Introduction to Aerospace Propulsion

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Lecture No - 2
Felix Du Temple de la Croix – Monoplane 1857
Thrust for Flight

In normal cruise flight \( L = W \) and \( T = D \) as force equilibrium.

- Lift created by the wings
- Thrust by propulsor
- Aircraft flight motion
- Weight
- Drag due to air resistance
Unpowered airplanes

George Cayle’s design (early 19th century)

Samuel P Langley’s Airplane (late 19th century)
Langlely’s Airplane no Flight
Lorin’s 1908 patent.

Lorin’s 1913 patent.

1921 Guillaume patent.

Guillaume’s Patent of a Jet Engine

Lorin’s Patent Drawings
Wright's' engine
First Flight 1903 Dec
Wright’s propeller 1903        Wright’s Propeller 1910
2 years, 4 months and 3 days before the successful flights of the Wright brothers, a monoplane took to the air at early dawn on August 14, 1901, at Bridgeport, Conn, USA carrying the inventor, Gustave Whitehead, a distance of $\frac{1}{2}$ mile.
• For the first fifty years of flight all flight vehicles were using propellers as the only means of propulsion through air.
• After I world war a high powered committee in USA had decided that flight with jet propulsion was not possible.
• As a result NACA (precursor to present NASA) was entrusted in 1940’s with creating a large number of propeller blade airfoil shapes.
Propeller Blade uses airfoil shapes

A propeller uses a type of airfoil (similar to a wing) that turns and accelerates air. As the blades of the propeller rotate they create lifting forces (just as a wing does), in the horizontal plane instead of the vertical as with the wings. Thus, the propeller creates a propulsive action force perpendicular to its plane of rotation, that moves the aircraft forward in air as a reaction. Propellers can either "pull" the aircraft from the front of the wings / fuselage (Tractor), or "push" it from behind (Pusher).
Propeller Blade airfoil shapes (NACA)
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Propeller undergoing a wind tunnel testing

Tractor type propeller

Pusher Propeller
IC (piston) Engine – multi-cylinder arrangements for Aircraft Propulsion
In-line

V-type

Opposed cylinder

Radial
Jet Engines
1930s - 40s

Heinkel Engine

Heinkel He 178 First Jet engine powered aircraft
Frank Whittle’s engine design for patent

P-V diagram depicting the cycle

2 - Air Intake
3 - Rotor Disks
4, 5 - Axial Compressor rotors
7 - Centrifugal compressor
10 - Central Shaft
11 - Combustion Chamber
15 - Axial Turbine rotor
17 - Exit nozzle
Comparison of various kinds of Aircraft Powerplants
Propulsive efficiency is a measure of end usage of available energy for final thrust creation. It is not same as the thermal or overall efficiencies of an engine.
Modern aircraft powerplant designers are using Prop-fans or Prop-jets that enable usage of propellers for high thrust and high efficiency at low Mach number flights (for take-off and climb) and then use essentially jet propulsion for cruise at high Mach number and high altitude.
The Thurst generation

\[ F = \frac{dM_t}{dt} = d(mV) = m \frac{dv}{dt} = \frac{m}{dt} dv = \dot{m} \cdot dv \]

- High mass activation (air), \( \dot{m} \) – Propellers
  - low dV
- High change of momentum, dV - Jet engines
  - low mass activation, \( \dot{m} \)
- Propellers typically operate on air mass flows
  30 to 40 times more than that of a jet engine.
A modern propeller
Prop-Fan uses a basic engine
Abbreviation :

NACA : National Advisory Committee for Aeronautics, USA

NASA: National Aeronautics and Space Administration, USA

ISRO : Indian Space Research Organisation, India

HAL : Hindustan Aeronautics Limited, India