Fundametals of gas turbine engine

Fundamental of Gas Turbine Engines

- Engine- Which change one form of energy into another form or mechanical force.
- Force- 1. Tendency to produce work or simple say the pressure exerted in some specific are
- 2.Vector Quantity 3. Unit is in Pounds(S.I unit is newton)
- Force=Pressure *Area
- Work –A body or anything which covers some distance after force acting on it.
- Work =force *distance (unit of work is foot pounds or in joule) (1 j=0.74 foot ponds)
- Power- The rate of doing work .
- Power=work /time (unit of power is foot pound per minute or watt) (1 w=44.25 ft lb/min)

Fundamentals of Gas Turbine Engine

Velocity-the distance should be covered in a particular time.

Velocity-distance * time (unit is feet per second or meter per second)

When velocity in feet per second and converted it into miles per hour than must be divided by 1.467

Acceleration-Change in velocity with respect to time .

Acceleration=final velocity-Initial velocity divided by time(unit feet per second square or meter per second square)

Fundamental of gas turbine Engines.

- Kinetic energy- Energy produced due to motion of an object . (unit is ft-lb or joule)
- K.E=1/2 *M*V*2

Where m=mass of an object ,v=velocity of an object

Potential Energy-energy calculated at certain heights.

P.E=m.g.h=w.h

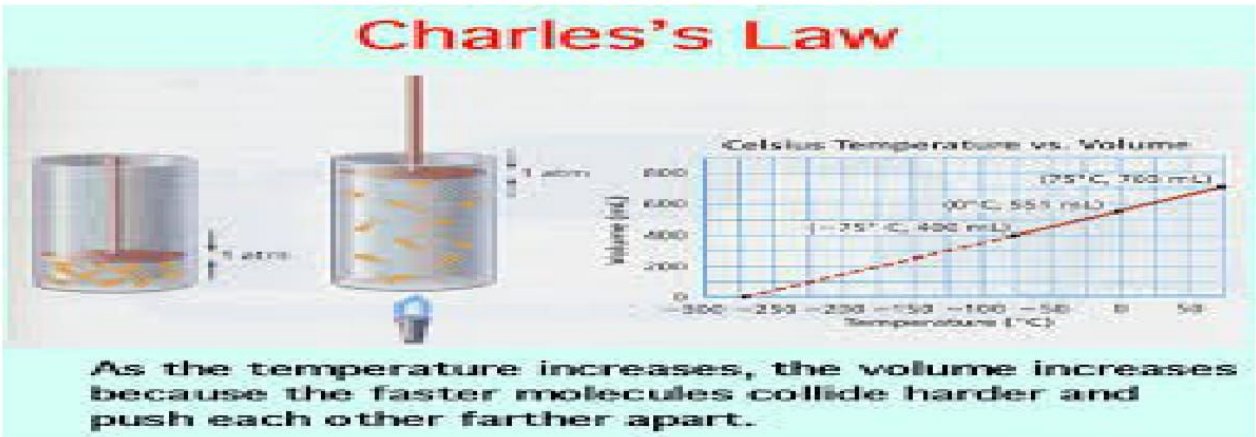
Fundamental of gas turbine engine

- NEWTONS LAWS OF MOTION
- FIRST LAW
- Objects at rest tend to remain at rest and objects in motion tend to remain in motion at the same speed and in the same direction, unless acted on by an external force.
- SECOND LAW
- When a force acts upon a body, the momentum of that body is changed. The rate of change of momentum is proportional to the applied force.
- Force = Weight (Velocity Final − Velocity Initial) Gravity (Time) F = W (Vf − Vi)/ Gt
- Example: A turbojet engine is moving 150 lbs of air per second through the engine. The air enters going 100 fps and leaves going 1 200 fps. How much thrust, in pounds, is the engine creating?

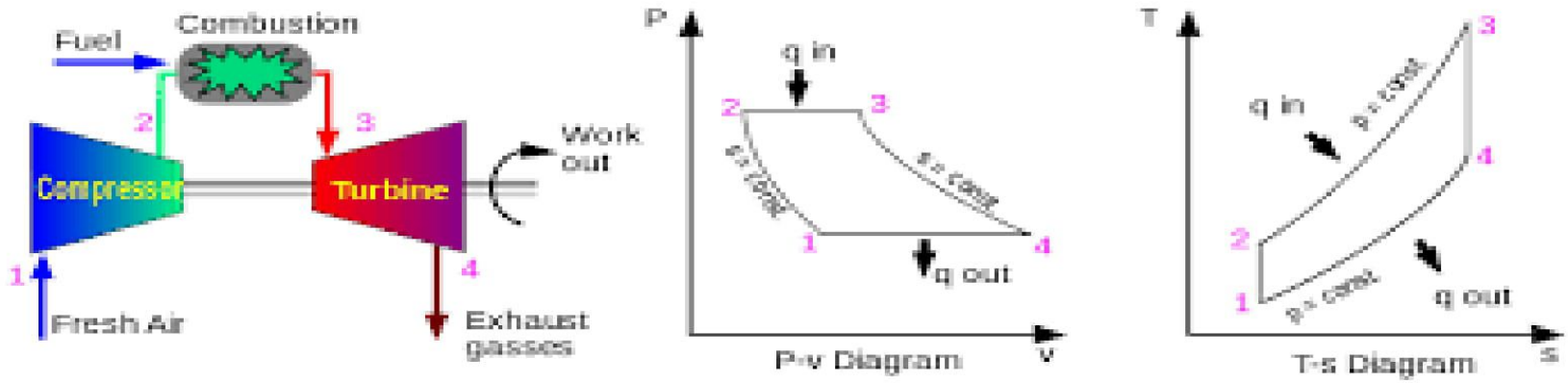
- THIRD LAW
- *For every action there is an equal and opposite reaction*
- *EXAMPLE- JET THRUST, ROCKET AND MISSILE.E.T.C*
- *Bryton cycle*-it is also called constant pressure cycle.
- *It having two types 1. open Bryton cycle 2.closed Bryton cycle.*
- *How to plot the graph?*

CHARLES LAW AND BOYLES LAW

- **C**harles law-that the volume occupied by a fixed amount of gas is directly proportional to its absolute temperature, if the pressure remains constant
- Boyles law- that the pressure of a given mass of an ideal gas is inversely proportional to its volume at a constant temperature.



OPEN BRYTON CYCLE

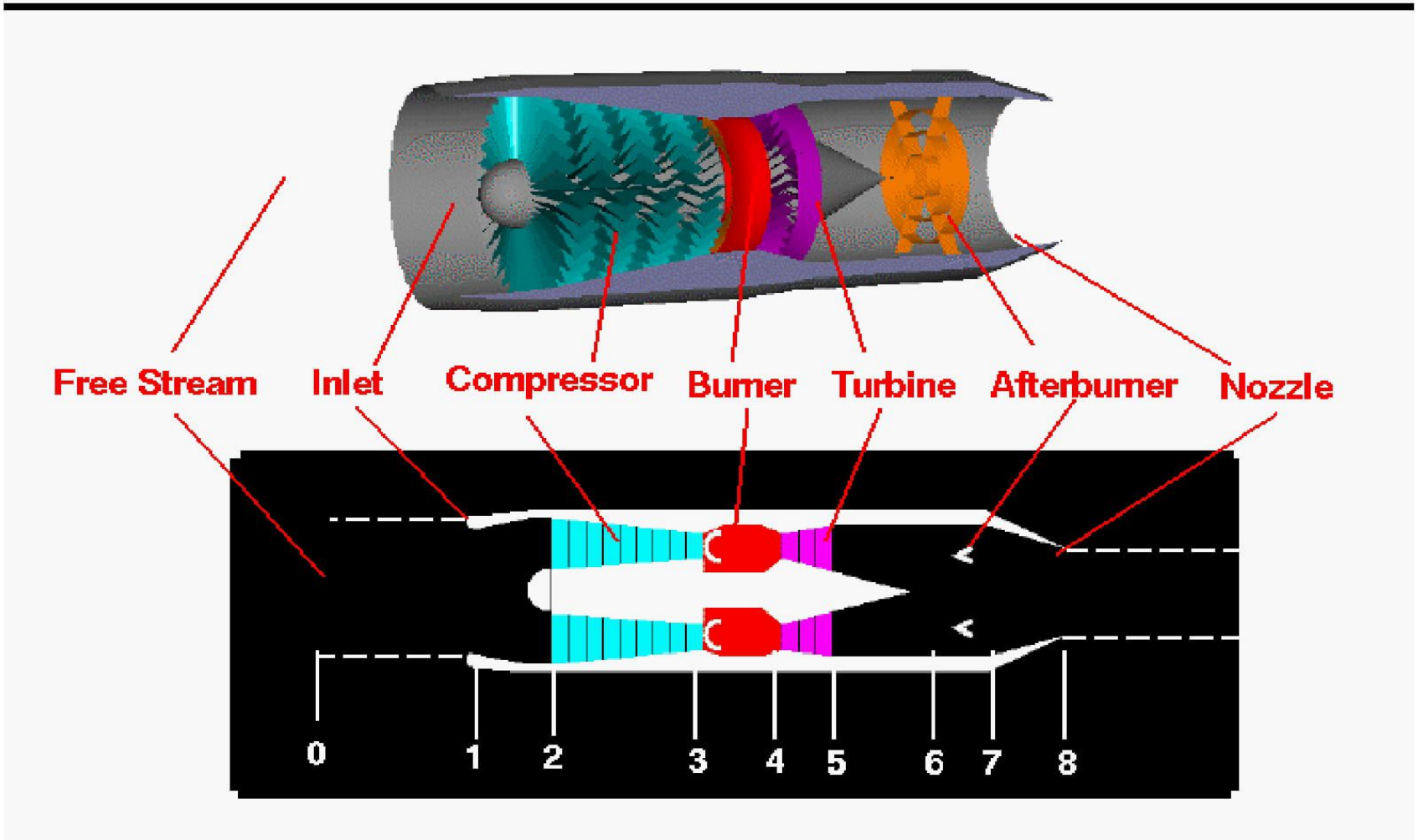


- Ideal Brayton cycle:isentropic process – ambient air is drawn into the compressor, where it is pressurized.

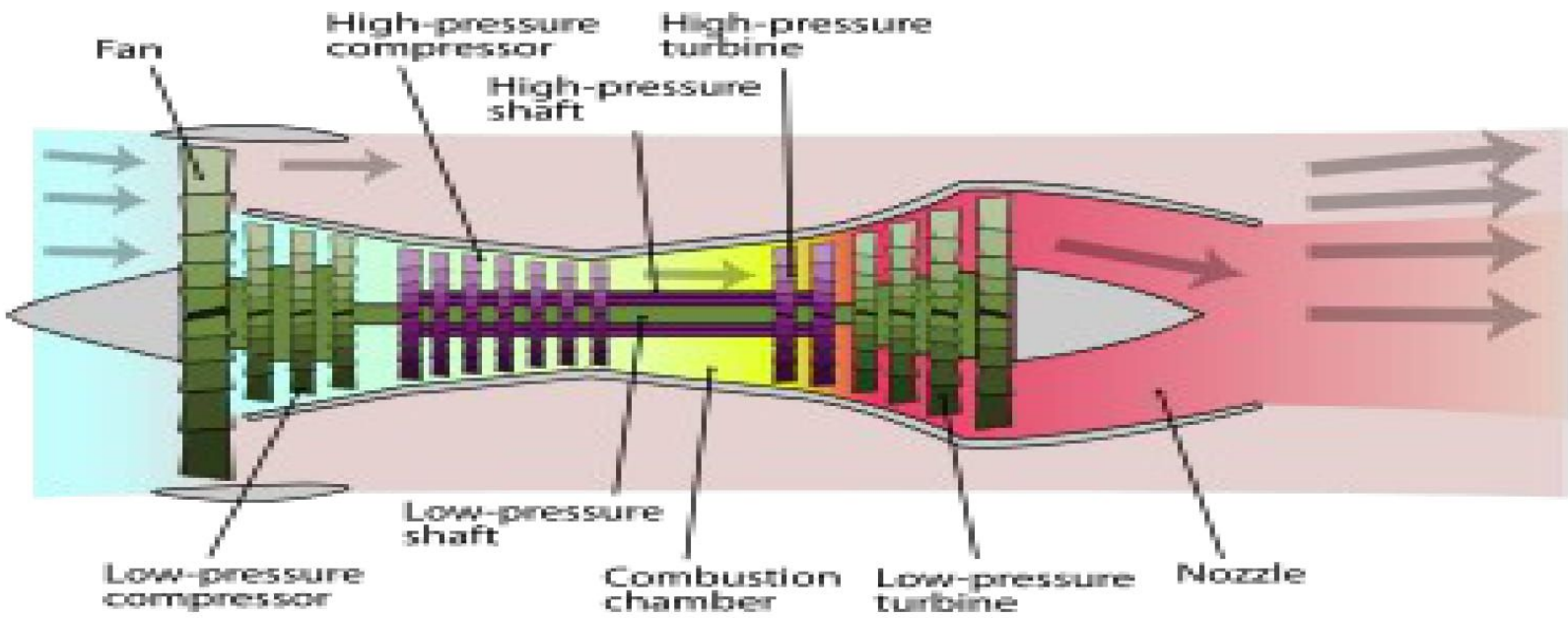
isobaric process – the compressed air then runs through a combustion chamber, where fuel is burned, heating that air—a constant-pressure process, since the chamber is open to flow in and out.

- isentropic process – the heated, pressurized air then gives up its energy, expanding through a turbine (or series of turbines). Some of the work extracted by the turbine is used to drive the compressor.
- isobaric process – heat rejection (in the atmosphere).
- Actual Brayton cycle:
- adiabatic process – compression, isobaric process – heat addition, adiabatic process – expansion
- isobaric process – heat rejection

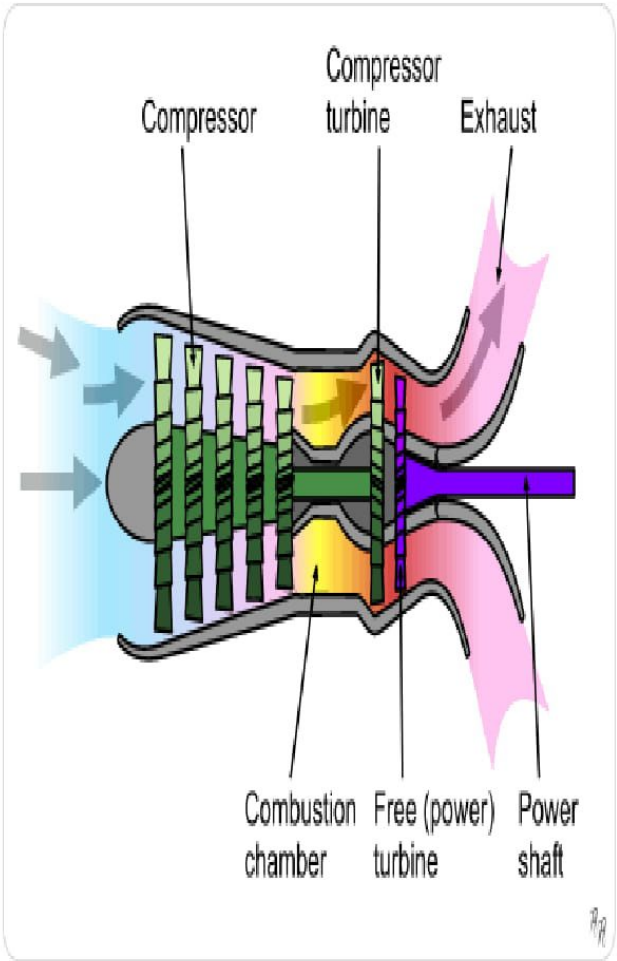
Constructional and Operational Arrangements



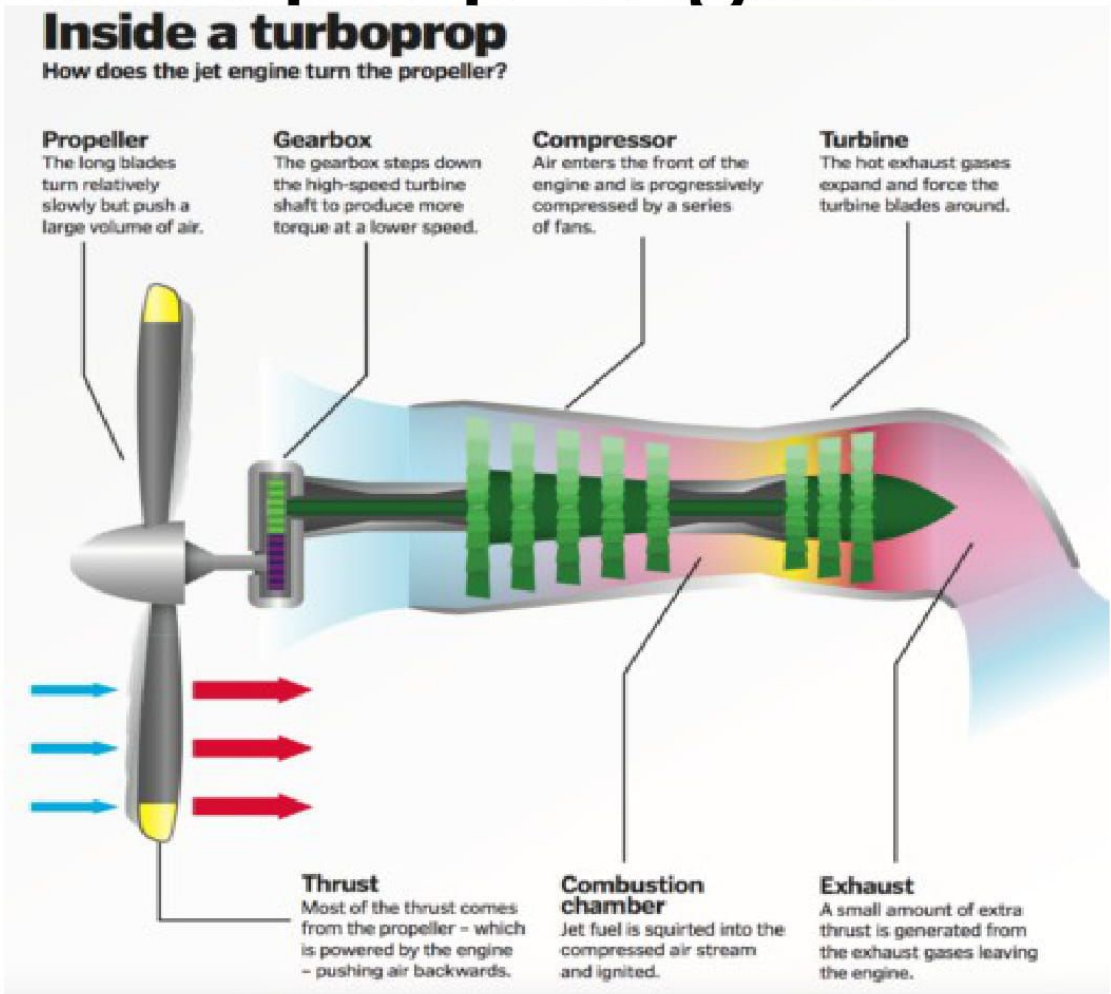
Turbofan engine



Turbo shaft engine



turboprop engine



Operation principle of turbojet engine

Turbojet aircraft work on the principle of accelerating a relatively small mass of air to a high speed. As optimum efficiency is achieved when the speed of the accelerated air approximates that of the aircraft, turbojet engines do not reach peak efficiency until speeds approaching mach 2. For sub-mach speeds, a turbofan engine is significantly more efficient and also much quieter due to the greater mass and lower speed of the exhaust stream leaving the engine

The component parts of a turbojet engine are the inlet, the gas turbine engine, consisting of a compressor, a combustion chamber and a turbine, and the exhaust nozzle. Air is drawn into the engine through the inlet and compressed and heated by the compressor. Fuel is then added in the combustion chamber and ignited. The burning fuel adds energy to the exhaust stream by heating and expanding the air. Sufficient energy to drive the compressor is extracted from the exhaust stream by the turbine. The remainder of the exhaust energy is used to produce thrust, a process which is enhanced by the geometry of the exhaust nozzle. As the exhaust gas passes through the nozzle, it is accelerated to high speed as it expands thus providing propulsion. The thrust produced by the engine can be selectively increased by incorporating an afterburner or re-heat into the engine design.

Characteristics of turbojet engine

- 1.Low thrust at low forward speeds
- 2.high thrust specific fuel consumption
- 3.long take off roll
- 4.lightest specific weight
- 5.ability to take advantages of high ram pressure ratios
- 6.small frontal area resulting in low drag
- 7.small frontal area reduce ground clearance problem.

Working principle of turboprop engine

- The primary difference between the turboprop and the turbojet is that additional turbines, a power shaft and a reduction gearbox have been incorporated into the design to drive the propeller. The gearbox may be driven by the same turbines and shaft that drive the engine compressor, mechanically linking the propeller and the engine, or the turbines may be separate with the power turbine driving a concentric, mechanically isolated shaft to power the gearbox.
- Examples of turboprop powered aircraft include the Bombardier Dash 8, the Alenia ATR 42 and the Pilatus PC-12.

Characteristic of turboprop engine

- 1.high propulsive efficiency
- 2.More complicated design and heavier weight than turbojet engine
- 3.lowest TSFC
- 4.large frontal area of [propeller and engine combination
- 5.possibility of efficient reverse thrust

Working of turbofan engine

- The core consists of high and low pressure, multistage compressors, a combustor section and high and low pressure, multistage turbine units. The turbine driving the low speed spool (N_1) of a turbofan engine is more robust, often containing more stages, than that of a turbojet of similar size. This is necessary as the low pressure turbine also powers the fan. In a conventional turbofan engine, the fan and the low pressure compressor turn at the same speed whereas in a geared turbofan, they do not. The fan itself is contained within a duct that surrounds the engine core. Low bypass engines often have a multistage fan which generates a low volume but relatively high speed air stream whereas high bypass engines usually have a single stage fan which generates a high volume but relatively low speed air stream. The fan airflow, referred to as the cold air stream, is accelerated by the fan and passes through the engine remaining outside of the engine core. The cold air stream moves much slower than the hot stream gas flow passing through the engine core. The cold stream serves to help cool the engine core and is then mixed with the hot stream exhaust to decrease both the temperature and the speed of the jet core exhaust flow. This speed reduction serves to both reduce the noise generated by the engine and to increase the engine efficiency by more closely matching the speed of the exhaust flow to the design speed of the aircraft.

Characteristics of turbo fan engine

- 1.weight falls between the turbojet and turboprop
- 2. ground clearance are less than turboprop but not as good as turbojet
- 3.increased thrust at forward speeds
- 4.TSFC and specific weight fall between turbojet and turboprop
- 5.considerable noise level reduction of 10 to 20 percent over the turbojet.

- BY PASS RATIO- The **bypass ratio** (**BPR**) of a turbofan engine is the ratio between the mass flow rate of the bypass stream to the mass flow rate entering the core. A 10:1 bypass ratio, for example, means that 10 kg of air passes through the bypass duct for every 1 kg of air passing through the core

Working of Turboshaft engine

- The primary difference between the turboshaft and the turbojet is that an additional power section, consisting of turbines and an output shaft, has been incorporated into the design. In most cases, the power turbine is not mechanically linked to the gas generator. This design, which is referred to as a "free power turbine", allows the speed of the power turbine to be optimised for the machinery that it will energize without the need for an additional reduction gearbox within the engine. The power turbine extracts almost all of the energy from the exhaust stream and transmits it via the output shaft to the machinery it is intended to drive.
- A turboshaft engine is very similar to a turboprop and many engines are available in both variants. The principal difference between the two is that the turboprop version must be designed to support the loads of the attached propeller whereas a turboshaft engine need not be as robust as it normally drives a transmission which is structurally supported by the vehicle and not by the engine itself.

Engine performance