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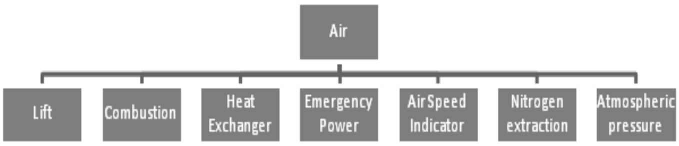
Free Resources for an Aircraft during Flight

Er. P Manoj Kumar
LSSBB, B.Sc (Aero), PGDBA (HR & FIN), AMAeSI, AMIE, M.Tech
Assistant Director of Airworthiness,
Ministry of Civil Aviation, Govt. of India.

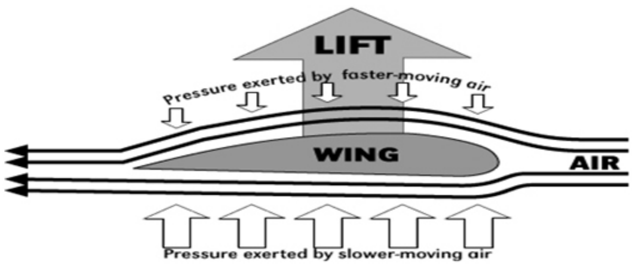
Surrounded by IT Professionals in the Silicon City of India, Bengaluru, I often face a 'welcome change' when I introduce myself during social get-togethers as one belonging to the Aviation Industry for over two decades. Enthusiasm of Kids to know about flying in general and technology behind aircraft in particular 'lifts' me. Not just Kids, people wonder, as I explain that the basic science behind most aircraft systems is often rooted in our high school science text books. One of the main hindrances for any aircraft to fly is its weight, so any equipment/machinery being used should justify its weight w.r.t its output for the aircraft to fly. In order to satisfy that, scientists always optimize the resources available to them - either free resources like air, atmospheric pressure and nitrogen or by-products of its existing equipment/machinery. Air is freely available in the atmospheric zone and it is one of the main free resource being utilized by an aircraft for its flight. Some of the utilizations the air are as follows:



LIFT:

Lift is the main source for an aircraft to become airborne, unlike rockets, missiles.

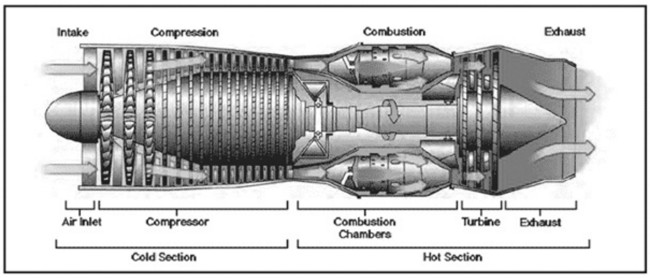
In rockets/missiles, their main source for flying is its propellant/fuel, which combusts and creates mammoth thrust and its flying control surfaces steer the missile accordingly towards the target. The same cannot be used in aircraft because it becomes too expensive, uncontrollable and can place the crew and passengers' lives at risk [1].



As we have learnt in our high schools regarding the Bernoulli's Theorem, the same principle is used to lift aircraft using its streamlined 'aerofoil' shaped wings. These wings are manufactured with the curvature of upper surface more than lower surface of the wing. When high speed air, after separating from the 'leading' edge of the aerofoil (see figure above), flows over and below the wing, air over the wing has to travel more w.r.t under the wing. But both the layers of air have to meet at the same time at the 'training' edge. Due to this, the speed of air is increased over the wing and this in turn creates a low pressure. Due to the low pressure over the wing and high pressure under the wing, the wing is pushed upwards , lift is created and, thus, the aircraft becomes 'airborne' [2].

COMBUSTION:

Here also, we can compare the aircraft with missiles, if the missiles travel in the earth's atmosphere, they come across lot of drag due to atmospheric air, moisture, etc. which reduces speed. The missiles are preferred to be flown above the atmospheric region to achieve greater speeds and lesser drag. So, it needs to use its own oxygen (oxidizer, increases weight) for combustion of propellant, which then creates thrust.



The aircraft should be stable, controllable and steady in flight. So, it is preferred to fly the aircraft inside the earth's atmosphere. For generating thrust by the engine of aircraft, it requires to burn the fuel in the presence of oxygen. It need not carry oxidizer/oxygen (like in missiles) as there is ample amount of oxygen in the atmosphere [3].

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HEAT EXCHANGER:

Heat exchanger is equipment where high temperature of a body is transferred to a lower temperature body.

In aircraft, various systems/equipment are required to be continuously running to keep it airborne. These systems /equipment, like hydraulics for flying controls, power transmission by engine, air-conditioning system, cooling of electronic equipment/engine, pumping of fuel to engines, etc. generate a lot of heat [4].

It is therefore important to extract the gained high temperature of these equipment to improve their efficiency. This heat exchanged is used for various other purposes such as engine anti-icing, wind shield heating, fuel heating, cabin heating, etc.

The following types of heat exchangers are used in an aircraft:
a) Air to Air
b) Air to oil
c) Oil to fuel

Air to Air:

When the aircraft is flying at higher altitudes, the atmospheric temperatures are very low. So, the temperature of skin of the aircraft comes down. And it can be used for various purposes.

There are electrical/electronic equipment in various compartments in the aircraft which are required to be operational throughout the sortie and the temperature of these equipment rises due to continuous operation. It is essential to bring their temperature down to the operational level for effective performance.

The air which is used to cool thiselectrical/electronic equipment can be routed through the skin of the aircraft, where the low temperature of skin is exchanged with the high temperature air, which cools the equipment. The same air can be reused.This process saves a lot of fuel as there is no necessity of employing an air-conditioning equipment [5].

Air to Oil:

The engine has to run continuously for generating thrust, driving the various gears for power transmission etc. in this process, a lot of geared components get heated up and oil is used to keep the temperature of the components low and keep them operational. The heat of the oil is exchanged with the low temperature atmospheric air using radiators. Here, we are able to reuse the oil and able to utilize the low atmospheric temperature.

Oil to Fuel:

The required fuel for the sortie is generally stored in the wings. The temperature of the fuel stored in the wings decreases due to lower atmospheric temperature at high altitude. Here, the heated oil which is passed through various aircraft components is exchanged with the low temperature fuel using liquid to liquid heat exchanger.

EMERGENCY POWER:

Aircraft requires electric power supply to fly and operate various electrical and electronics equipment. Even though the main source of electrical supply to the aircraft is from main/auxiliary engine generators; additionally, aircraft batteries are also used as a redundancy for electric supply.

Since electric and hydraulic power play an important role for safe flight, having one more level of redundancy adds value to the safety of aircraft. So, most of the aircraft have one or more redundancies of emergency sources for electric and hydraulic power. For example: Ram Air Turbine (RAT).

Ram Air Turbine is operated for important aircraft systems in case of any of the two kinds of emergencies, loss of hydraulic power or electrical power, occurs. In case hydraulic or electric emergency arises during a flight, RAT can be operated automatically or manually. It is similar to a propeller; when operated it extends from the fuselage and rotates with the help of ambient high speed atmospheric air.

NITROGEN EXTRACTION:

Approximately, 78% of atmospheric air contains Nitrogen, which is an “inert gas” and can be used for fire suppression. The fuel tank contains fuel and fuel fumes which are highly explosive. During an emergency landing / belly landing, there is a maximum possibility of fuel tanks or engines striking the run way or land and can generate a spark, or sufficient heat for the fumes to catch fire and the fuel tanks to explode like a bomb.

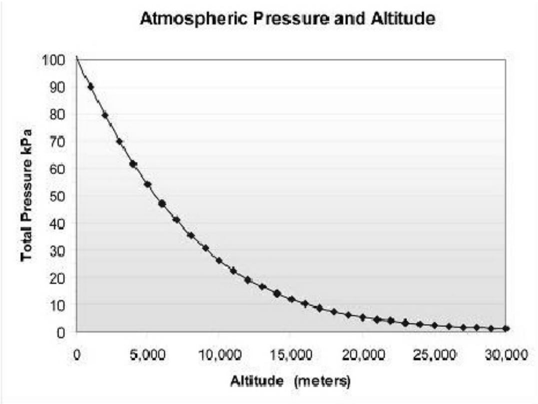
This may damage and burn the entire aircraft instantly. In order to avoid this kind of explosion of fuel tanks, the empty space in the fuel tanks is filled with nitrogen. Carrying huge volume of nitrogen in aircraft will reduce the payload carrying capacity. So, the ‘inert gas system’ has been designed to extract and store the abundant nitrogen from the atmosphere while flying and use it when necessary.

ATMOSPHERIC PRESSSURE:

The atmospheric pressure reduces proportionately to the increase in altitude.

Altimeter:

As a redundancy to the aircraft altimeter (electronic equipment - used to know aircraft's altitude), atmospheric pressure can also be used to determine the aircrafts altitude.



The above picture clearly indicates that, the atmospheric pressure falls down proportionate to the increase in altitude. These charts can be used in emergency to determine the altitude of aircraft.

Blowing out smoke from electronic compartment:

Low atmospheric pressure can be used to suck out unwanted air and smoke from the aircraft. The electronic bay is cooled with the air as a medium. In case of smoke generation due to some electric / electronic defects in the electronic bay, the same can be sucked out to atmosphere using a controlled valve between aircraft and atmosphere. As the atmospheric pressure is less than the aircraft electronic bay, the smoke is sucked and reduces a major fire in the aircraft electronic bay.

Flushing in toilet:

For transferring the waste from the toilet to the waste tank, it is necessary to have pumps, and electric supply to run these pumps. However, using the low atmospheric pressure, the requirement of pump is obviated. A noticeable sound is observed in the aircraft's toilet, whenever the flush of the toilet is operated. While operating the flush, a controlled valve is operated to connect the low atmospheric pressure to transfer the waste from the toilet to waste tank using pressure difference between low atmospheric pressure and relatively higher cabin pressure.

The utilization of air plays a very important role in aircraft, not only for the basic purpose of generating lift but also for various other important purposes as discussed above. Usage of air has led to reduction in the requirement of various equipment, systems, storage tanks etc. It has not only reduced cost, maintenance cost, overheads for stores, etc. but has also reduced the total weight of aircraft.

Conclusion:

We saw in the foregoing paragraphs how free resources such as air, air pressure and nitrogen available in the atmosphere collaborate to keep the aircraft in air. From generation of lift, engine thrust and cooling to operation of various components and systems, these free resources are always at play right from start to shut down of the aeroengine.

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