

Introduction to aeronautics

Part 4. The era of the jet-propelled airplane

4.1 The basics of the supersonic flow

- Mach number:

$$M = \frac{V}{a}$$

where

M is the Mach number,

V is the velocity of the source relative to the medium and

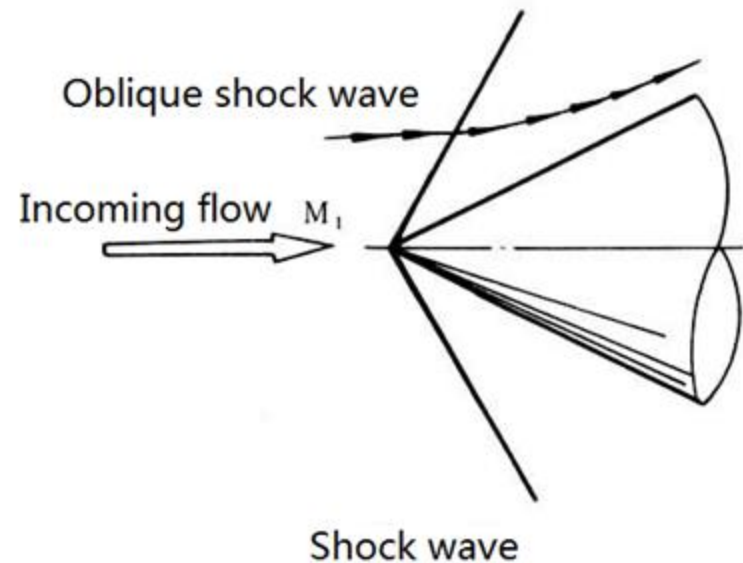
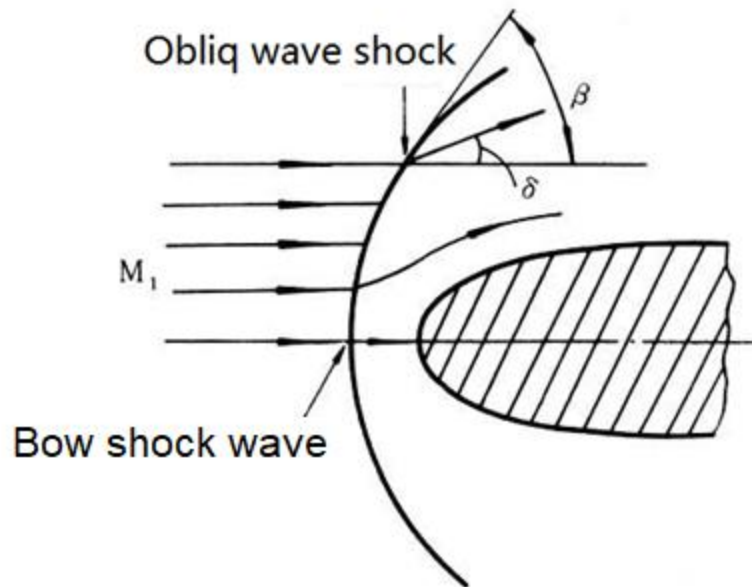
a is the speed of sound in the medium.

4.1 The basics of the supersonic flow

- **The terms about the flight speed:**
 - **Supersonic: $Ma > 1$**
 - **Subsonic: $Ma < 1$**
 - **Low speed: $Ma < 0.3$**
 - **Transonic: $1.2 > Ma > 0.8$**
 - **Hypersonic: $Ma > 5$**

4.1 The basics of the supersonic flow

- The shock waves and supersonic flow

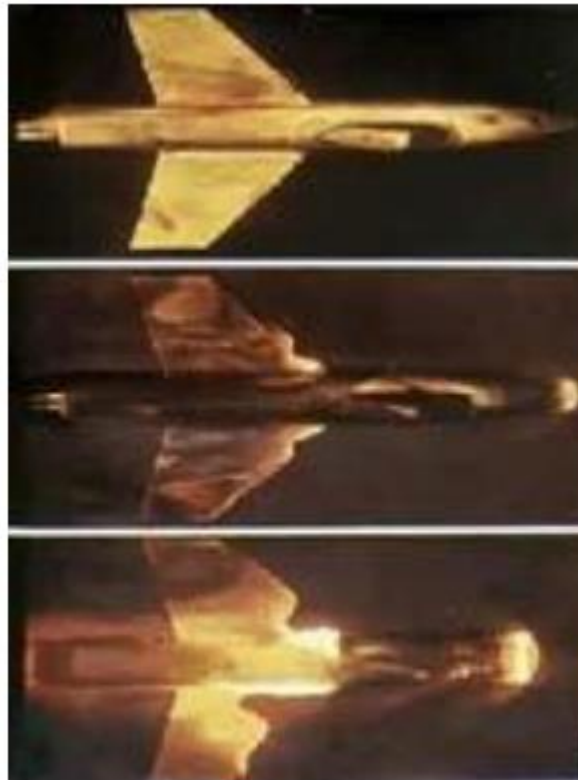


4.1 The basics of the supersonic flow

- **The Sound barrier**

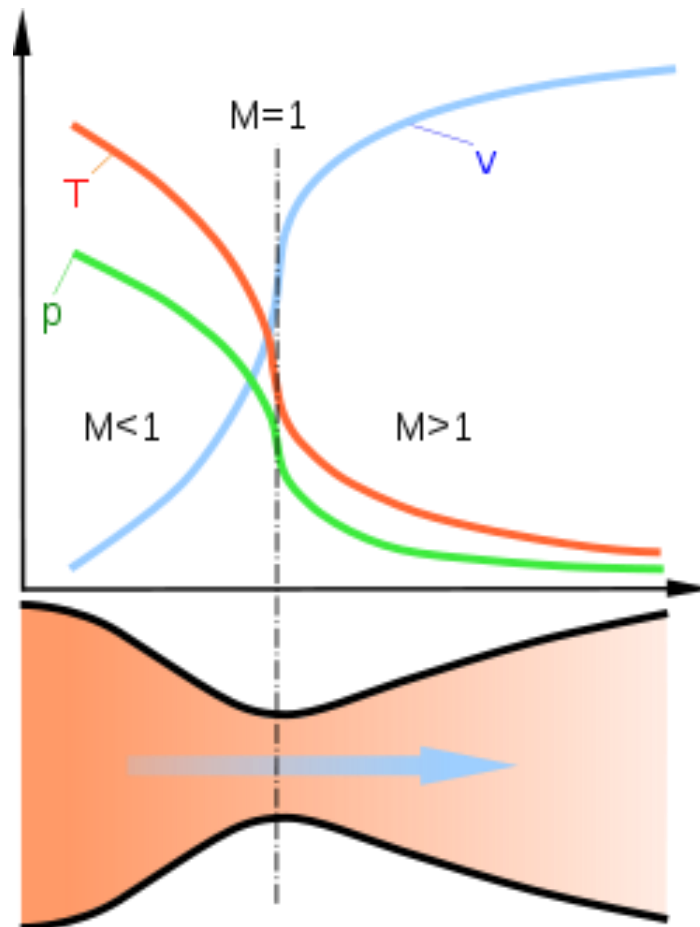
- The point at which an aircraft moves from transonic to supersonic speed

- **The thermal barrier**



4.1 The basics of the supersonic flow

- The Laval nozzle (convergent-divergent nozzle, CD nozzle or con-di nozzle)

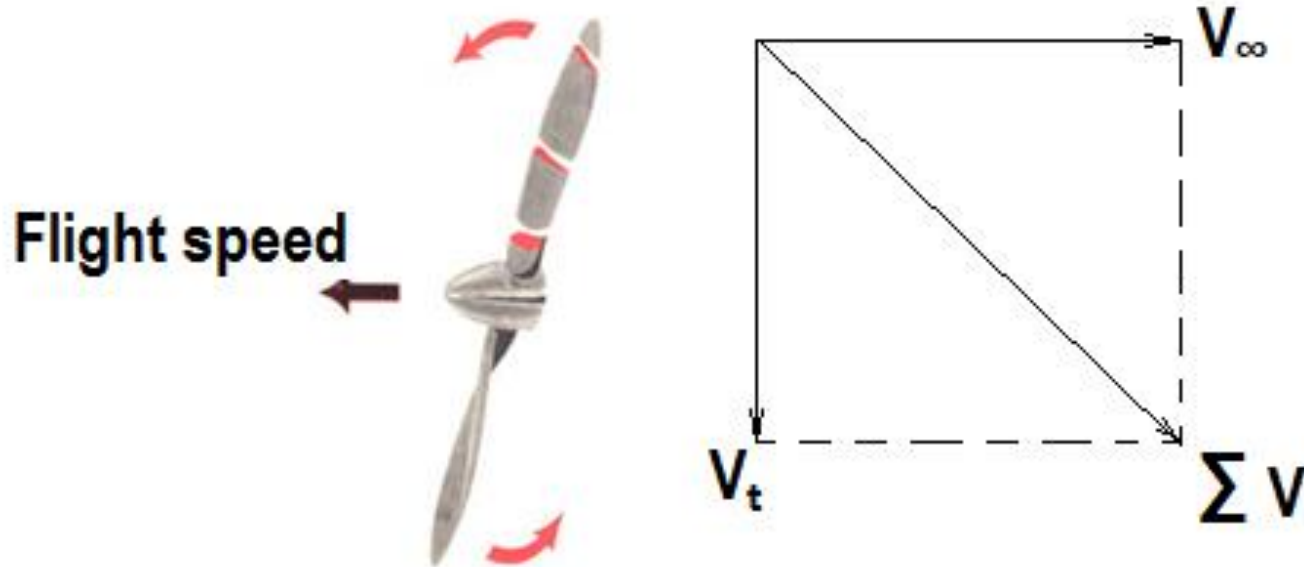


4.1 The basics of the supersonic flow

- Wave drag
 - The drag caused by shock waves
- Flutter
 - High-frequency instability, caused by airflow separation or shock wave
- Sonic boom
 - A sonic boom is the sound associated with the shock waves created by an object traveling through the air faster than the speed of sound.

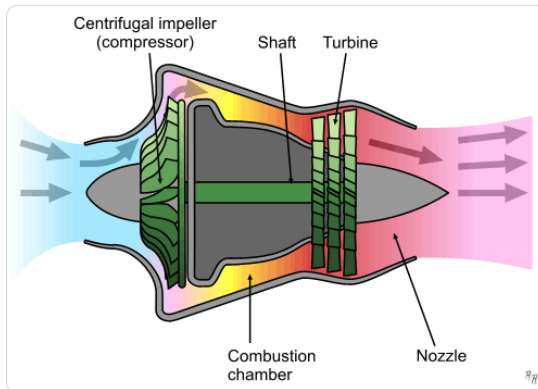
4.1 As the speed of the aircraft increased significantly, propeller driven airplane met their limit

- The propeller driven aircrafts can not fly faster than 800km/h in nature

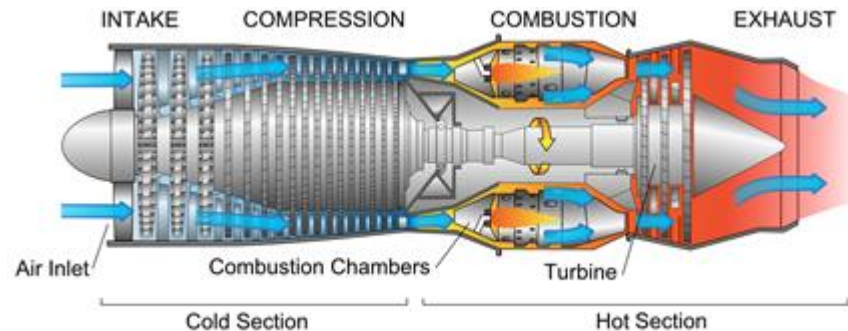


4.2 The jet engines

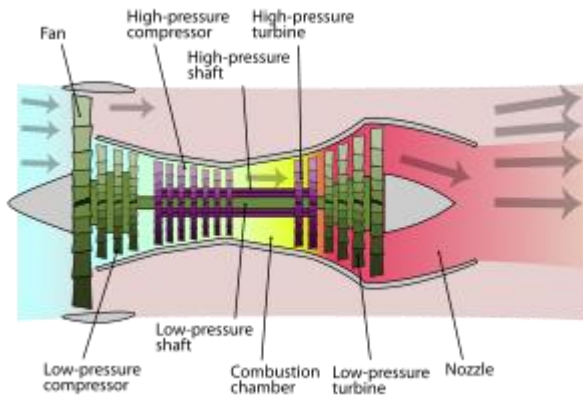
- The British and Germans invented jet airplanes independently



Jet engine with centrifugal impeller



Jet engine with axial impeller

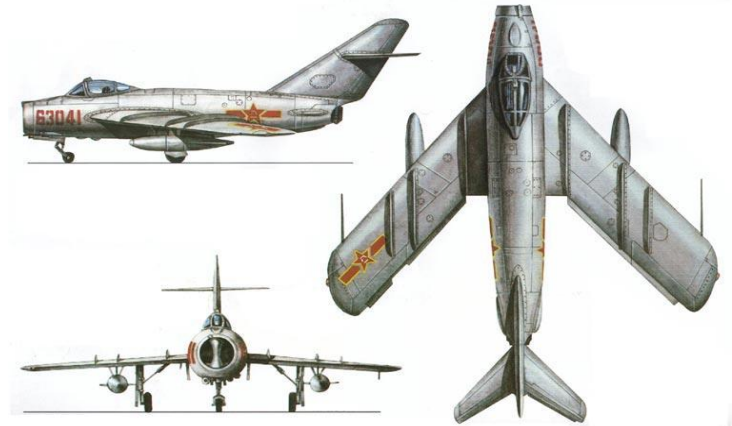


Turbofan



Jet airliner equipped with high bypass ratio engine

4.2 The jet engines

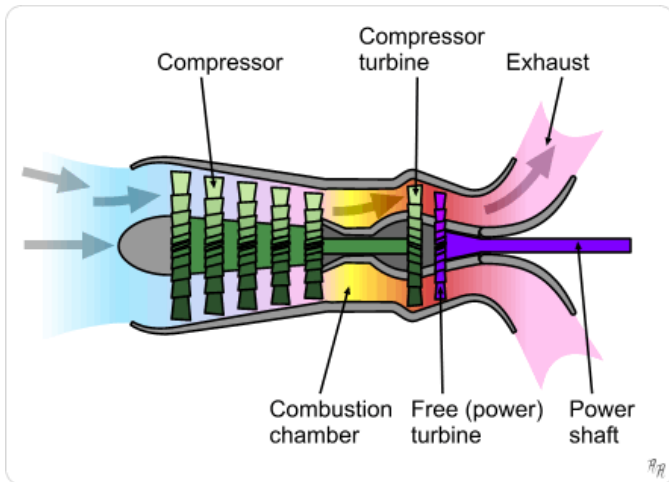


4.2 The jet engines

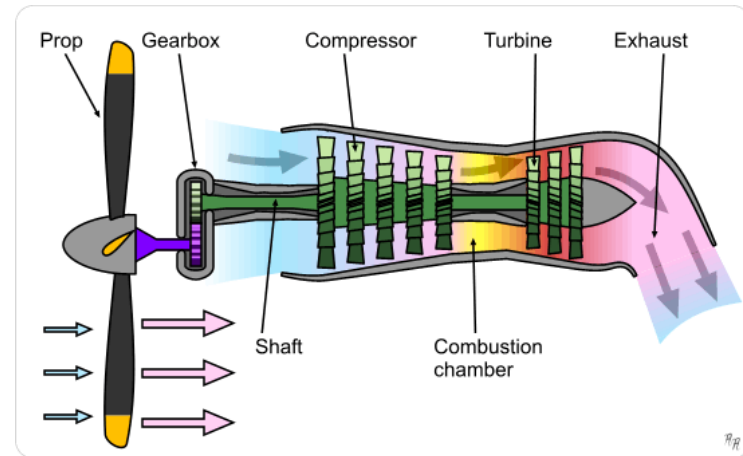


The low by-pass ratio engine

4.2 The jet engines



Turbo shaft engine

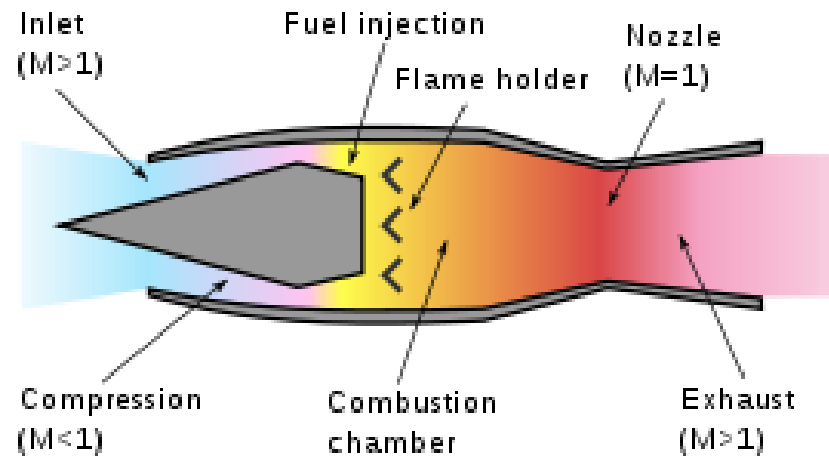


Turbo propeller engine

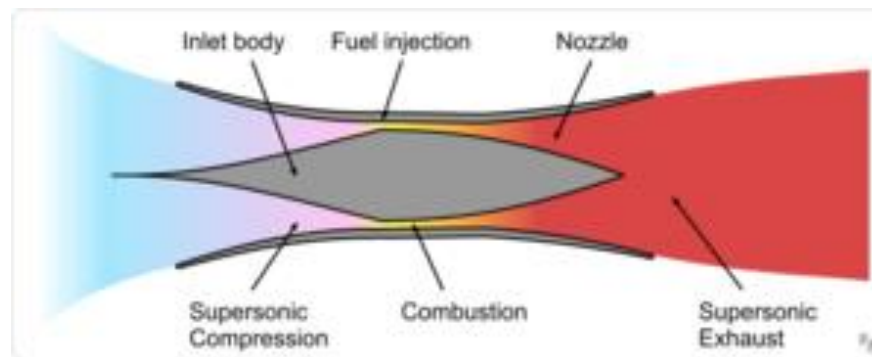


4.2 The jet engines

- The engines for high speed flight



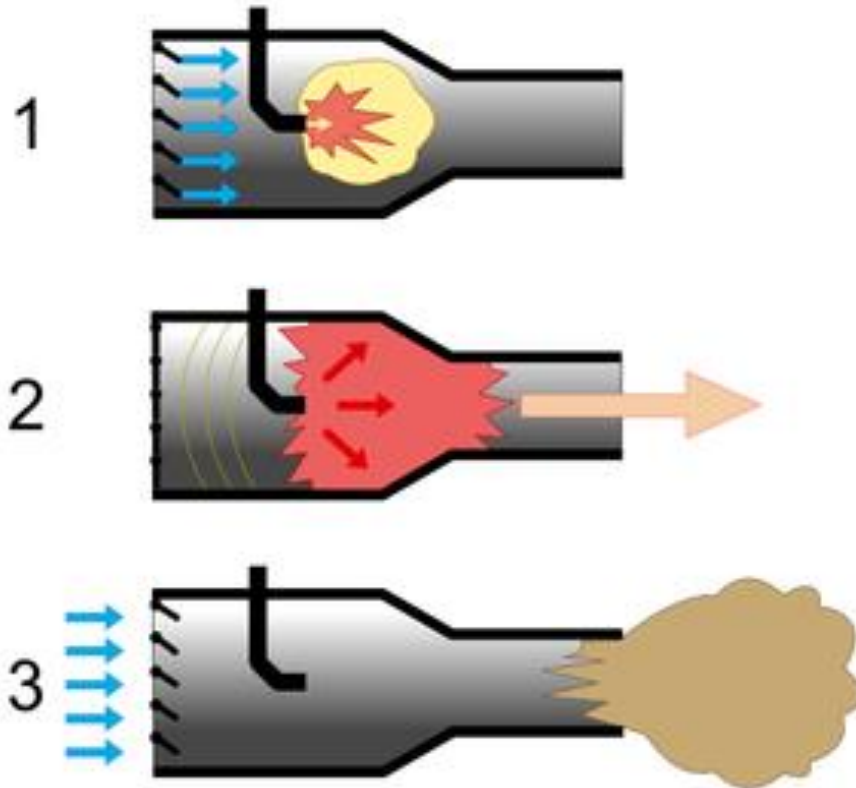
The ram jet



The scram jet

4.2 The jet engines

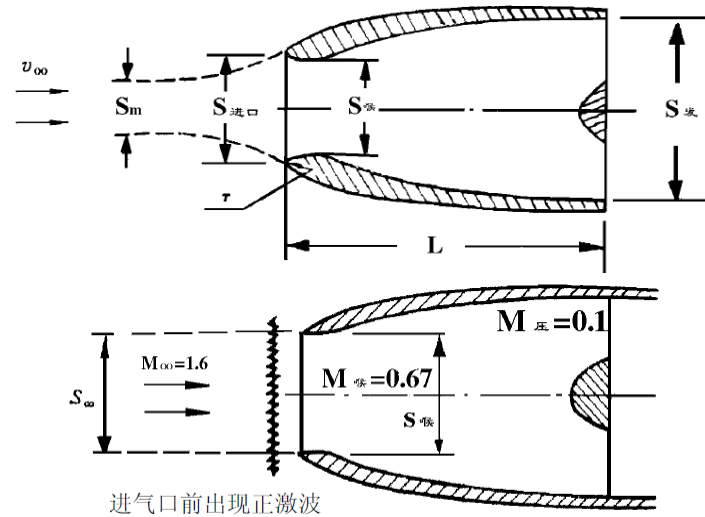
- The pulse engine



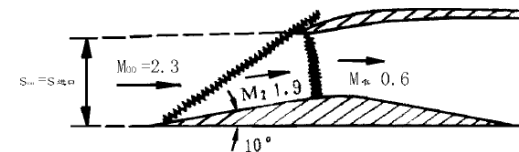
4.3 The jet engine intake

- **The function of the intake**
 - **Slow down the air for supersonic flights**
 - **Provide evenly distributed air flow for the engine**
 - **At high speed, generate thrust**

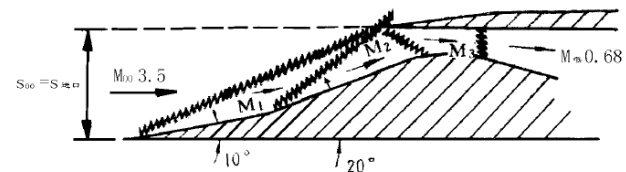
4.3 The jet engine intake



Subsonic air inlet



(a) 外压式进气道 ($M_{\infty} < 2.5$)



(b) 混合式进气道 ($M_{\infty} > 2.5$)

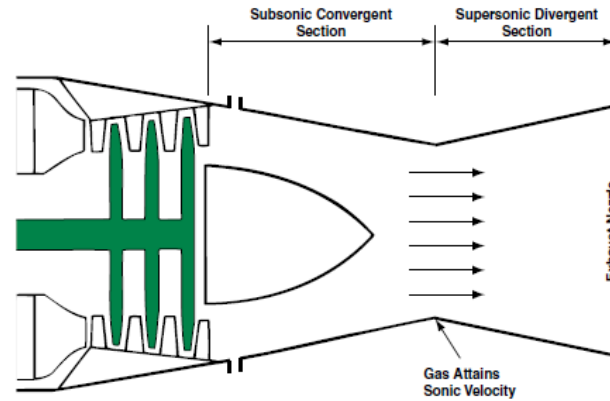
Super sonic air inlet

4.3 The jet engine exhaust

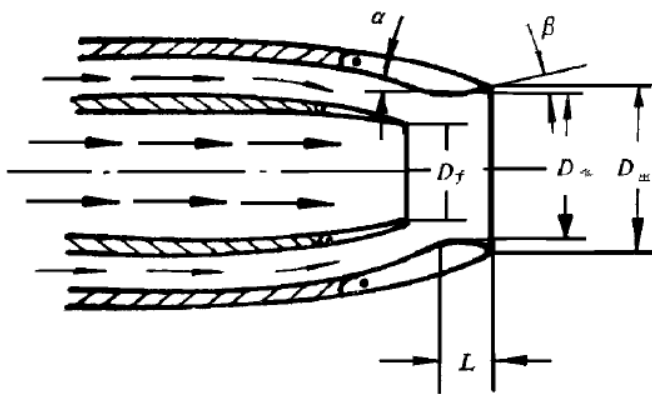


Convergent

Convergent nozzle



CD nozzle



Ejector nozzle



Iris nozzle



Vectored thrust nozzle

4.3 The jet engine after burner

- The device to boost the thrust
- Not fuel efficient

