Aircraft Engine

The Engine of an aircraft is the part or component that works as a pushing(propulsion) system for the aircraft by which mechanical power is generated. The engines of an aircraft come in two types one is the piston, and the second one is a gas turbine(turbo engine). 1930 was the year when Frank Whittle invented the first aircraft turbojet engine.

Generally, commercial airplanes, the aircraft use four engines to fly. Engines of commercial aircraft fly from one continent to another in a couple of hours. The engines used in commercial aircraft are 2x times bigger in size than the aircraft which only fly in the country.

These engines are powerful and reliable, which is important for long travel. The Engine of the aircraft is also known as an aero engine. The big aircraft like boeing777 use big dual engines, the GE90-115B engine.

It helps aircraft to travel from one continent to another smoothly and safely because of its powerful engines. Engines in the aircraft are placed below an aircraft's wings, which allow aircraft thrust to push or speed up the aircraft towards forwarding direction by air.

The aircraft which fly in the air at low speed use a fan on the nose of the aircraft to push the aircraft instead of using turbo engines.

Types of Aircraft Engines

Five types of Engines are used in aircraft. Every Engine has its benefits and disadvantages. In this article, you will get all the knowledge related to aircraft and the engines used. Below there is the list of the aircraft engines:

There are five main types of aircraft engines:

SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

COIMBATORE-35

DEPARTMENT OF AEROSPACE ENGINEERING

19ASB204 – Aerospace Propulsion

Unit –I Types of Aircraft Engines

- **Turbojet Engine**
- **Turbofan Engine**
- **Turboprop Engine**
- **Turboshaft Engine**
- **Ramjet Engine**

1. Turbojet Engine

The turbojet engine was firstly built/developed by British and german aero scientists during world war 2. Turbojets fly in the sky through the air with the push of powerful gas.

- The concept used in aircraft with a turbojet engine is very easy and simple.
- The Engine of an aircraft takes the air from the rear side of the Engine and then compresses it in the compressor.
- But at the same time, it is necessary to add fuel to the combustion chamber and burn to increase the fluid mixture temperature by 1000 degrees.
- Because of this process, hot air is produced and passed from the turbine, which rotates the compressor.
- The pressure created when the turbine gets discharged should be twice the pressure in the atmosphere.

- Although it depends on the level of efficiency of an engine that is used in the aircraft.
- The imprudent pressure then transfers to the nozzle by which gas streams get generated.

2. Turbofan Engine

Using a big fan in aircraft makes it easy to intake air. A turbofan engine is designed in such a way that it combines features and technology of turboprop and turbojet engines.

Turbofan engines have some benefits, like producing thrust at low speed. The first aircraft company was Boeing which used turbofan engines while mounting its 737-300 aircraft starting in the 1980s.

- In 2018, the big GE9X turbofan engine was built to power aircraft like the 777X by the company Boeing.
- Turbofan engines come with big fans to suck the air.
- While using a turbofan engine, the airflow is from the aircraft engine's exterior to give the aircraft more power to fly in the air.

- Nowadays, most airlines get power from turbofan jet engines. Air enters the turbofan jet engine and flows from a generator that produces hot air.
- A generator in an aircraft is made up of a turbo/turbine combustion chamber and a compressor.
- Less air will pass through the Engine (turbofan) and reach the combustion chamber.
- The remaining air will pass through the compress, which has low pressure or pass by a fan. Afterward, it will be mixed with gas produced, or otherwise, it will eject directly.
- The main reason behind this process is to produce power at the same time they are trying to maintain a consistent level of consumption.

3. Turboprop Engine

A turboprop engine is like an engine of a turbojet that uses a system of gears to connect the aircraft propeller. The gearbox used in the aircraft comes with a turbojet that spins the shaft attached to it. To connect the gear to the propeller gearbox, slowly spin the shaft. To produce power/thrust, propellers produce through the air.

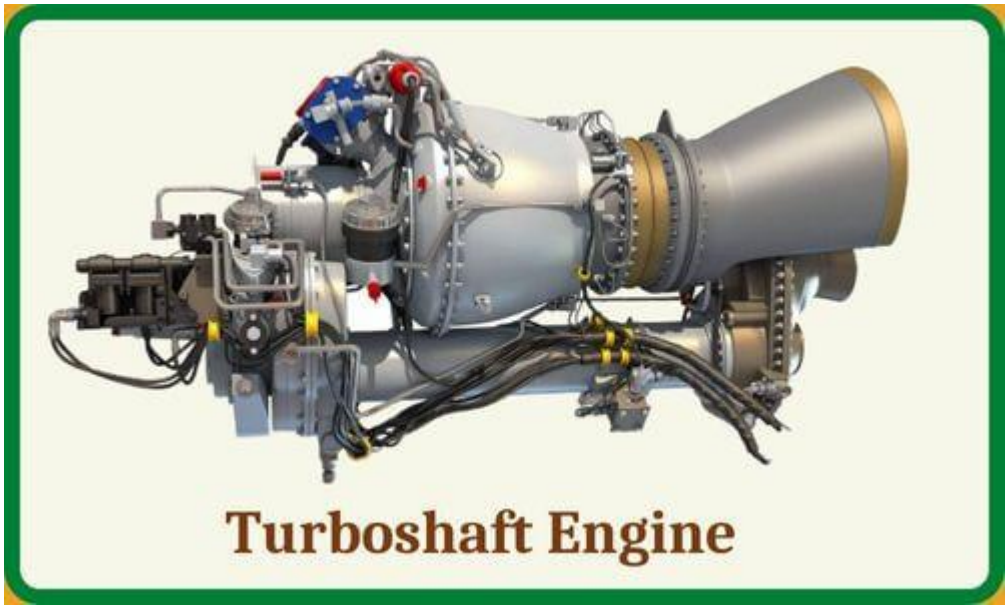
The engines of the turbofan aircraft are fuel-efficient, and it rotates at a medium speed like 200 to 350 knots.

As engines of turbofan aircraft are efficient at medium range, they can break down rapidly because aircraft are heavyweight. A turboprop engine comprises combustion chambers that have pressurized air and gas that work together and run the

Turbine:

- To run the compressor, power is needed to run the compressor that is created by the gas and air.
- The fan blades of an aircraft are in scimitar shape, and the tip edge is swept to the back side for efficiency when the flight is traveling at high speed.
- The engines of aircraft which come with such propellers are defined as the profits. We all know that aircraft which have turbofan engines can convert gas streams into mechanical power to gain power.
- The first ever turboprop engine was built and designed in Budapest in 1938. The testing of the turboprop engine was done in 1940 in an august month. In 1942 the first turboprop engine was started to operate.

4. Turboshaft Engine



A turboshaft engine is a form of a turbine that is gas-powered, and it operates the same as a turboprop engine. But it can't operate a propeller-like turboprop engine. As the turboshaft engine can't operate the propeller it used to provide.

Power to a rotor used in helicopters.

- The design of turboshaft engines is designed to make the rotor speed rotate independently of the speed of the gas generator.
- It makes the helicopter capable of maintaining the speed of the rotor constantly even when it declines the speed of the gas generator.
- The engines, like the turboshaft, are generally used in helicopters. The main difference between a turboshaft engine and a turbojet engine is that the turbojet engine uses its power to turn its turbine instead of generating force.
- The turbojet and turboshaft engines are similar, but the turbojet has a long shaft connecting the front and back sides.
- In helicopters, most engines are used as turboshaft engines in which a shaft connects the transmission of the helicopter rotor blade.
- Most of the components used in turboshaft engines are turbojet engines or the same as turbojet engines. The turbine is fitted with a shaft to provide the power to the transmission of the rotor blade.
- Transmission of rotor blade works to transfer the shaft rotation to the rotor blade. Piston engines are a little bigger than that turboshaft engines, but the weight of the turboshaft engine is higher than the weight of the piston engine.
- The gear system of the turboshaft engine is on the downside, and it can break down easily.

5. Ramjet Engine

SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

COIMBATORE-35

DEPARTMENT OF AEROSPACE ENGINEERING

19ASB204 – Aerospace Propulsion

Unit –I Types of Aircraft Engines

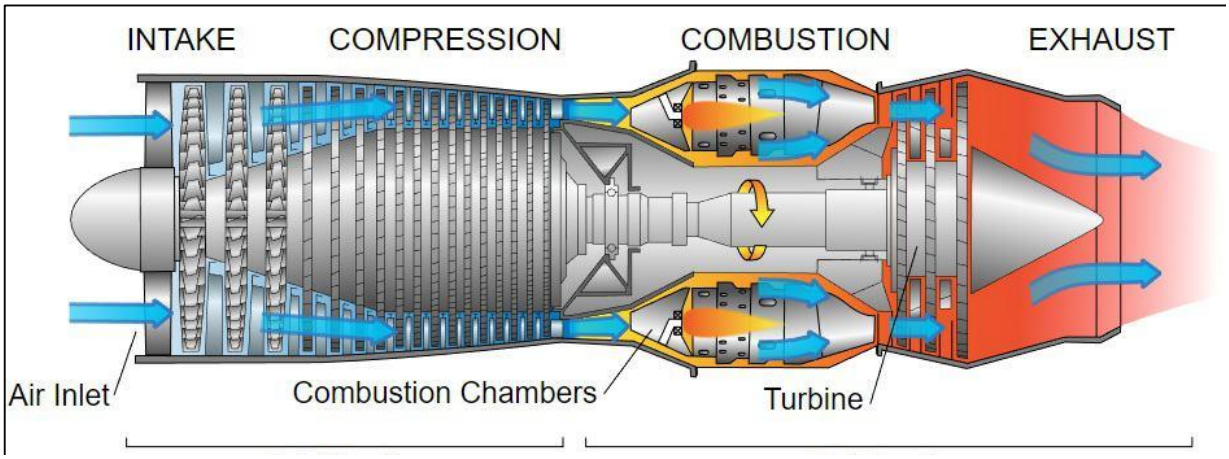
Nowadays, lightweight engines are coming into the aircraft, and some parts of these engines are not moveable. When it comes to an aircraft's speed, it is responsible for taking air into the Engine.

- Ramjet engines also dive the same as turbojet engines use. But only the parts which rotate are not present in the Engine.
- Ramjet engines are not like other engines as other engines develop static force. Ramjet engines are not capable of developing static force; instead of this, it produces a little force below the speed of sound.
- It means that aircraft using or running ramjet engines need assistance while taking off.
- Engines like ramjets are generally used in space vehicles and some missiles.
- In ramjet engines, as the speed of the aircraft starts to increase, the efficiency of this Engine starts to drop because the air temperature in the vent increases due to its compression.

MRS.P.KALPANADEVI
ASSISTANT PROFESSOR - AERO

Turbojet Engine : Construction, Working, Advantages and Disadvantages

The Turbojet engine was developed for the aircraft before the Second World War. It has an open tube that burns the fuel continuously and produces the required power. In this engine propulsion, third laws of Newton's "every action has equal and opposite reactions" comes into the picture. When the mixture of air and fuel burn, it produces the high amount of hot gases which expand out from the rear end of the engine, as the hot gases expands, engine is accelerated in the opposite direction.



Construction of Turbojet Engine:

Main components of the turbojet engine are

1. Inlet
2. Burner
3. Compressor
4. Turbine
5. Combustion chamber
6. Nozzle

Inlet:

Design of the turbojet engine is like an open tube. A large amount of air getting inside the engine and is drawn into the rotating compressor. There are two types of compressor is used in the engine operation. Centrifugal and axial.

In the above figure, an axial type of compressor is used. When the air is drawn into the compressor, the pressure of the air increases by passing it through the series of rotating and stationary blades. As the gases pass further in the low volume region pressure of the gas increases and also the gas heated up. Compression ratios of these types of engines are 40:1 and it much higher than the piston engine. The efficiency of the engine can be maximized because it has two different compressors low and high compressor on a different shaft.

Burner

As you can see in the above figure, fuel is being injected into the combustion chamber by the burner where the compressed air gets mixed and whole air-fuel mixture ignited to produce a high amount of heat energy in the combustion chamber. Gas energy increases rapidly which accelerated towards the engine due to the high pressure created by the compressor. These engines are capable of producing very high temperatures that can melt the material used for the turbine. The experimental data says that the only 12-25 per cent of the air is used for the combustion process and the rest of the air is used to cool combustive gases below the melting temperature of the Turbine.

Turbine: 17.26Remaining Time -2:39llscreen

Turbine is connected to the common shaft at which the compressor is mounted. As the heated gas of the combustion chamber passes through the turbine it rotates the shaft and it consumed very less energy. Still, there is enough energy in the gas to do work as it exits the nozzle.

Nozzle:

As you can see the area of the nozzle, at the inlet diameter is more than the exit diameter. Nozzle converts the high pressure and low velocity of the gases into the high velocity and low pressure at the outlet. Nozzle restricts the flow somewhat before allowing gas to expand and thus it creates additional pressure that results in additional thrust.

Working:

Four cycles involved in the Gas Turbine Cycle.

1. Suction or intake of air.
2. Compression of sucked air.

3. Combustion of the fuel: Where the fuel is injected mixed with the sucked air and burnt to produce the energy.
4. Expansion and exhaust or turbine sections: Where the converted stored energy is being used to for propulsion.

Turbine section.

The turbine section is the most important section of the engine. It produces the useful shaft power to drive the propeller and also to provide enough power to drive the engine accessories. It take place in the engine by converting the gaseous energy into the mechanical energy in the form of shaft power.

A large amount of air is being supplied to the turbine to produce the required power. A compressor is used to draw them into the engine and squeezes it to provide the high pressure air to the turbine. The compressor performs this by converting the mechanical energy from the turbine to gaseous energy and obviously in the form of pressure and temperature.

Advantages:

- It has much higher power to weight ratio than the piston engine.
- Turbojet engine can operate at very high temperatures.
- It can produce more thrust than the propeller engine.
- Mating parts are less so less wear.
- Low grade fuel can be used.

Disadvantages:

- The turbojet engine is less efficient at low speed and at low altitude.
- Noisy.
- Thrust is low at the time of take off

Turbofan

Turbofans were developed to combine some of the best features of the turbojet and the turboprop. [Figure 2] Turbofan engines are designed to create additional thrust by diverting a secondary airflow around the combustion chamber.

SNS COLLEGE OF TECHNOLOGY

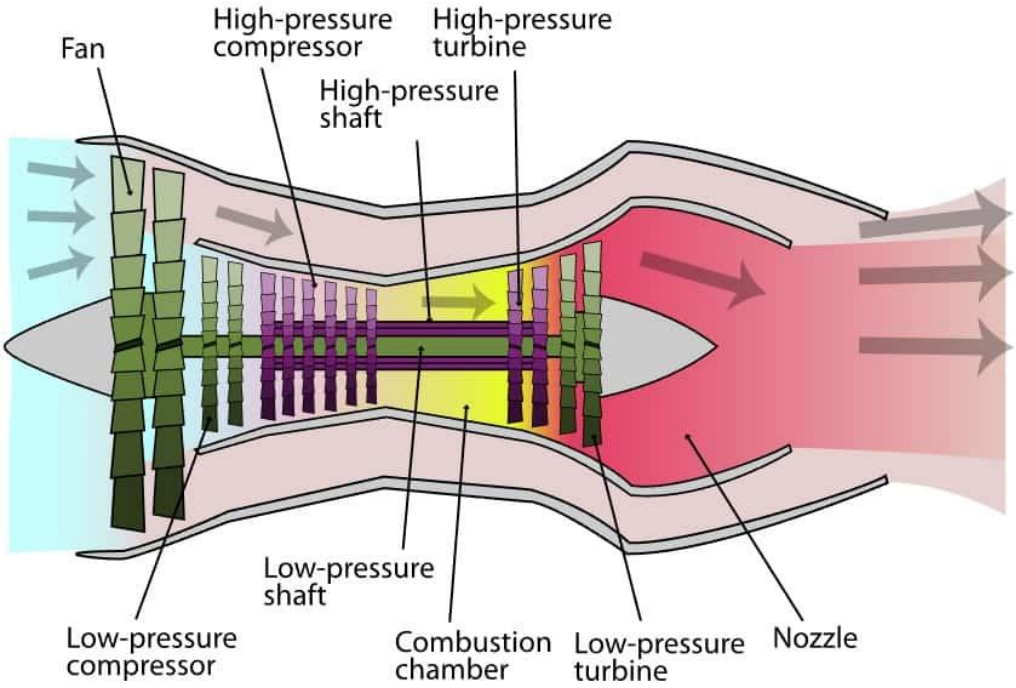
(An Autonomous Institution)

COIMBATORE-35

DEPARTMENT OF AEROSPACE ENGINEERING

19ASB204 – Aerospace Propulsion

Unit –I Types of Aircraft Engines



So, almost all airliner-type aircraft use a turbofan engine. It was developed to turn a large fan or set of fans at the front of the engine and produces about 80 percent of the thrust from the engine. This engine was quieter and has better fuel consumption in this speed range. Turbofan engines have more than one shaft in the engine; many are two-shaft engines. This means that there is a compressor and a turbine that drives it and another compressor and turbine that drives it. These two shafted engines use two spools (a spool is a compressor and a shaft and turbines that driven that compressor). In a two-spool engine, there is a high-pressure spool and a low-pressure spool. The low-pressure spool generally contains the fan(s) and the turbine stages it takes to drive them. The high-pressure spool is the high-pressure compressor, shaft, and turbines. This spool makes up the core of the engine, and this is where the combustion section is located. The high-pressure spool is also referred to as the gas generator because it contains the combustion section.

Turbofan engines can be low bypass or high bypass. The amount of air that is bypassed around the core of the engine determines the bypass ratio. As can be seen in Figure, the air generally driven by the fan does not pass through the internal working core of the engine.

The amount of air flow in lb/sec from the fan bypass to the core flow of the engine is the bypass ratio.

Some low-bypass turbofan engines are used in speed ranges above .8 Mach (military aircraft). These engines use augmenters or afterburners to increase thrust. By adding more fuel nozzles and a flame holder in the exhaust system extra fuel can be sprayed and burned which can give large increases in thrust for short amounts of time.

Two different exhaust nozzle designs are used with turbofan engines. The air leaving the fan can be ducted overboard by a separate fan nozzle [Figure 2], or it can be ducted along the outer case of the basic engine to be discharged through the mixed nozzle (core and fan exhaust together). The fan air is either mixed with the exhaust gases before it is discharged (mixed or common nozzle), or it passes directly to the atmosphere without prior mixing (separate nozzle). Turbofans are the most widely used gas turbine engine for air transport aircraft. The turbofan is a compromise between the good operating efficiency and high thrust capability of a turboprop and the high speed, high altitude capability of a turbojet.

Advantages of turbofan engine;

- Fuel efficient
- Quieter than turbojets
- They look awesome

Disadvantages of turbofan engine;

- Heavier than turbojets
- Larger frontal area than turbojets
- Inefficient at very high altitudes

Turboprop engine

A turboprop engine is a turbine engine that drives a propeller through a reduction gear. The exhaust gases drive a power turbine connected by a shaft that drives the reduction gear assembly. Reduction gearing is necessary in turboprop engines because optimum propeller performance is achieved at much slower speeds than the engine's operating rpm. Turboprop engines are a compromise between turbojet engines and reciprocating powerplants. Turboprop engines are most efficient at speeds between 250 and 400 mph and altitudes between 18,000 and 30,000 feet. They also perform well at the slow airspeeds required for takeoff and landing and are fuel efficient. The minimum specific fuel consumption of the turboprop engine is normally available in the altitude range of 25,000 feet to the tropopause. Approximately 80 to 85 percent of the energy developed by the gas turbine engine is used to drive the propeller. The rest of the available energy exits the exhaust as thrust. By adding the horsepower developed by the engine shaft and the horsepower in the exiting thrust, the answer is equivalent shaft horsepower. [Figure 4]

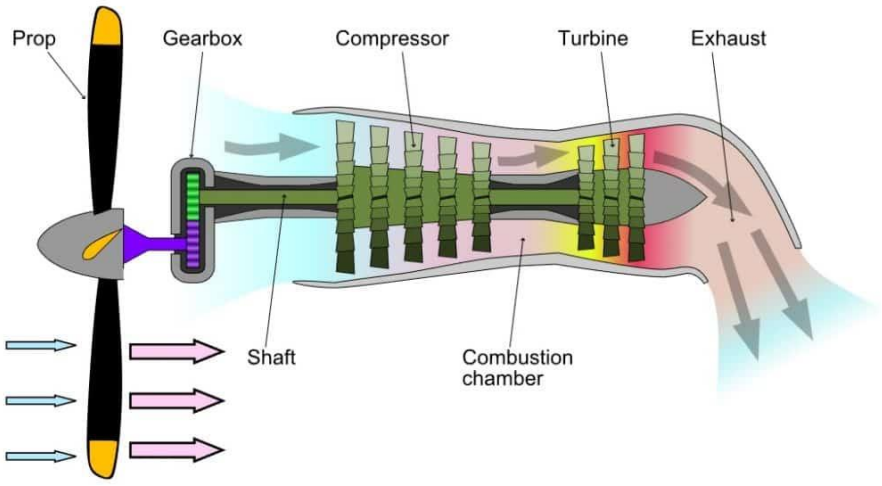


Figure 4. Turboprop engine

Some engines use a multirotor turbine with coaxial shafts for independent driving of the compressor and propeller. Although there are three turbines utilized in this illustration, as many as five turbine stages have been used for driving the two rotor elements, propeller,

and accessories.

The exhaust gases also contribute to engine power output through thrust production, although the amount of energy available for thrust is considerably reduced. Two basic types of turboprop engine are in use: fixed turbine and free turbine. The fixed turbine has a mechanical connection from the gas generator (gas-turbine engine) to the reduction gear box and propeller. The free turbine has only an air link from gas generator to the power turbines. There is no mechanical link from the propeller to the gas turbine engine (gas generator).

Since the basic components of normal gas-turbine and turboprop engines differ slightly only in design features, it should be fairly simple to apply acquired knowledge of the basic gas turbine to the turboprop.

The typical turboprop engine can be broken down into assemblies as follows:

1. The power section assembly—contains the usual major components of a gas turbine engine (i.e., compressor, combustion chamber, turbine, and exhaust sections).
2. The reduction gear or gearbox assembly—contains those sections unique to turboprop configurations.
3. The torquemeter assembly—transmits the torque from the engine to the gearbox of the reduction section.
4. The accessory drive housing assembly—mounted on the bottom of the compressor air inlet housing. It includes the necessary gear trains for driving all power section driven accessories at their proper rpm in relation to engine rpm.

There are advantages and disadvantages of each system, with the airframe generally dictating the system used.

Advantages of turboprop engine;

- Very fuel efficient
- Most efficient at mid-range speed between 250-400 knots
- Most efficient at mid-range altitudes of 18,000-30,000 feet

Disadvantages of turboprop engine;

- Limited forward airspeed
- Gearing systems are heavy and can break down

Turboshaft

The fourth common type of jet engine is the turboshaft. [Figure 5] It delivers power to a shaft that drives something other than a propeller. The biggest difference between a turbojet and turboshaft engine is that on a turboshaft engine, most of the energy produced by the expanding gases is used to drive a turbine rather than produce thrust. Many helicopters use a turboshaft gas turbine engine. In addition, turboshaft engines are widely used as auxiliary power units on large aircraft. The first turboshaft engine was built by the French firm, Turbomeca in 1949.

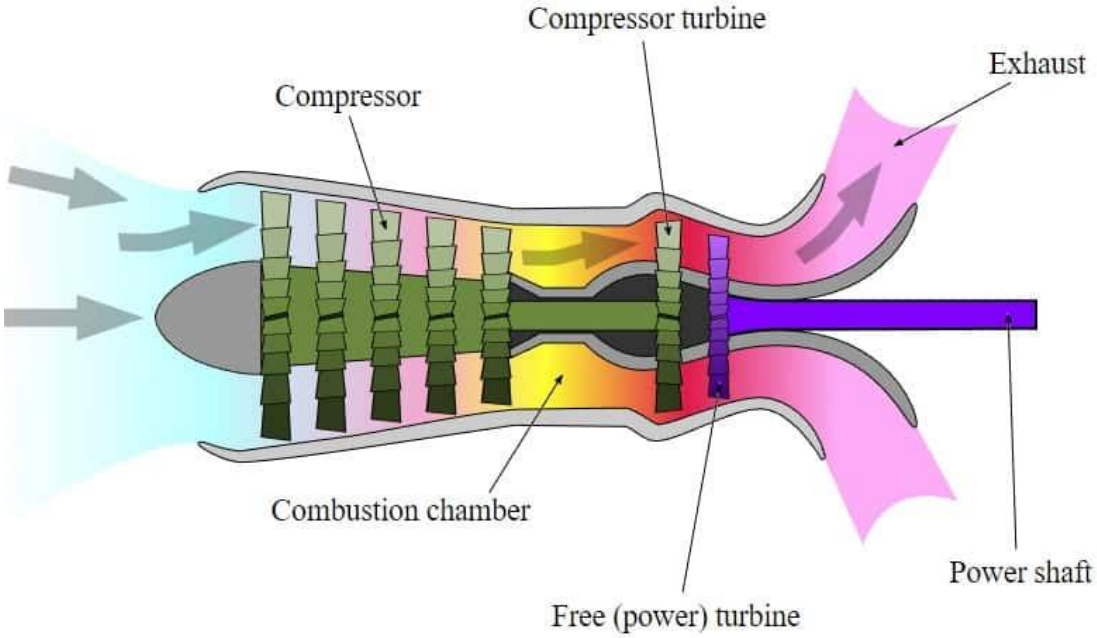


Figure 5. Turboshaft engine

With regard to aircraft, the turboshaft engine is a gas turbine engine made to transfer

horsepower to a shaft that turns a helicopter transmission or is an onboard auxiliary power unit (APU). An APU is used on turbine-powered aircraft to provide electrical power and bleed air on the ground and a backup generator in flight. Turboshaft engines can come in many different styles, shapes, and horsepower ranges.

Advantages of turboshaft engine;

- Much higher power-to-weight ratio than piston engines
- Typically smaller than piston engines

Disadvantages of turboshaft engine;

- Loud
- Gear systems connected to the shaft can be complex and break down

Ramjet Engine

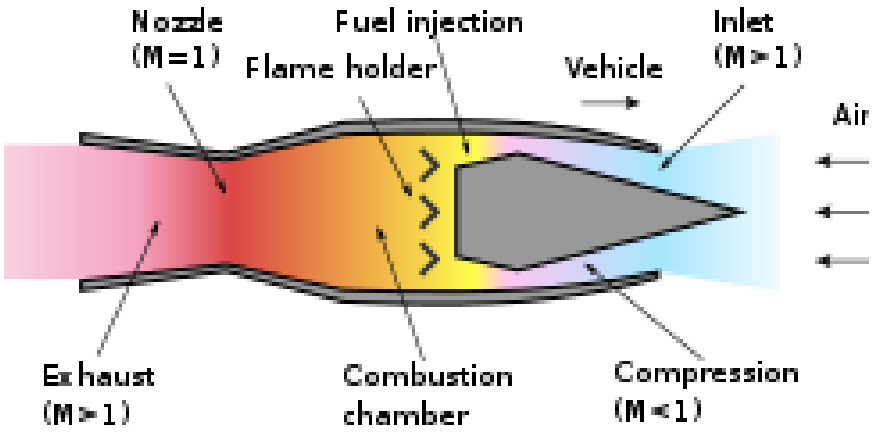
Ram Jet Engine

In these types of jet engines, the ramjet is the simplest of all the propulsive units. Ramjet requires neither a compressor nor a turbine. The ramjet is the simplest type of jet engine because it has no moving parts.

It consists of three main components such as a diffuser, combustion chamber, and expansion nozzle. The pressure of the incoming air improves to a high value by the diffuser.

This type of engine requires a hollow tube into which fuel is injected, mixed with air, and burned to generate thrust, as shown below. The ramjet only works if it is already moving fast enough to compress the incoming air by simply forcing it into the engine.

Working of Ram Jet Engine



At the start, the ramjet is moved and accelerated to about 500km/h by some booster device with maybe a small turbo-jet unit. After high speed is attained in the ramjet, air enters into the diffuser with the speed of the ramjet.

The use of a diffuser is to convert the kinetic energy of entering air into its pressure energy. Fuel is now injected through a fuel injection nozzle and ignited through a spark plug. Hot gases are generated, now diffuse into the expansion chamber, and eventually leave the expansion unit through the expansion nozzle.

As the exhaust gases pass through the nozzle, their pressure energy is converted into kinetic energy. Then, the gases leave the nozzle with very high velocity producing a reactive force or trust in the opposite direction.

The ramjet engine works efficiently only when its speed is supersonic. For this reason, this engine is not used in aircraft; It is used in missiles.