Abdulla Aljunibi

TURBINE SECTION

The turbine transforms a portion of the kinetic (velocity) energy of the exhaust gases into:

- mechanical energy to drive the gas generator compressor and accessories

The sole purpose of the gas generator turbine is to:

- absorb approximately 60 to 70 percent of the total pressure energy from the exhaust gases.
- The rest 20 or 30 percent is used as thrust

The exact amount of energy absorption at the turbine is determined by the:

- load the turbine is driving (i.e., compressor size and type, number of accessories, and the load applied by the other turbine stages)

These turbine stages can be used to drive:

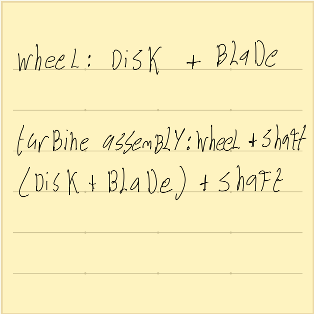
- low pressure compressor (fan)
- propeller
- shaft

The turbine section of a gas turbine engine is located aft, or downstream, of the :

- combustion chamber

Specifically, it is directly :

- behind the combustion chamber outlet



The two types of turbine engines are the:

1, axial flow turbine

2, the radial flow turbine

1, AXIAL FLOW TURBINES

The axial flow turbine has two main elements:

1, turbine rotors (or wheels, as they are sometimes called)

2, stationary vanes.

The turbine blade themselves are of two basic types,:

- the impulse and the reaction comprising the impulse and reaction sections

meaning ; (my statement) :

- Turbine blades are divided into impulse and reaction types: impulse blades convert fluid kinetic energy to mechanical energy using high-speed jets, while reaction blades use pressure differences across curved blades to generate propulsion, with both types arranged in sections to maximize efficiency across varying fluid pressures and velocities.

The stationary vane assembly of each stage in the turbine is usually referred to as :

- the turbine nozzle guide vanes

2, RADIAL INFLOW TURBINE

The radial inflow turbine has the advantage of:

- ruggedness
- simplicity
- is relatively inexpensive
- easy to manufacture when compared with axial flow type

Inlet gas flows through:

- peripheral nozzles to enter the wheel passages in a radial direction

Then The speeding gas exerts force on the:

- wheel blades and then exhaust the air in an axial direction to the atmosphere

Figure 6-2. A radial inflow turbine rotor.

These turbine wheels used for :

- small engines, are well suited for lower range of specific speeds and work at relatively high efficiency

The primary differences between axial and radial flow turbines are:

RADIAL (Centrifugal)	AXIAL
Used for small engines.	Used for large engines
Small mass flow rates.	Large mass flow rates.
Lower efficiencies.	Better efficiencies.
Cheap.	Expensive.
Easy to manufacture.	Difficult to manufacture.

Table 6-1. A comparison of benefits and drawbacks of axial and radial type engines.

STATOR AND TURBINE BLADE SECTIONS

The turbine assembly consists of two basic elements:

1, the stator consisting of the nozzle and inlet guide vanes

2, the turbine blades (rotor) each connected by the turbine shaft.

1, STATOR NOZZLE GUIDE VANES:

The stator element is known by a variety of names, of which :

- turbine inlet nozzle vanes
- turbine inlet guide vanes
- and nozzle diaphragm

are three of the most commonly used.

The turbine inlet nozzle vanes are located :

- directly aft of the combustion chambers and immediately forward of the turbine wheel

This is the :

- highest or hottest temperature that comes in contact with metal components in the engine

The turbine inlet temperature must be :

- controlled or damage will occur to the turbine inlet vanes.

After the combustion chamber has introduced the heat energy into the mass airflow and delivered it evenly to the turbine inlet nozzles:

- the nozzles must prepare the mass air flow to drive the turbine rotor

The first purpose nozzle converts a varying portion of the heat and pressure energy to:

- velocity energy

that can then be converted to :

- mechanical energy through the turbine blades

The second purpose of the turbine inlet nozzle is to:

- deflect the gases to a specific angle in the direction of turbine wheel rotation
- Since the gas flow from the nozzle must enter the turbine blade passageway while it is still rotating, it is essential to aim the gas in the general direction of turbine rotation.

The turbine inlet nozzle assembly consists of an:

- inner shroud and an outer shroud between which the nozzle vanes are fixed.

The vanes of the turbine inlet nozzle may be assembled:

- between the outer and inner shrouds or rings in a variety of ways

Although the actual elements may vary slightly in configuration and construction features, there is one characteristic peculiar to all turbine inlet nozzles:

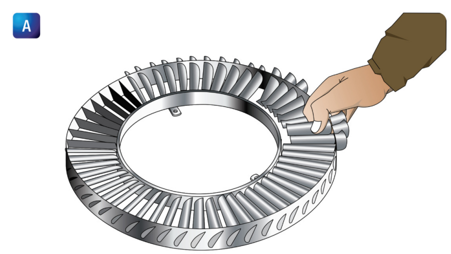
- the nozzle vanes must be constructed to allow thermal expansion.

Otherwise:

- there would be severe distortion or warping of the metal components because of rapid temperature changes.

The thermal expansion of turbine nozzles is accomplished by one of several methods:

1, One method necessitates loose assembly of the supporting inner and outer vane shrouds



Turbine nozzle vane assembly with loose fitting vanes.

Another method of thermal expansion construction is to fit the vanes into inner and outer shrouds; however, in this method the vanes are:

- welded or riveted into position.

Some means must be provided to allow thermal expansion; therefore:

- either the inner or the outer shroud ring is cut into segments

The saw cuts separating the segments allow

- sufficient expansion to prevent stress and warping of the vanes.

Turbine nozzle vane assembly with welded vanes.

Figure 6-3. Typical turbine nozzle vane assemblies.

TURBINE BLADES OPERATION AND CHARACTERISTICS

TURBINE BLADE TYPES

Turbine blades can be classified among these three types:

- Impulse configuration.
- Reaction configuration.
- Reaction-Impulse configuration

1, Impulse Configuration

With the Impulse type the total pressure:

- drop across each stage occurs in the fixed nozzle guide vanes which because of their convergent shape
- increase the gas velocity whilst reducing the pressure

The gas is directed onto the turbine blades which experience an:

- impulse force caused by the impact of the gas on the blades

All pressure energy of gas is converted to:

- kinetic energy

Area of the inlet and exit between the blades is

- equal

The impulse force does not act directly in the plane of rotation of the:

- turbine wheel but is resolved in to two components.

2, Reaction Configuration

With the Reaction type the fixed nozzle guide vanes are designed to :

- alter the gas flow direction without changing the pressure.

- The converging blade passages experience a reaction force resulting from the expansion and acceleration of the gas

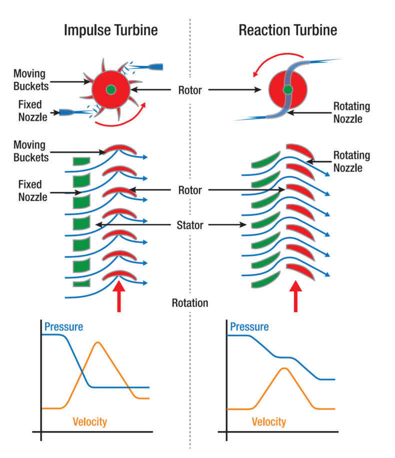


Figure 6-4. The differences in operation and performance of impulse and reaction turbine blades.

3, Reaction-Impulse Configuration

Combination of both ()

TURBINE BLADES CONSTRUCTION

Many turbine blades are:
- cast as a single crystal

which gives the blades:
- better strength and heat properties

Heat barrier coating, such as:
- ceramic coating, and air flow cooling help keep the turbine blades and inlet nozzles cooler.

This allows the exhaust temperature to be:
- raised, increasing the efficiency of the engine

Most turbines are open at the:
- outer perimeter of the blades

However :

second type called the:
- shrouded turbine is sometimes used

The shrouded turbine blades in effect, form a :
- band around the outer perimeter of the turbine wheel.

This improves :
- efficiency and vibration characteristics, and permits lighter stage weights
- On the other hand, it limits turbine speed and requires more blades.

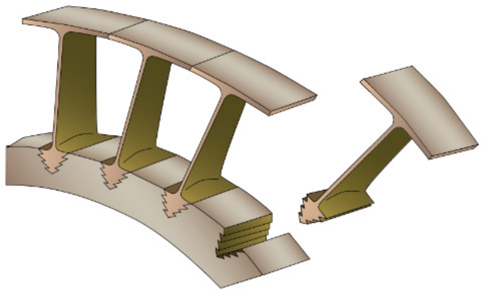


Figure 6-6. Shrouded turbine blades.

BLADE TO DISK ATTACHMENT

The rotor element of the turbine section consists essentially of a :
- shaft and a wheel.

The turbine wheel is a:
- dynamically balanced unit consisting of blades attached to a rotating disk

The disk, in turn, is attached to:
- the main power transmitting shaft of the engine

The exhaust gases leaving the turbine inlet nozzle vanes act on the:
- blades of the turbine wheel, causing the assembly to rotate at a very high rate of speed

the engine speed and temperature must be controlled to keep turbine operation within :
- safe limits.

Figure 6-7. Rotor elements of the turbine assembly.

When the turbine blades are instal led, the disk then becomes the
- turbine wheel.

the shaft is welded to:
- the disk

Another method is by
- bolting

The turbine shaft must have some means for attachment to the:
- compressor rotor hub

This is usually accomplished by a :
- spline cut on the forward end of the shaft

The spline fits into a :
- coupling device between the compressor and turbine shafts

There are various ways of attaching turbine blades, some similar to compressor blade attachment. The most satisfactory method uses the:
- fir tree design

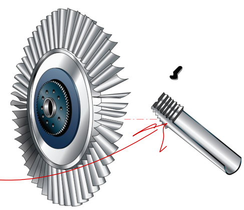


Figure 6-8. Turbine blade with fir-tree design and lock-tab method of blade retention.

The blades are retained in their respective grooves by a variety of methods, the more common of which are :
peening, welding, lock tabs, and riveting.

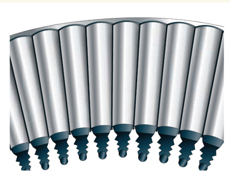


Figure 6-9. Rivet method of turbine blade retention.

TURBINE BLADE STRESS AND CREEP

Inspection for cracks in turbine section components is very important

Cracks are :
- not normally allowed

Any cracks found on the disk require the disk to be :
- rejected and the turbine rotor to be replaced.

Slight pitting caused by the impingement of foreign matter may be:
- blended by stoning and polishing. Fixed BY this

Strong light and a magnifying glass are used for
- inspection of turbine blades for stress rupture cracks and deformation of the leading edge.

streer: apper in the leadingedge as a human hair

Deformation caused by over temperature, may appear as:
- waviness and/or areas of varying airfoil thickness along the leading edge.

creep:
- This is a slow structural deformation on a molecular level caused by prolonged exposure to high stresses.

Creep increases with
- temperature and can result in observable dimensional changes to the blades

Blades removed for a detailed inspection or for a check of turbine disk stretch must be:
- reinstalled in the same slots from which they were removed.
- Number the blades prior to removal

TURBINE SECTION CONFIGURATION

TURBINE STAGES

turbine stage consists of a:
- row of stationary vanes or nozzles, followed by a row of rotating blades.

It should be remembered that, regardless of the number of wheels necessary for:
- driving engine components
- there is always a turbine nozzle preceding each wheel (to direct the air flow)

single stage rotor turbine:
In the single stage rotor turbine:
- the power is developed by one turbine rotor
- all engine driven parts are driven by this single wheel

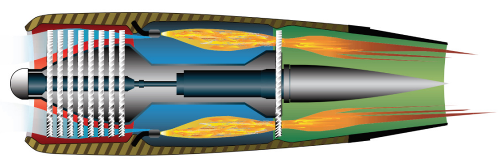


Figure 6-12. Single stage rotor turbine.

multistage turbine:
This arrangement is used on engines where :
- the need for low weight and compactness predominates
- This is the simplest version of the pure turbojet engine

In multiple spool engines, each spool has its
- own set of turbine stages.

Each set of turbine stages:
- turns the compressor attached to it

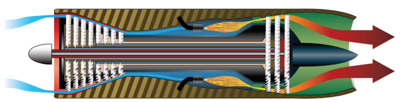


Figure 6-13. Multirotor turbine.

Most turbofan engines have two spools:
- low pressure (fan shaft a few stages of compression and the turbine to drive it)
- high pressure (high pressure compressor shaft and high pressure turbine)

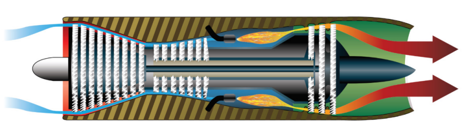


Figure 6-14. Dual rotor turbine for split spool compressor.

TURBINE HOUSING

The turbine casing encloses the:

- turbine wheel
- the nozzle vane assembly
- gives either direct or indirect support to the stator elements of the turbine section.

It always has Flanges provided front and rear for

- bolting the assembly to the combustion chamber housing
- and the exhaust cone assembly,

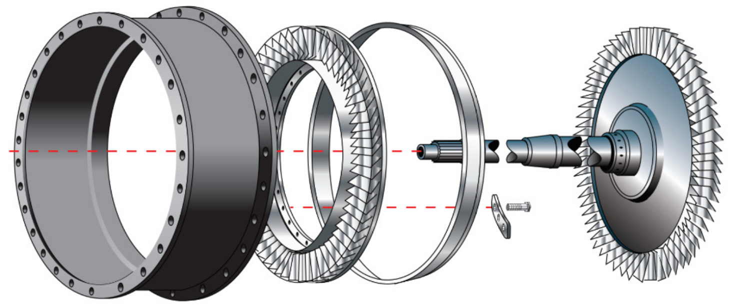


Figure 6-15. Turbine casing assembly.