditions and climatic conditions like rainy day etc. [8]-It is shown that consumption of aircraft fuel and cost of fuel is a major problem faced by aircraft industry since past years. Reduction in consumption of fuel ss important is as leads to reduction of emissions like greenhouse gases and pollutants that can cause damage to us. This paper discusses a method to model airplane terminal to reduce fuel consumption that will lead to differences between fuel consumption which is modelled and one which is measured. One way by which fuel consumption could be minimized is by procedures such as continuous arrivals which are descent and tailored. In present era, available airplane performance models show that error in fuel consumption in terminal area is order of 20 to 40%. The method is based on using airplane manufacturers' existing airplane performance tools and for existing fuel consumption methods, it is not a modification. Nowadays, due to increasing fuel costs, aircraft stakeholders have developed some algorithms for modelling consumption of fuels. [9]-It is shown that the main motives in the design of aircrafts of future is to reduce nose made in airports, emissions in reduced level and less amount of fuel burn. Over last 50 years, aircraft industry got many changes due to increase in air traffic through various processes by use of technology due to which already levels of noise pollution and fuel consumption decreased but at a low level. Technology which have to be used in engines of aircraft are enhanced design in propulsion of system that which uses superconducting, electric generators that are cooled and drives low noise electric fans by use of motors. New propulsion systems lead to fuel efficiency. The bypass ratio (BPR) which is known as the ratio of rate of flow of stream that passes outside core divided by that flowing through the core, plays a crucial role in designing of engine. A BPR which is higher means exhaust with lower speed which reduces fuel consumption at the cost of an increase in fan diameter. Aero propulsions which are electric offers huge benefits in the design of aircraft, resulting in much more energy efficient engine. [10]-Air travel is one of the fastest growing modes of transportation. It is the most important mode to travel. Increase in the total fuel consumption and the potential impacts of aircraft engines emissions on the global atmosphere has led to thinking among the engineers, scientist and authorities. So, they have to search for the various emission options and to reduce fuel demand of engines. The technological and operational fuel efficiency of aircraft was first analysed by using Breguet range equation. By using the equation, the aviation system efficiency parameter was defined which determines its efficiency and load factor. Multivariable statistical analysis was used to determine and correlate this parameter with direct operating cost.

The fuel burn reduction potential for future aircraft system is to be estimated by this paper with the help of extrapolation of historical trend in aircraft technology and operations and the fuel burn reduction for future aircraft systems.

## Findings

After reading all papers it is clear that bio fuels can be a replacement for the fossil fuels because of their balanced emissions of the CO2 and other greenhouse gases. Further fuel efficiency could be achieved by modifying engine design, using electric propulsion etc. Fuel cooled thermal management systems is also a way for cycle improvements and pollution emission regulation in gas turbine engine application. Fuel efficiency of a turbofan engine can be greatly increased by decreasing weight, size and also decreasing engine specific fuel consumption.

Over last 50 years, aircraft industry got many changes due to increased air traffic through various processes of technology that has decreased the noise levels and fuel consumption. Technology which is new for use in aircraft engines like in a propulsion system design that involves advanced superconducting, cooled electric generators and motors in order to drive low noise electric fans which increases fuel efficiency.

## Recommendation & Conclusion

Consumption of fuel and costs of current generation fuels like petrol etc. is a major problem of the aircraft industry. In total operating costs of aircrafts, cost of fuel constitutes the largest ratio. Many organizations regulating aircraft industry and airplane manufacturers are trying to find ways to reduce fuel consumption. These researches have also focused to reduce emission of greenhouse gases and emissions of those pollutants which can cause illness.

There is a huge research going on to find alternate fuels, modify design to make aircrafts more fuel efficient. Next generation electric aircraft with new electric propulsion systems are in process to achieve a sustainable aviation. The main points which should be in mind while designing future aircrafts are noise made at airports should be reduced, burn of fuel should be reduced and also reduced of emissions (both pollutants and greenhouse gasses). There is a lot to be found in this area to make future aircrafts more fuel efficient, pollution free and achieve sustainable aviation.

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