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Turbine engine fundamentals

1, Energy:

Energy is Typically Defined as something that:

- gives us the capability's to perform work

2, potential energy

Potential energy is defined as energy at :

- rest, or energy that is stored

Potential energy may be classified into three groups:

- that due to position Water in an elevated reservoir, and an airplane raised off the ground sitting on jacks are examples of the first group
- that due to distortion of an elastic body, stretched bungee cord on a Piper Tri-Pacer or compressed spring are examples of the second group; and energy in aviation gasoline,
- that which produces work through chemical action. food, and storage batteries are examples of the third group.

To calculate the potential energy of an object due to its position, as in height, the following formula is used:

$$\text{Potential Energy} = \text{Weight} \times \text{Height}$$
$$PE = 450\,000\ lb \times 4\ ft$$
$$PE = 1\,800\,000\ ft\text{-}lbs$$

3, Kinetic Energy

Kinetic energy is defined as being energy in:

- motion

Kinetic energy has the same units as potential energy, namely :

- foot-pounds
- inch-pounds

To calculate the kinetic energy for something in motion, the following formula is used:

$$\text{Kinetic Energy} = \tfrac{1}{2}\,\text{Mass} \times \text{Velocity}^2$$

4, NEWTON'S LAWS OF MOTION

1, Newton's 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.

2, Newton's Second Law:

- When a force acts upon a body, the momentum ofthat body is changed.
- The rate of change of momentum is proportional to the applied force.

Bodies in motion have the property called : momentum

A body that has great momentum has a :

- strong tendency to remain in motion and is therefore hard to stop

Newton's second law:

$$(F = MA)$$

$$Force = \frac{Weight\ (Velocity\ Final - Velocity\ Initial)}{Gravity\ (Time)}$$

$$F = \frac{W\ (Vf - Vi)}{Gt}$$

3, Newton's Third Law:

- For every action there is an equal and opposite reaction

5, BERNOULLI'S PRINCIPLE

- The static pressure ofa fluid (liquid or gas) decreases at points where the velocity ofthe fluid increases, provided no energy is added to nor taken away from the fluid

Or

My statement:

- Bernoulli's principle states that an increase in the speed of a fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy

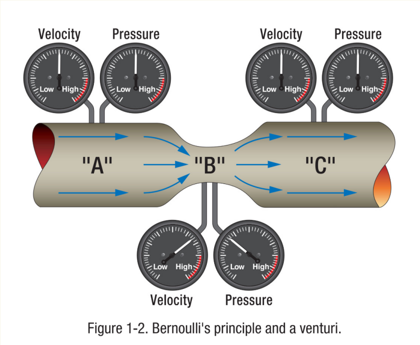
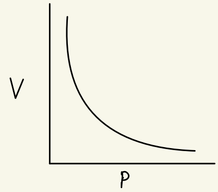


Figure 1-2. Bernoulli's principle and a venturi.



BOYLE'S LAW

Boyle's Law states that

- when the temperature of a gas is kept constant and the pressure increased, its volume is decreased proportionately.

In reverse:

- when a gas is at a constant temperature and pressure decreases, volume increases

My statement:

- when temperature is constant and pressure increases volume will decrease
- When temperature is constant and pressures decrease volume will increase

Meaning pressure and volume in Boyles law are : inversely proportional

6, Charles' Law

Charles' Law states that if air is
- heated at a constant pressure, the change in volume will vary with the change in temperature.

My statement:
- Charles' Law states that the volume of a gas is directly proportional to its temperature (in Kelvin) when pressure is kept constant.

7, THE BRAYTON CYCLE

The Brayton cycle is the name given to the:
- thermodynamic cycle of a gas turbine engine to produce thrust
- This is a variable volume constant-pressure cycle of events and is commonly called the constant-pressure cycle. A more recent term is "continuous combustion cycle."

The four continuous and constant events are:
- intake
- compression
- expansion (includes power)
- exhaust

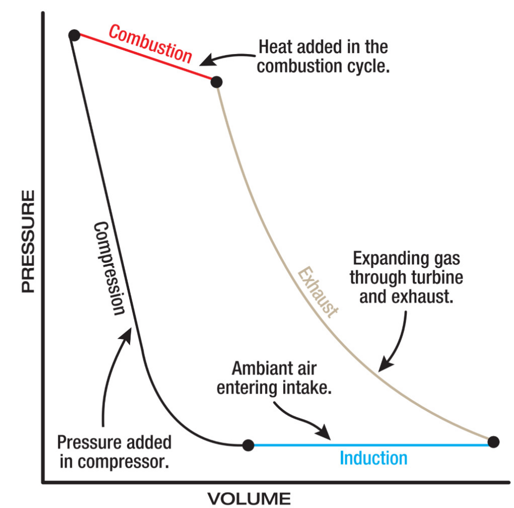


Figure 1-4. Pressure/volume relationship.

THE BRAYTON CYCLE

1, intake cycle:

- air enters at ambient pressure and at a constant volume
- It leaves the intake at an increased pressure and a decrease in volume.

2, compressor section

- air is received from the intake at an increased pressure, slightly above ambient, and a slight decrease in volume.
- Air enters the compressor where it is compressed.
- It leaves the compressor with a large increase in pressure and decrease in volume, created by the mechanical action of the compressor

3, expansion

- takes place in the combustion chamber by burning fuel, which expands the air by heating it
- The pressure remains relatively constant
- increase in volume takes place
- The expanding gases move rearward through the turbine assembly and are converted from velocity energy to mechanical energy by the turbine.

4, The exhaust section

- which is a convergent duct, converts the expanding volume and decreasing pressure of the gases to a final high velocity

Conclusion:

- The force created inside the engine to keep this cycle continuous has an equal and opposite reaction (thrust) to move the aircraft forward.

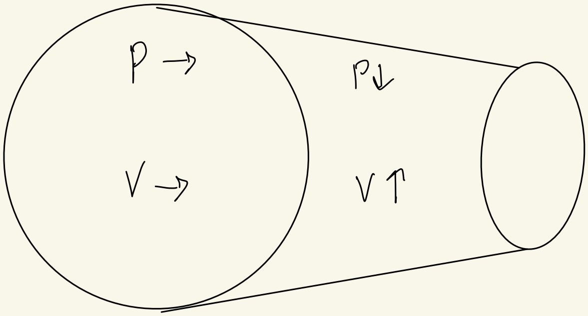
convergent and divergent duct

1, The convergent duct :

- increases velocity and decreases pressure

The convergent principle is usually used for the

- exhaust nozzle.

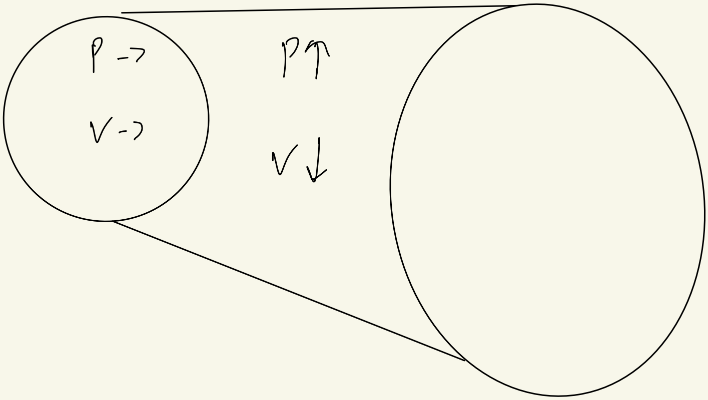


2, The divergent duct

- decreases velocity and increases pressure.

The divergent principle is used in the :

- compressor and diffuser where the air is slowing and pressurizing



Supersonic:flip the pressure and velocity in both convergent and divergent

7, FORCE, WORK, POWER, MOTION

1, FORCE

force is the
- intensity of an impetus

or
- the intensity of an input

Meaning:
- How strong we push or pull

Another way to look at it is that for work, power, or torque to exist, there has to be a :
- force that initiates the process

The unit for force in the English system of measurement is
- pounds,

in the metric system it is :
- newtons

2, WORK

Work, in the mechanical sense of the term, is done when a
- resistance is overcome by a force acting through a measurable distance.

Two factors are involved:

1, force

2, movement through a distance

definition, work is accomplished only when an
- object is displaced some distance against a resistive force.

To calculate work, the following formula is used:

Work = Force (F) × distance (d)

the force is identified in newtons (N) and the distance in meters

3, POWER

consideration-time. In other words:

- how long does it take to accomplish the work

The formula for power is as follows:

Power = Force × distance ÷ time

The units for power will be;

- foot-pounds per minute
- foot-pounds per second
- inch-pounds per minute or second
- possibly mile-pounds per hour.

The units depend on how distance and time are measured.

4, Torque

Torque is something that creates :

- twisting and tries to make something rotate.

Torque = Force × distance

5, MOTION

Motion may be defined as a:

- continuing change of position or place, or as the process in which a body undergoes displacement.
- relationship between velocity, acceleration, and distance is known as kinematics

6, Speed and Velocity

Speed refers to :

- how fast an object is moving

or

- how far the object will travel in a specific time.

speed is a scalar:

- no direction

Velocity is that quantity in physics:

- which denotes both the speed of an object and the direction in which the object moves.

7, Acceleration

Acceleration is defined as the:

- change of velocity with respect to time

formula is used:

$$\text{Acceleration } (A) = \frac{\text{Velocity Final } (Vf) - \text{Velocity Initial } (Vi)}{\text{Time } (t)}$$

FUNDAMENTALS OF OPERATION

Thrust

For an aircraft to remain in level flight:

- thrust must be provided that is equal to and in the opposite direction of the aircraft drag.

This thrust, or propulsive force, is provided by a :

- suitable type of aircraft heat engine

All heat engines have in common the ability to:

- convert heat energy into mechanical energy by the flow of some fluid mass (generally air) through the engine.

The propulsive force is obtained by the :

- displacement of a working fluid (again, atmospheric air).

Atmospheric air is the principal fluid used for

- propulsion in every type of aircraft powerplant
- except the rocket, in which the total combustion gases are accelerated and displaced.

A rocket carries its own oxidizer rather than using ambient air for combustion

Propeller

The propellers of aircraft powered by reciprocating or Turboprop engines:

- accelerate a large mass of air at a relatively lower velocity by turning a propeller

The same amount of thrust can be:

- generated by accelerating a small mass of air to a very high velocity

The working fluid (air) used for the:

- propulsive force is a different quantity of air than that used within the engine to produce the mechanical energy to turn the propeller

Turbojets, ramjets, and pulse-jet

Turbojets, ramjets, and pulsejets are examples of engines that :
- accelerate a smaller quantity of air through a large velocity change.

They use the same working fluid for propulsive force that is:
- used within the engine (Air)

One problem with these types of engines is the:
- noise made by the high velocity air exiting the engine

Many aircraft use a form of the gas turbine engine to produce :
- power for thrust

These engines are normally the
- Turboprop
- turboshaft
- turbofan
- few turbojet engines. "Turbojet" is the former term for any turbine engine

The term turbojet was used to describe any;
- gas turbine engines, but with the differences in gas turbines used in aircraft, this term is used to describe a type of gas turbine that passes all the gases through the core of the engine directly.

By all means All aircraft engines must meet cer tain general requirements of
- efficiency
- economy
- reliability

DURABILITY AND RELIABILITY

An aircraft engine is reliable when it can perform at the

- specified ratings in widely varying flight attitudes
- in extreme weather conditions

Durability is :

- the amount of engine life obtained while maintaining the desired reliability

reliability of the engine is determined by the :

- maintenance
- overhaul
- operating personnel.

OPERATING FLEXIBILITY

Operating flexibility is the:

- ability of an engine to run smoothly and give desired performance at all speeds from idling to full power output.

The aircraft engine must also function efficiently through all :

- the variations in atmospheric conditions encountered in widespread operations.

COMPACTNESS:الشكل و الحجم مظغوط

To affect proper streamlining and balancing of an aircraft:

- the shape and size of the engine must be as compact as possible

CONSTRUCTIONAL ARRANGEMENT

A significant feature of the gas turbine engine is that

- separate sections are devoted to each function,
- and all functions are performed simultaneously without interruption.

A typical gas turbine engine consists of:

1, An air inlet,
2, Compressor section,
3, Combustion section,
4, Turbine section,
5, Exhaust section,
6, Accessory section,
7, The systems necessary for starting, lubrication, fuel supply, and auxiliary purposes, such as anti-icing, cooling, and pressurization.

There are two sections in the gas turbine engine:

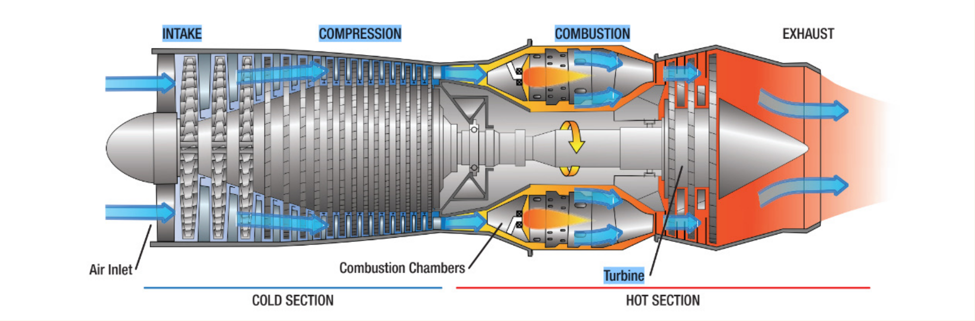
- cold section
- Hot section

Cold section refers to the parts of the engine from

- the inlets up through the compressors and/or diffusers.

Hot section refers to the areas past the

- compressors from the combustion chambers through the exhaust.



One of the greatest single factors influencing the construction features of any gas turbine engine is the type of

- compressor or compressors for which the engine is designed.

Four types of gas turbine engines are used to propel and power aircraft. They are the

1, turbojet
2, turbofan
3, turboshaft
4, Turboprop

1, TURBOJET

Definition of Turbojet

The term "turbojet" originally referred to any gas turbine engine used in aircraft.

Technological Evolution

As gas turbine technology advanced, new engine types were developed to replace pure turbojets.

Issues with Turbojets

Turbojet engines have problems with noise and fuel consumption, especially at airliner speeds of 0.8 Mach.

Limited Use of Turbojets

Due to these drawbacks, the use of pure turbojet engines is now very limited.

Turbofan Engines as a Replacement

Most airliners today use turbofan engines, which have largely replaced turbojets.

A Turbojet, turbine engine is one in which a

- turbine driven compressor draws in and compresses air,
- forcing it into a combustion chamber into which fuel is injected

Ignition causes the gases to :

- expand and to rush first through the turbine and then through a nozzle at the rear.

Forward thrust is generated as a

- reaction to the rearward momentum of the exhaust gases

2, TURBOFAN ENGINES

Turbofan engines were 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 is:

- quieter
- has better fuel consumption in the high sub Mach speed range.

Turbofan engines have:

- more than one shaft in the engine; many are two shaft engines

This means:

- that there are compressors and turbines that drive 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.

3, TURBOSHAFT

A turboshaft engine is a :
- variant of a jet engine

that has been optimized to:
- produce shaft power to drive machinery instead of producing thrust

Turboshaft engines are most commonly used in applications that require a:
- small but powerful, light weight engine
- inclusive of helicopters and auxiliary power units (APU's).

turboshaft engine uses the same principles as a:
- turbojet to produce energy,
- that is, it incorporates a compressor, combustor and turbine within the gas generator of the 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 optimized for the machinery that it will energize without the need for an additional reduction gearbox within the engine.

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

4, TURBOPROP

Turboprop engine uses the same principles as a:

- turbojet to produce energy
- that is, it incorporates a compressor, combustor and turbine within the gas generator of the engine.

The primary difference between the Turboprop and the turbojet is that:

1, additional turbines
2, 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

The latter design

is referred to as a free power turbine or, more simply, a "free turbine" engine. In either case, the turbines extract almost all of the energy from the exhaust stream using some of it to power the engine compressor and the rest to drive the propeller.

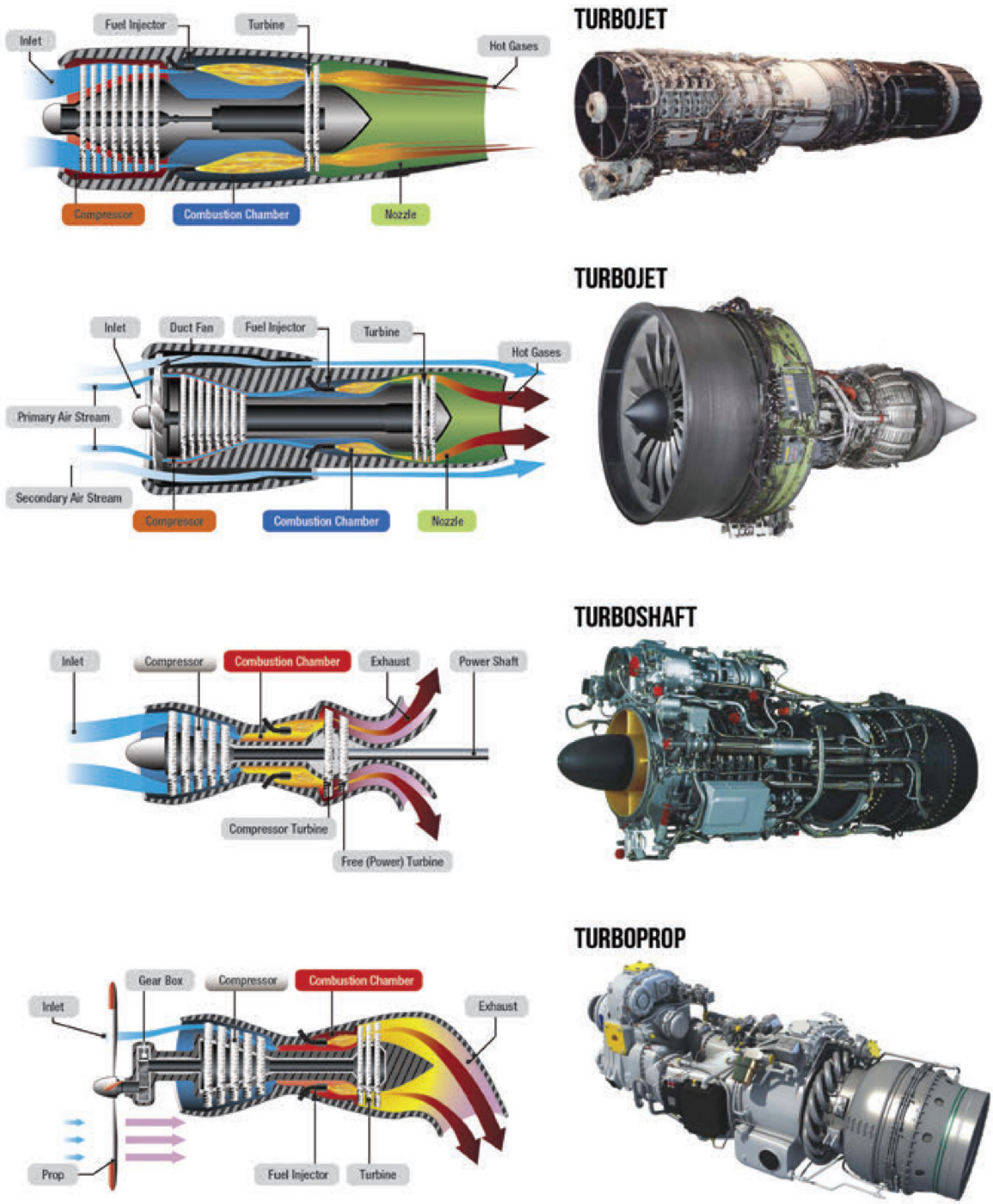


Figure 1-8. The four primary types of gas turbine engines.