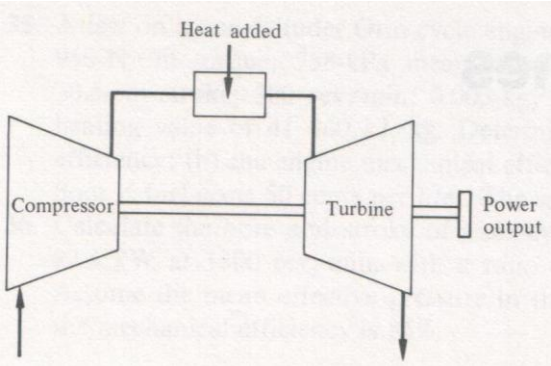
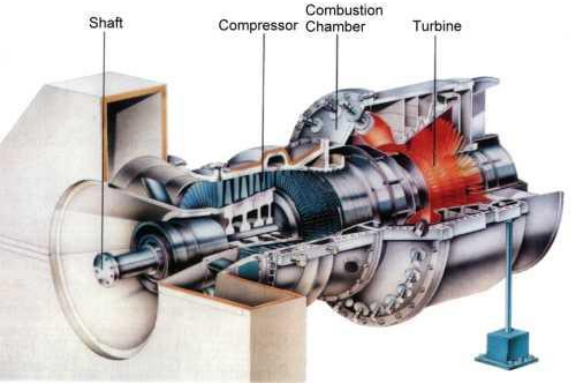
GAS TURBINES

Brayton or Joule Cycle was developed in 1870.

First successful gas turbine : 1903 - Aegidius Elling of Norway built it using both rotary compressors and turbines - the first gas turbine with excess power.





In the gas turbine, there is a continuous flow of the working fluid. This working fluid is initially compressed in the compressor. It is then heated in the combustion chamber. Finally, it goes through the turbine. The turbine converts the energy of the gas into mechanical work. Part of this work is used to drive the compressor(back power). The remaining part is known as the net work of the gas turbine.

Back Power = Power required to drive the compressor (40-80%), Back work ratio = P_c/P_t

Pressure ratio = $P_{Compressor} / P_{Inlet} = P_{Turbine} / P_{Exhaust}$ (ranging 5-20) Efficiency = 20-40%

Advantages of gas turbines:

- Very high power-to-weight ratio (5-10 kW/kg), compared to reciprocating engines(<1 kW/kg);
- Smaller than most reciprocating engines of the same power rating.
- Moves in one direction only, with far less vibration than a reciprocating engine.
- Fewer moving parts than reciprocating engines.
- Low operating pressures; High operation speeds.
- Low lubricating oil cost and consumption.

Disadvantages of gas turbines:

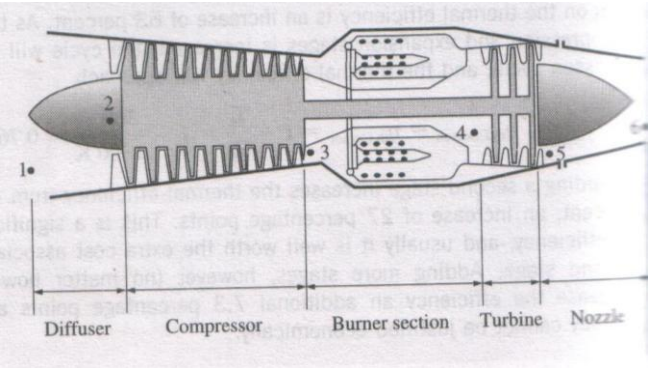
- Cost is much greater than for a similar-sized reciprocating engine since the materials must be stronger and more heat resistant.
- Machining operations are also more complex; Usually less efficient than reciprocating engines, especially at idle.
- Delayed response to changes in power settings.

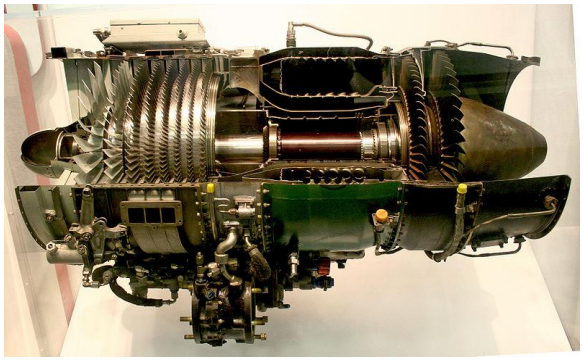
Use of gas Turbine

Power generation Aviation(Jet Planes and Helicopters) Ships

TURBO JET ENGINES

The jet engine is a special type of gas turbine, with a nozzle at the end and a diffuser at the front. The turbine of the unit is sized so that it produces only enough power to drive the compressor. The remaining energy of the burnt gases is expanded in the nozzle creating an outgoing high velocity jet of exhaust gases from the unit. The jet caused a reaction thrust on the GT-unit called the jet engine, which propels it in a direction against the jet (Newton's 3rd Law). Aviation fuel, Jet fuel, Kerosene etc. are used as fuel for jet engines.



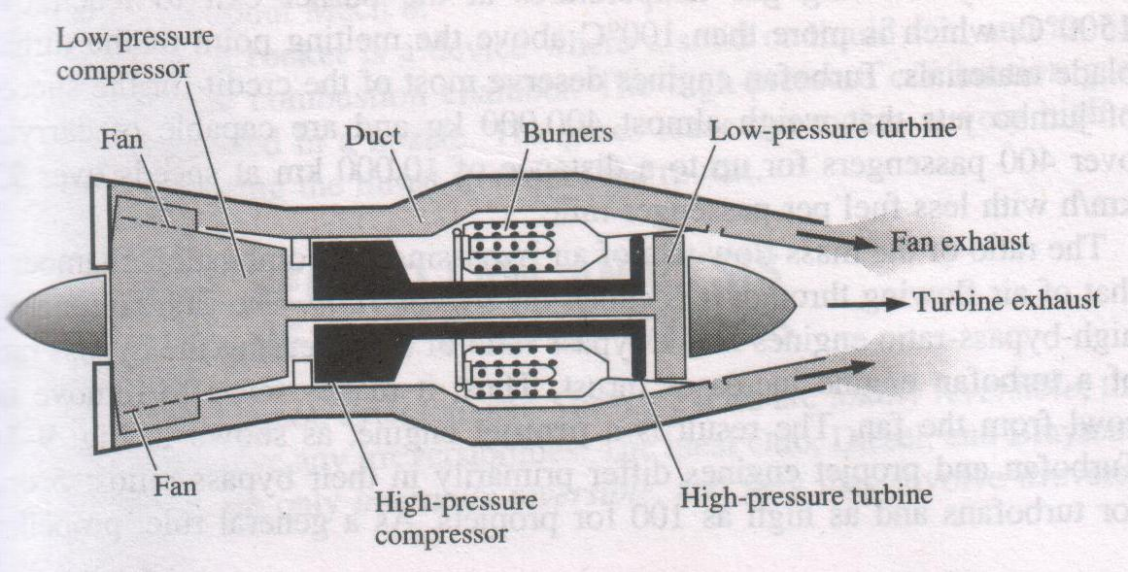


Thrust developed in a turbojet engine is the unbalanced force that is caused by the difference in the momentum of the relative low-velocity air entering the engine and the high velocity exhaust gases leaving the engine. The power developed from the thrust of the engine is called "Propulsive Power".

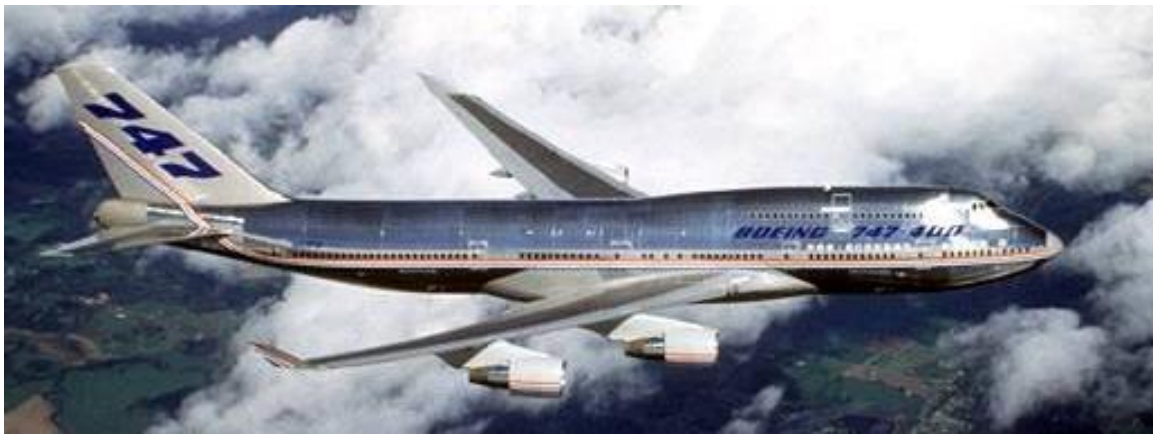
4 Rolls-Royce Turbofans each giving 90,000 lb thrust (30 MW power) to Airbus A380

Jet aircraft fly much faster than propeller-powered aircraft and at higher altitudes — as high as 10,000 to 15,000 meters (about 33,000 to 49,000 ft). At these altitudes, jet engines achieve maximum efficiency over long distances. The engines in propeller powered aircraft achieve their maximum efficiency at much lower altitudes. Jet aircraft can move faster than sound. Mach-1 stands for speed of sound in atmospheric air, which is about 1100 km/h. The fastest military jet plane was the SR-71 Blackbird at Mach 3.2.The other types of Jet engines include:

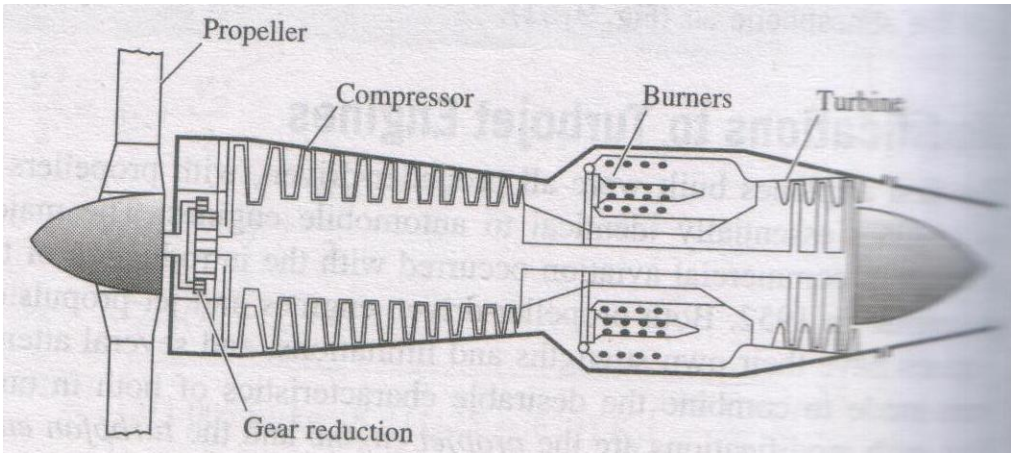
TURBOFAN JET



Turbofan engine is based on the principle that using same turbine power a large volume of relatively slower moving air produces more thrust than a small volume of fast moving air. Here a large fan driven by the turbine blows a considerable amount of air through a duct surrounding the engine. Turbofans combine the hot air jet with bypassed air from a fan, also driven by the turbine. The use of bypass air creates a quieter engine with greater boost at low speeds, making it a popular choice for commercial airplanes. Typical bypass ratio is about 5:1. Turbo fan engines are more efficient than the turbo jet engines and most widely used in aircraft propulsion. Modern airliners cruise at speeds of 0.75 to 0.85 Mach, or 75% to 85% of the speed of sound (420 to 580 mph/ 680-900 km/h). A typical 400 ton 747-JumboJet carrying over 400 passengers, is propelled by 4 turbofan units - each rating about 38 Ton of thrust , 20 MW propulsive power. The largest passenger jet plane is the AirBus 380, capable of carrying 560 people, is thrusted by 4 x 30MW turbofan Jets.



TURBO PROPELLER



Propellers are more efficient than jet engines, but they are limited to low altitude and low speed operation. For such uses the propellers are larger and most of the turbine is used to drive the large propeller along with the compressor. C-130 Hercules is a turboprop aircraft. Turboprop engines are driven almost entirely by a propeller mounted in front of the engine, deriving only 10 percent of their thrust from the exhaust jet. Typical bypass ratio is about 100:1.

A big breakthrough in helicopter design was the introduction in the 1950s of compact, light, and powerful engines based on jet technology. One of the first helicopters designed for turbine power from the ground up was the Bell UH-1 “Huey,”