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COMPRESSOR SECTION

The compressor section of the gas turbine engine performs critical functions

Its primary function is to:

- supply air in sufficient quantity to satisfy the requirements of the combustion burners.

Specifically, to fulfill its purpose the compressor must

- increase the pressure of the mass of air received from the air inlet duct,
- then, discharge it to the burners in the quantity and at the pressures required

A secondary function of the compressor is to :

- supply air for various purposes in the engine and aircraft

bleed air is taken from:

- any of the various pressure stages of the compressor.

The exact location of the bleed ports is dependent on the:

- pressure or temperature required for a particular job.

The ports are:

small openings in the compressor case adjacent to the particular stage from which the air is to be bled.

Air is often bled from the :

- final or highest pressure stage since, at this point, pressure and air temperature are at a maximum.

At times it may be necessary to:

- cool this high pressure air

If it is used for cabin pressurization or other purposes to which excess heat would be:

- uncomfortable or detrimental, the air is sent through an air conditioning unit before it enters the cabin

BLEED AIR

- The air that is used for other stuff other than the turbojet

Some of the current applications of bleed air are:

1. Cabin pressurization, heating, and cooling
2. Deicing and anti-icing equipment
3. Pneumatic starting of engines
4. Auxiliary drive units (ADU)

COMPRESSOR TYPES AND APPLICATIONS

The two principal types of compressors currently being used in gas turbine aircraft engines are:

1, centrifugal flow

2, axial flow

The centrifugal flow compressor achieves its purpose by :

- picking up the entering air and accelerating it outwardly by centrifugal action

The axial flow compressor compresses air:

- while the air continues in its original direction of flow, thus avoiding the energy loss caused by turns

stage in a compressor is considered to be a :

- rise in pressure.

Axial flow compressors are normally found on:

- turbofan engines which are widely used in aviation.

Centrifugal flow compressors are commonly used in:

- Turboprop
- turboshaft engines

CONSTRUCTION FEATURES, OPERATING PRINCIPLES, AND APPLICATIONS

CENTRIFUGAL FLOW COMPRESSOR (First type of compressor)

The centrifugal flow compressor consists of an:
1, impeller (rotor)
2, a diffuser (stator)
3, a compressor manifold.

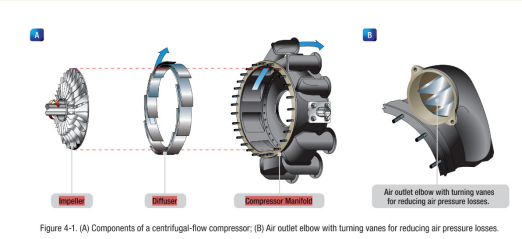


Figure 4-1. (A) Components of a centrifugal-flow compressor; (B) Air outlet elbow with turning vanes for reducing air pressure losses.

Centrifugal compressors have a high pressure rise per stage that can be around:
- 8:1 MULTIPLY BY 9

Generally centrifugal compressors are limited to:
- two stages due to efficiency concerns

1, impeller

The two main functional elements are the:
- impeller and the diffuser

The impeller, whose function is to
- pick up and accelerate the air outwardly to the diffuser

may be either of two types (two types of impeller)
- single entry
- double entry.

The principal differences between the two types of impellers are
1, size
2, ducting arrangement

The difference is:

The double entry type has:
- smaller diameter, but is usually operated at a higher rotational speed to assure sufficient airflow

The single entry impeller,
- permits convenient ducting directly to the impeller eye (inducer vanes) as opposed to the more complicated ducting necessary to reach the rear side of the double entry type

the single entry impeller must be :

- large in diameter to deliver the same quantity of air as the double entry type.

This, of course will:

- increases the overall diameter of the engine.

in the ducting for double entry compressor engines is the

- plenum chamber.

This chamber is necessary for a

- double entry compressor because the air must enter the engine at almost right angles to the engine axis.

My statement about plenum chamber: only For DuBle Inbre Y

1. Plenum Chamber: This is a box that surrounds the engine and helps direct air into it smoothly.
2. Why it's needed: Air has to come into the engine from the side (almost at a right angle), so the plenum chamber makes sure there's enough pressure around the engine to push air in properly.
3. Blow-In Doors: These are doors that open to let extra air into the engine when needed, especially when the engine is running on the ground and needs more air than the main ducts provide.
4. How the doors work:
   - When the engine is off: The doors stay closed, held by springs.
   - When the engine is running: If the engine needs more air, the doors open automatically.
   - During flight: Fast-moving air keeps the doors shut, helping the springs hold them closed.

These doors make sure the engine always gets enough air, whether it's on the ground or flying!

Therefore, in order to give a positive flow, the air must surround the engine compressor at a positive pressure before entering the compressor

Figure 4-2. Single-entry impeller.

double entry impeller

2, Diffuser

The diffuser is an:

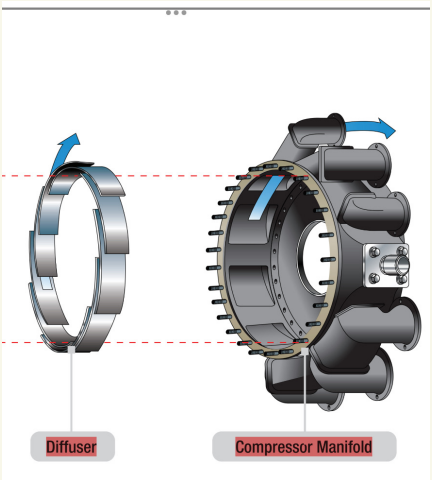
- annular chamber provided with a number of vanes forming a series of divergent passages into the manifold

The diffuser vanes direct the flow of air from the:

- impeller to the manifold at an angle designed to retain the maximum amount of energy imparted by the impeller

They also deliver the air to the:

- manifold at a velocity and pressure satisfactory for use in the combustion chambers.



note :

- the arrow indicating the path of airflow through the diffuser, then through the manifold

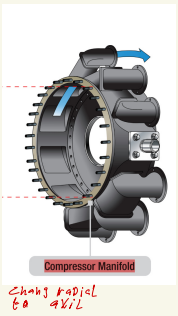
3, compressor manifold

The compressor manifold diverts the flow of air from:

- the diffuser, which is an integral part of the manifold,
- into the combustion chambers

The manifold has:

- one outlet port for each chamber so that the air is evenly divided



compressor outlet elbow is :

- bolted to each of the outlet ports

outlet ducts perform a very important part of the diffusion process:

- they change the radial direction of the airflow to an axial direction, in which the diffusion process is completed after the turn.

AXIAL FLOW COMPRESSOR (second type of compressor)

The axial flow compressor has two main elements:

- rotor
- stator

The rotor has:

- blades fixed on a spindle.

These blades:

- impel air rearward in the same manner as a propeller because of their angle and airfoil contour.

The rotor, turning at high speed, takes in air at the compressor inlet and impels it through a series of :

- stages

From inlet to exit, the air flows along an axial path and is compressed at a ratio of approximately 1.25:1 per stage.

The action of the rotor:

- increases the compression of the air at each stage and accelerates it rearward through several stages
- With this increased velocity, energy is transferred from the compressor to the air in the form of velocity energy

The stator blades act as :

- diffusers at each stage, partially converting high velocity to pressure.

Each consecutive pair of rotor and stator blades constitutes a:

- pressure stage

The number of rows of blades (stages) is determined by the:

- amount of air and total pressure rise required

Compressor pressure ratio increases with the number of:

- compression stages

Most engines utilize up to 16 stages and more

The stator has rows of vanes, which are in:

- turn attached inside an enclosing case
- The first stage stator : inlet guide vanes

The stator vanes, which are:

- stationary

project radially toward the:

- rotor axis and fit closely on either side of each stage of the rotor blades

In some cases, the compressor case, into which the stator vanes are fitted, is :

- horizontally divided into halves

The function of the stator vanes is to:

- receive air from the air inlet duct

or

- from each preceding stage and increase the pressure of the air and deliver it to the next stage at the correct velocity and pressure

They also control the:

- direction of air to each rotor stage to obtain the maximum possible compressor blade efficiency

The first stage rotor blades can be preceded by an

- inlet guide vane assembly that can be fixed or variable.

The guide vanes:

- direct the airflow into the first stage rotor blades at the proper angle and impart a swirling motion to the air entering the compressor

The inlet guide vanes are

- curved steel vanes usually welded to steel inner and outer shrouds

At the discharge end of the compressor:

- the stator vanes are constructed to straighten the airflow to eliminate turbulence.

These vanes are called:

- straightening vanes or the outlet vane assembly

rotor blades

The design of blade attachment to the:

- rotor disk rims varies

but they are commonly fitted into:

- disks by either bulb type or fir tree methods.

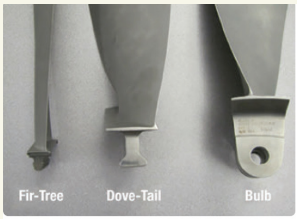


Figure 4-4. Common designs of compressor blade attachment to the rotor disk.

The blades are then locked into place by :

- differing methods

Compressor blade tips are reduced in thickness by:

- cutouts, referred to as blade profiles.

These profiles prevent:

- serious damage to the blade or housing should the blades contact the compressor housing. If This condition can occur if rotor blades become excessively loose or if rotor support is reduced by a malfunctioning bearing

The rotor features either:

1, drum type
2, disk type

1, drum type

The drum type rotor consists of:

- rings that are flanged to fit one against the other
- wherein the entire assembly can then be held together by through bolts.

This type of construction is satisfactory for

- low speed compressors
- where centrifugal stresses are low

2, disk type

The disk type rotor consists of a:
1, series of disks
2, with rotor blades dovetailed into the disk rims

disks and shaft from a
- single aluminum forging, and then to bolt steel stub shafts on the front and rear of the assembly
- to provide bearing support surfaces and splines for joining the turbine shaft

The combination of the compressor stages and turbine stages on a common shaft is an engine referred to as an:
- engine spool

Compensation : compressr turbine shaft : single spool: one single shaft : the same rpm

2 spool: two shaft each have their own set of compressor and turbine there will be a big and a small shaft the small shaft is faster because it's shorter

The engine's spool is supported by:
- bearings, which are seated in suitable bearing housings

There are two configurations of the:
- the single rotor/spool
- the dual rotor/spool, sometimes referred to as solid spool and split spool (two spool, dual spool)

solid spool (one spool) compressor uses:
- variable inlet guide vanes.

the first few rows of stator vanes are:
- variable

The main difference between variable inlet guide vane (VIGV) and a variable stator vane (VSV) is their:
- position with regard to the rotor blades

VIGV are in : front of the rotor blades

and VSV are : behind the rotor blades.

ADVANTAGES AND DISADVANTAGES

The centrifugal flow compressor's advantages are:

- High pressure rise per stage,
- Efficiency over wide rotational speed range,
- Simplicity of manufacture and low cost,
- Low weight, and
- Low starting power requirements

The centrifugal flow compressor's disadvantages are:

- Its large frontal area for a given airflow and
- Losses in turns between stages.

The axial flow compressor's advantages are:

- High peak efficiencies;
- Small frontal area for given airflow;
- Straight through flow, allowing high ram efficiency;
- Increased pressure rise by increasing number of stages, with negligible losses

The axial flow compressor's disadvantages are:

- Good efficiencies over only narrow rotational speed range,
- Difficulty of manufacture and high cost,
- Relatively high weight, and
- High starting power requirements; (partially overcome by split compressors).

FAN BALANCE

High bypass fans require particular attention to:

- balance while in service due to their large diameter and high rotational forces.

Even minor damage can cause the fan to become:

- unbalanced and compromise the integrity of the rotating assembly and its bearings.

The blades are fitted and a

- vibration survey is carried out.

If necessary:

- trim balance weights will be fitted to reduce the vibration.

Trim balance weights may be either:

- oversize bolts securing the fan spinner
- special trim balance bolts fitted at right angles to the spinner securing bolts
- special balance weights that fit on the fan balance ring below the blade root.

(The oposit blade have to be the same weight.)

If a fan blade is damaged in the field and replacement is needed, there are three trim balance options:

1, The blade can be replaced with a blade that is within a small tolerance of the original radial moment weight so the balance of the whole assembly is not affected

2, The blade could also be replaced with another of different weight then, using a formula from the maintenance manual, a correcting weight could be fitted to maintain assembly balance.

3, The third option is to replace the blade and the blade that is diametrically opposite to the damaged blade with a pair of blades that are of matching weights

CAUSE AND EFFECT OF COMPRESSOR STALL

When a single compressor blade or stage stalls, it is said to have :

- stalled

When the entire compressor stalls, it is known as:

- surge

Compressors experience stall or surge on the ground when:

- a high wind suddenly blows across the engine inlet duct.
- And FOD

The distortion of the inlet airflow can be such that

- the angle of the air striking the compressor blades causes the stall or surge

icing, a rapid throttle movement, rapid maneuver, or a fuel governor malfunction may cause:

- stall or surge

Any deterioration of blade shape due to :

- erosion, build up of deposits or blade damage contributes to the problem.

Airflow control systems must function as designed to provide the compressor with a

- steady flow of air at the designed angle so the compressor can function properly

Failure of the variable inlet guide vanes, variable stator vanes, or even a compressor bleed system malfunction can all contribute to a:

- stall or surge

The technician may recognize a compressor stall or surge during a ground run up by:

- hearing abnormal noises
- rumbling or moaning or just a bang

This accompanied by rapid changes in:

- values indicated for RPM, EGT, and EPR
- are signs of compressor stall or surge

Poor throttle response is another sign

The effects of stall or surge are detrimental to the:

- engine and, moreover to engine life

Changes in :

- material properties and fatigue due to shock loading of internal engine components occur

High EGT spikes during a surge reflect high turbine section temperatures that may:

- exceed design capabilities

The result is a:

- reduction in engine life.

COMPRESSOR RATIO

For a turbine engine there is one set of conditions (mass flow, pressure ratio and rpm) at which :

- all the compressor components are operating at their optimum effect

Under this condition the compressor produces a:

- given compression ratio.

The axial velocity of the gas remains constant from:

- the front to the rear of the compressor

Although compression ratio varies with rpm

- it is not proportional to RPM.

This fact is due to the:

- fixed blade angles which can only be correct at a certain point

$C.R = \frac{\text{Discharge (outlet)}}{\text{inlet}}$