An Introduction to Aircraft Power Plant

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Thrust

Propeller - moves LARGE MASS of air at low velocity

Jet - moves small mass of gas at HIGH VELOCITY
Propulsion Efficiency

\[ \eta_p = \frac{\text{useful power available}}{\text{total power generated}} \]

\[ \eta_p = \frac{2}{1 + \frac{V_j}{V_\infty}} \]

Mass flow rate 250 kg/s

Slipstream velocity 16 m/s

Thrust = 250 \times 16 = 4000 \text{ N}

Energy rate = \frac{250 \times 16^2}{2} = 32000 \text{ W}

Mass flow rate 50 kg/s

Jet velocity 80 m/s

Thrust = 50 \times 80 = 4000 \text{ N}

Energy rate = \frac{50 \times 80^2}{2} = 160000 \text{ W}
Efficiency

![Graph showing efficiency vs Mach number for different types of engines including propfan, turboprop, piston engine, turbofan engines with BPR of 5 and 1, turbojet, low BPR turbofan, high BPR turbofan, conventional, and advanced turboprop.]
Piston Engines
Piston Engines Classification
Engine components

(A) block
(B) camshaft
(C) combustion chamber
(D) connecting rod
(E) crankcase
(F) crankshaft
(G) cylinder
(H) exhaust manifold
(I) head
(J) intake manifold
(K) oil pan
(L) piston
(M) piston rings
(N) push rod,
(O) spark plug
(P) valve
(Q) water jacket.
Piston engine accessory

- Ignition coil
- Spark plug
- Breaker points
- Capacitor
- Flywheel magnet

**Fuel/Air Mixture**

Air is drawn into the carburetor and mixed with fuel from the float chamber. The mixture is then fed into the engine for combustion.

**Throttle Valve**

The flow of the fuel-air mixture is controlled by the throttle valve. The valve is adjusted by the throttle lever.

**Discharge Nozzle**

Fuel is forced through the discharge nozzle into the venturi by the pressure difference between the carburetor and the engine intake manifold.

**Venturi**

The shape of the venturi creates an area of low pressure, which draws air into the carburetor.

**Air Bleed**

Air is bled from the discharge nozzle to prevent the fuel mixture from being too rich at idle conditions.

**Float Chamber**

Fuel level is maintained by a float-type device, which regulates the amount of fuel delivered to the engine.

**Fuel Inlet**

Fuel is drawn into the carburetor through the fuel inlet, where it is mixed with air.

**Mixture Needle**

The mixture needle controls the fuel flow to the carburetor. The position of the needle can be adjusted to optimize the fuel-air mixture for different operating conditions.
Propeller
Gas Turbine Engines
Fundamental
Gas turbine type

- Compressor
- Diffuser
- Burner
- Fuel injection
- Turbine
- Nozzle
- Fan
- Propeller
- Gear
Air flow system
Inlet

Dashed line represents captured stream tube
\( A_\infty \) = Captured stream tube area far upstream
\( A_1 \) = Intake highlight area

Maximum Cruise
\( A_\infty = A_1 \)

Normal Cruise
\( A_\infty < A_1 \)

Takeoff
\( A_\infty > A_1 \)

At Incidence
Compressors
Combustion Chambers
Turbines
Exhaust System

- Secondary air
- Tertiary air
- Engine flow
- Nozzle position during take-off and subsonic flight
- Supersonic flight
- Mechanical position control
- Spring loaded
- Freely movable position controlled by pressure differential
Accessory

Air flow to prevent formation of carbon over orifice

TANGENTIAL HOLES

FILTER

SWIRL CHAMBER

Fuel pressure

Compressor delivery
Afterburning
Ramjet/Scramjet

(a)

(b)

(c)

Compression  Combustion  Expansion

X-43A Vehicle
Basic science

- Fluid mechanics
- Aerodynamics
- Thermodynamics
- Gas dynamics
Text books

• 1 Thomas A. Ward., Aerospace Propulsion Systems, John Wiley & Sons. 2010
• 2 ROBERT D. ZUCKER and OSCAR BIBLARZ, FUNDAMENTALS OF GAS DYNAMICS, 2nd Eds, John Wiley & Sons. 2002
• 4 Willard W. Pulkrabek, Engineering Fundamentals of the Internal Combustion Engine, Prentice Hall,