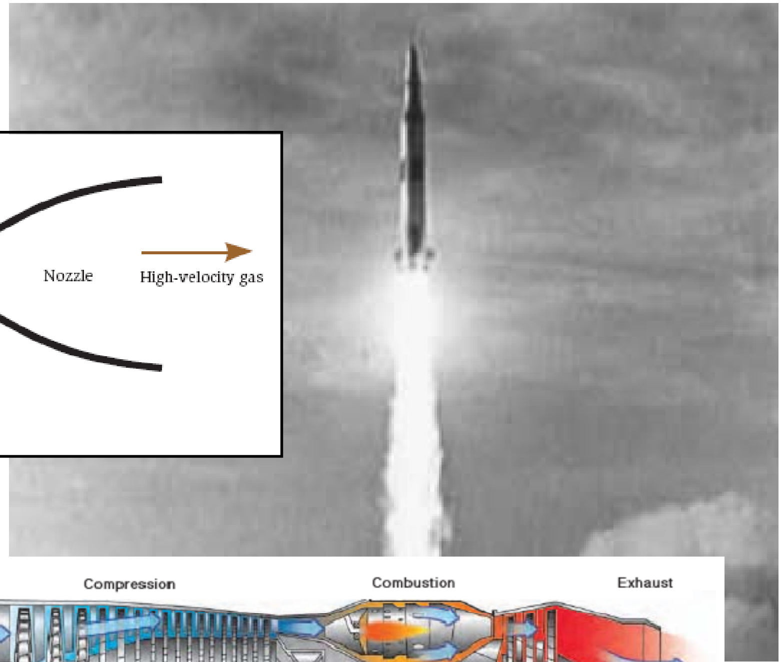
Cap.6 – Caratteristiche propulsive

- Razzi (Rockets)
- Ramjet
- Turbojet
- Turbofan
- Turboprop
- Motoelica



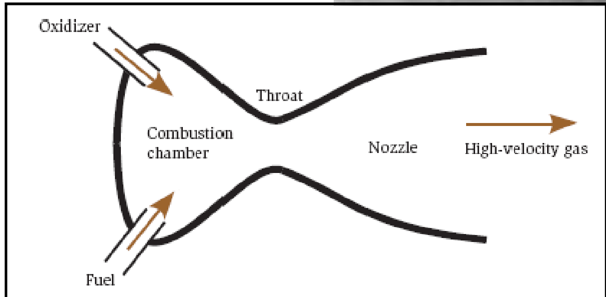
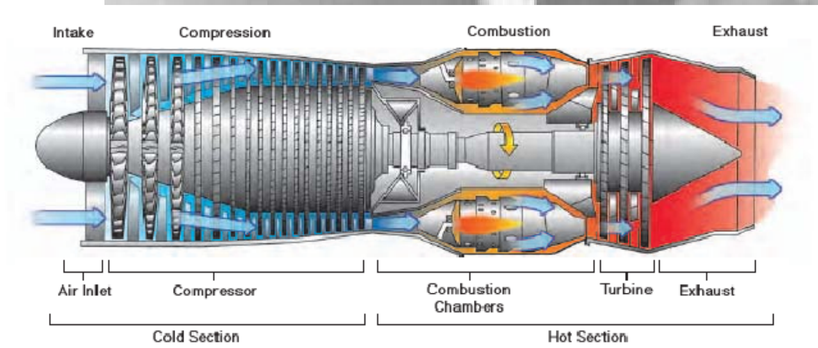
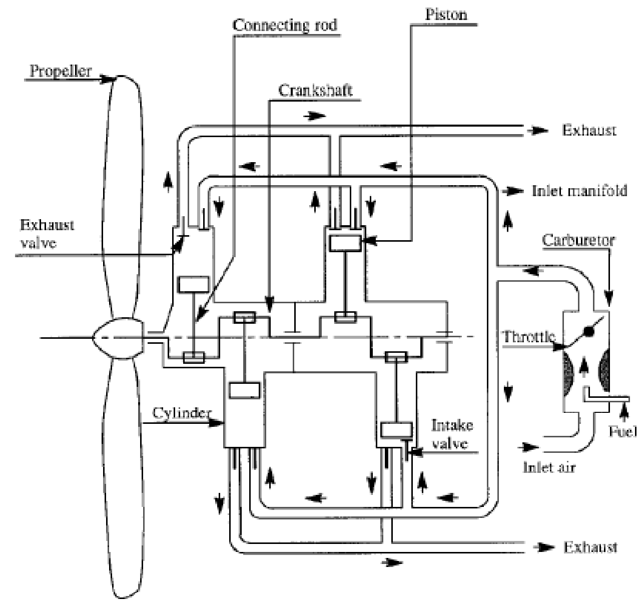


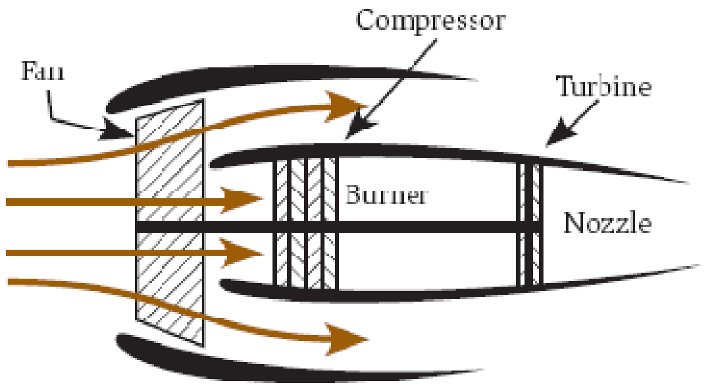
Fig. 5.1. Schematic of a rocket engine.





Note: modern engines tend to use fuel injection rather than carburetors

Figure 6.6 Typical Cross–section of a Four–cylinder Piston Engine



Cap.6 – Caratteristiche propulsive

- Razzi (Rockets) (o anche Endoreattori)

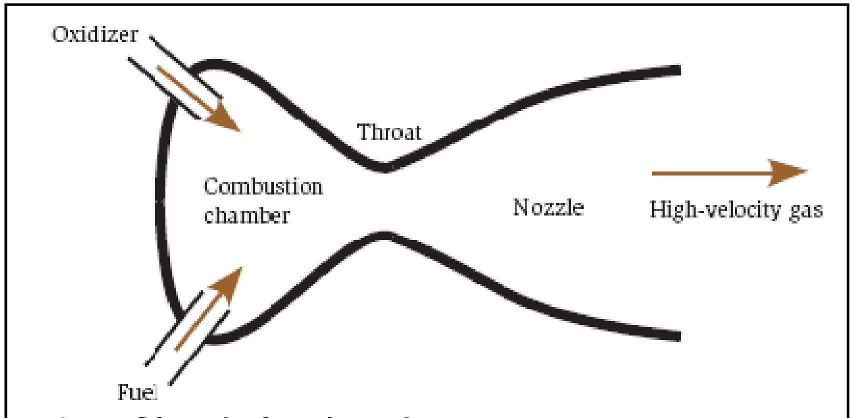
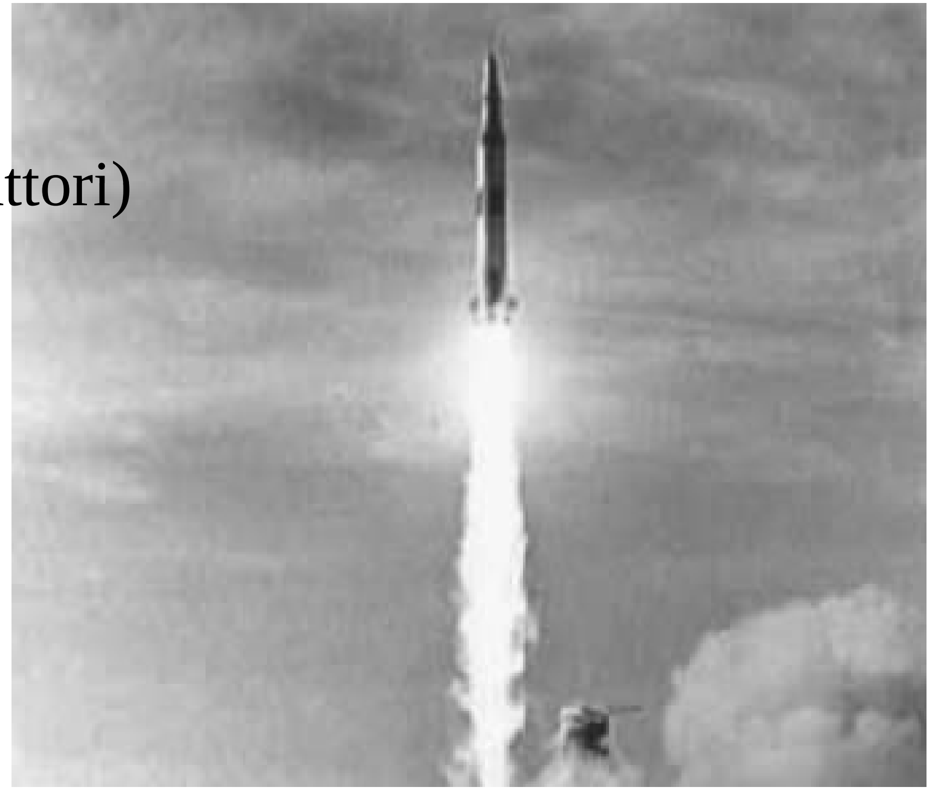
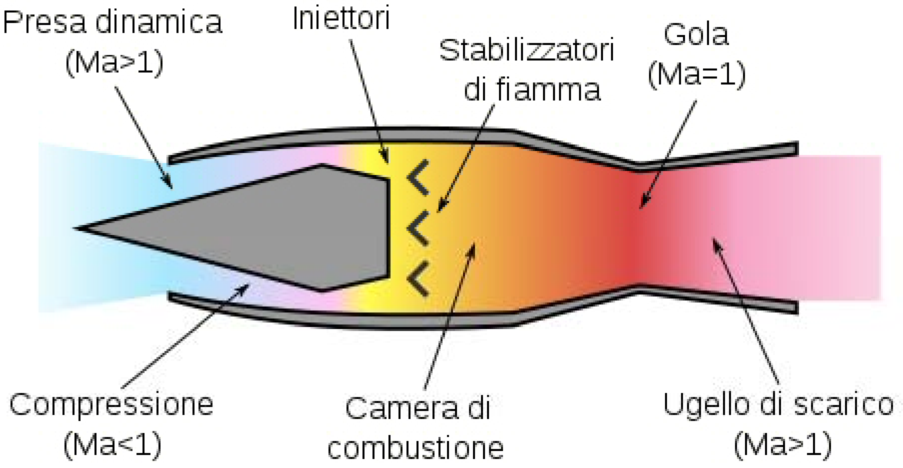


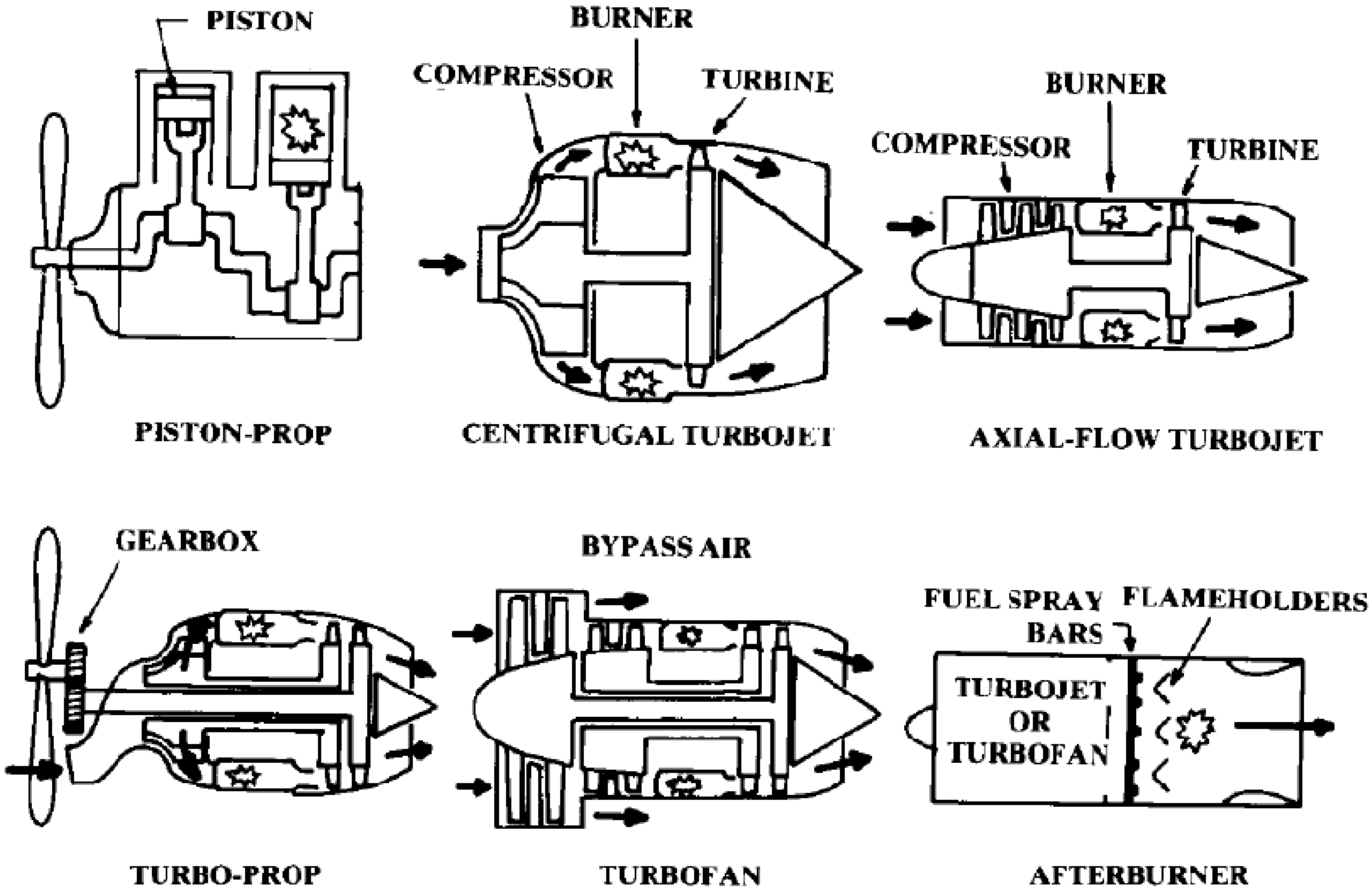
Fig. 5.1. Schematic of a rocket engine.



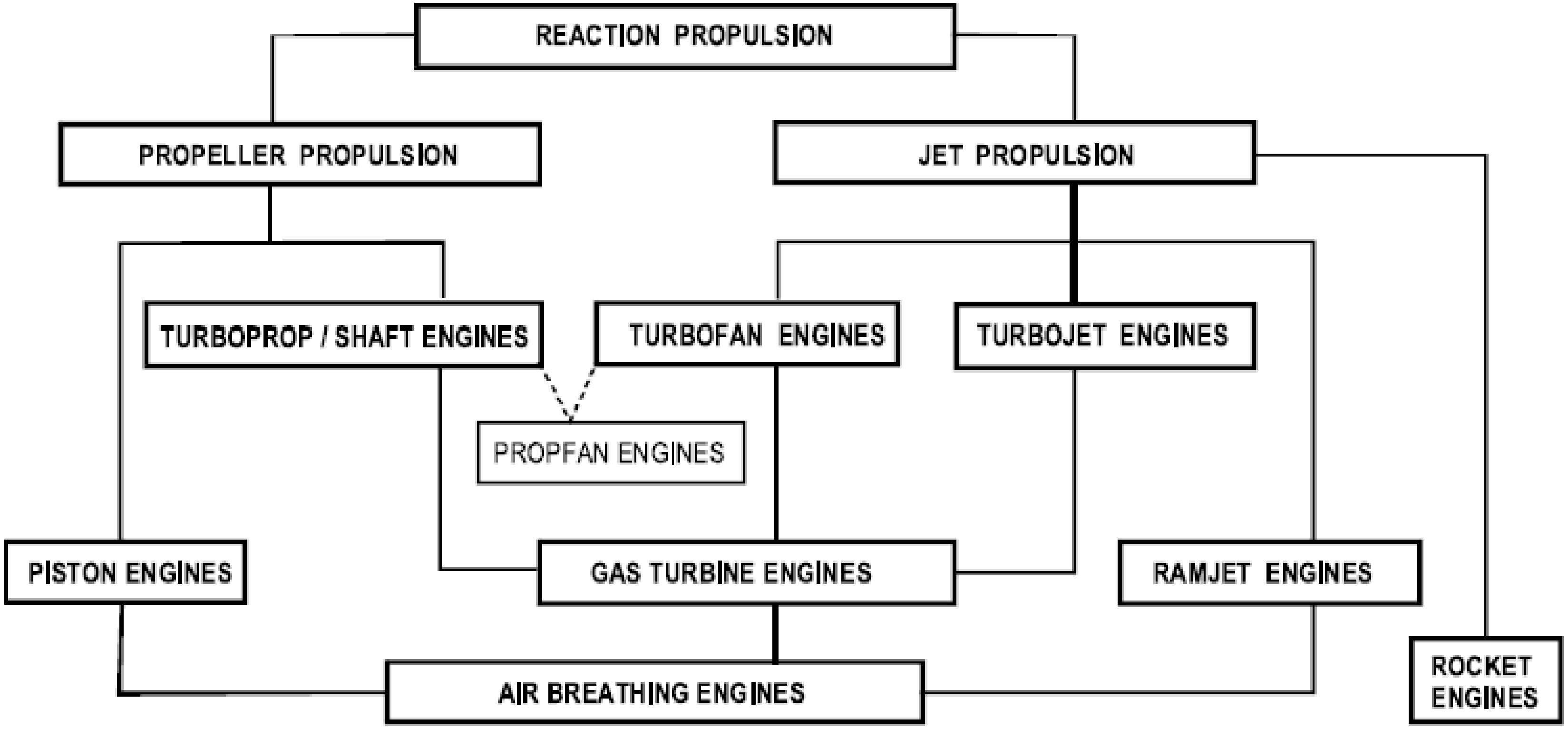
- Ramjet



Cap.6 – Caratteristiche propulsive

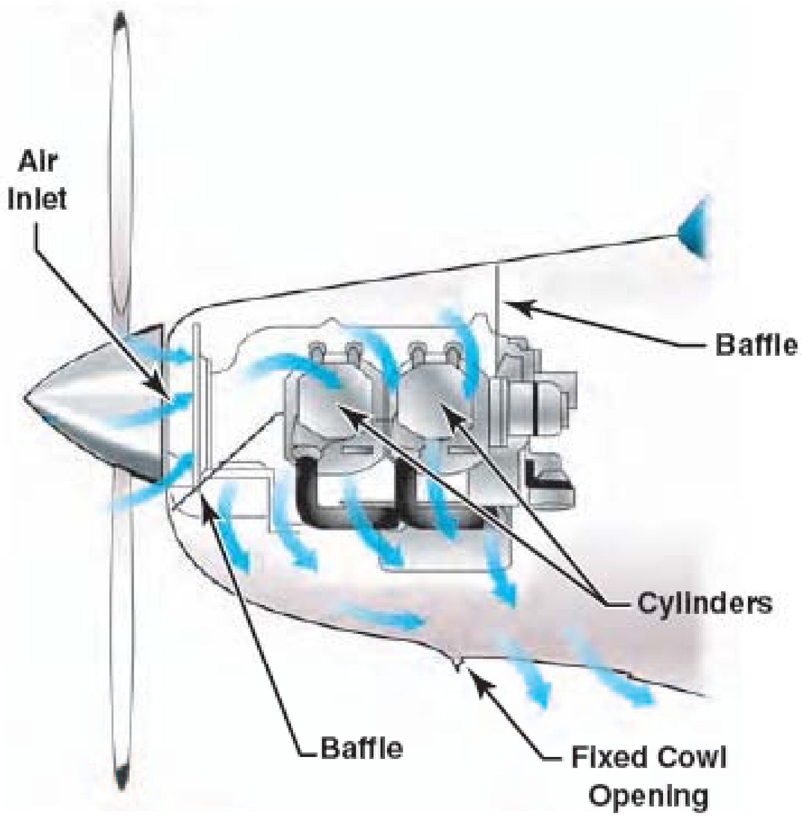


Cap.6 – Caratteristiche propulsive



Cap.6 – Caratteristiche propulsive

Motoelica



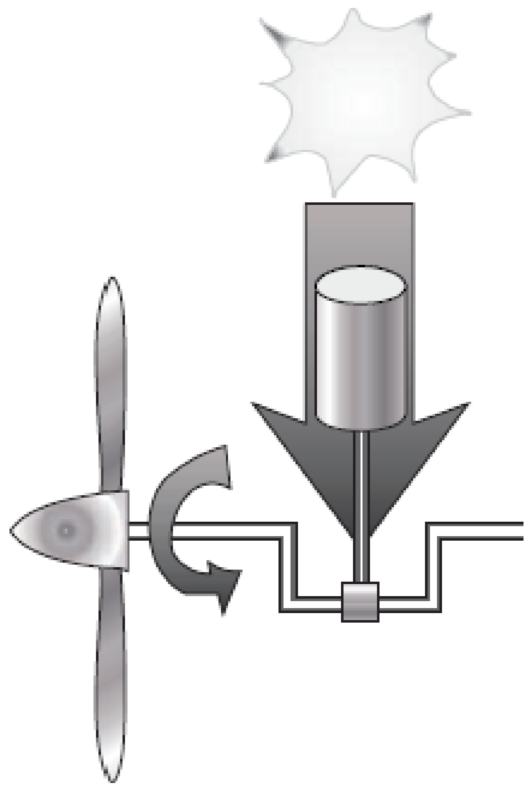


Fig. 5.7. How a piston engine converts chemical energy to propeller rotation.

Cap.6 – Caratteristiche propulsive

Motoelica

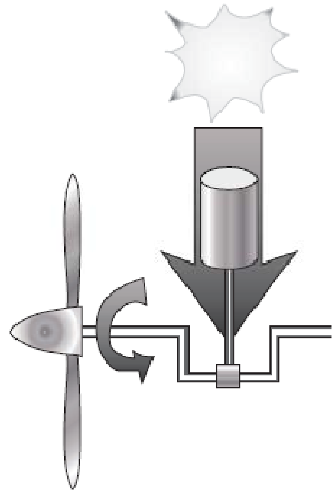
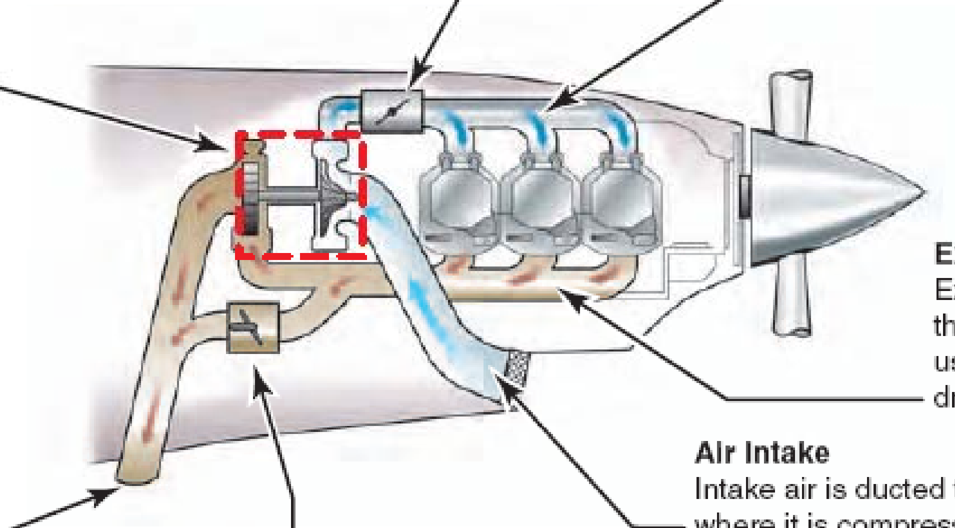
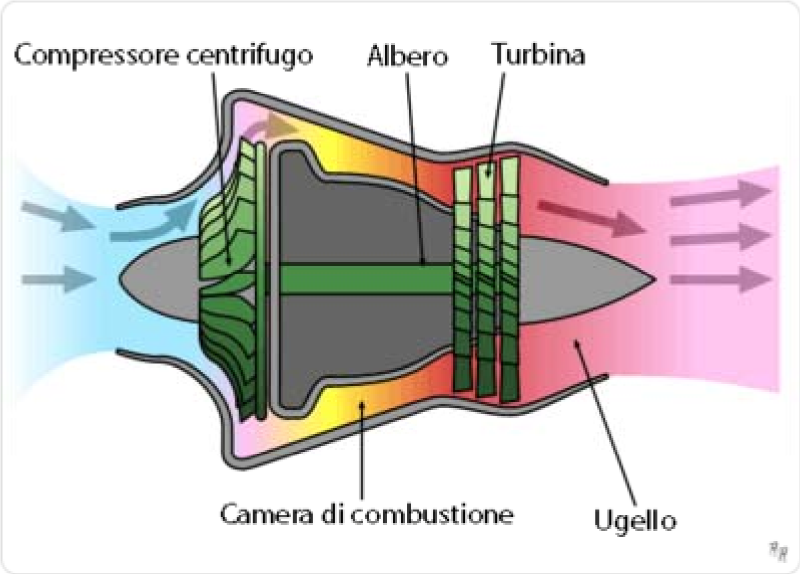


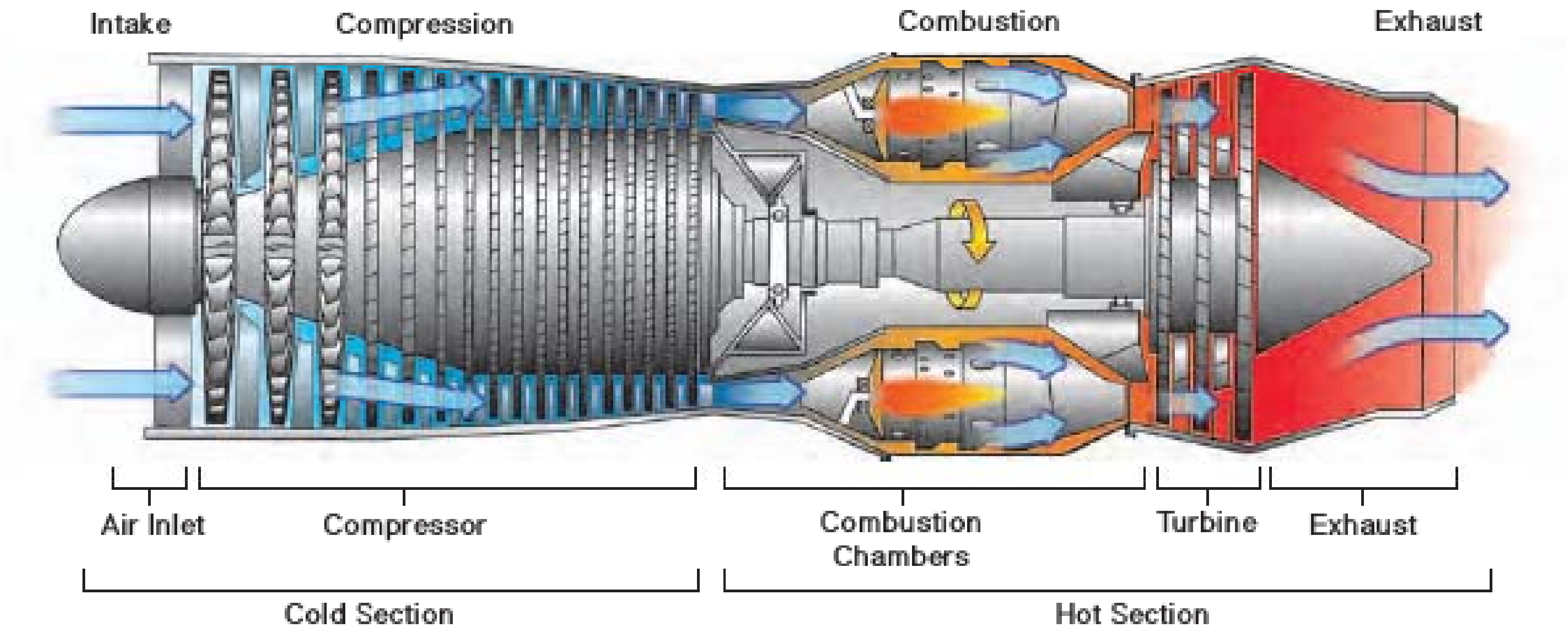
Fig. 5.7. How a piston engine converts chemical energy to propeller rotation.



Cap.6 – Caratteristiche propulsive

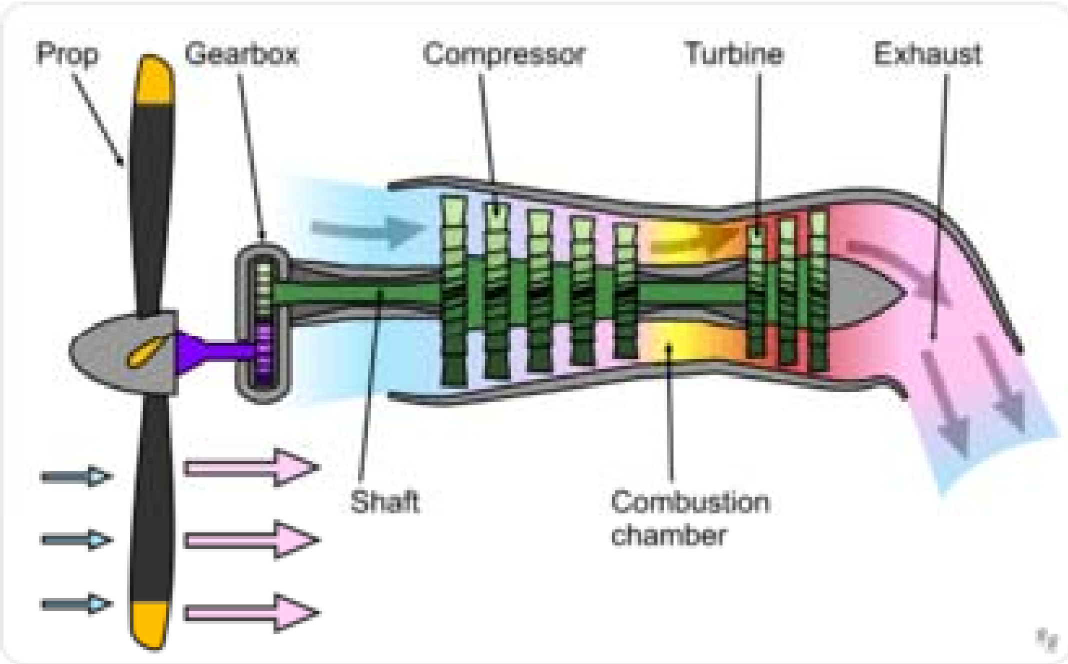
Turbogetto

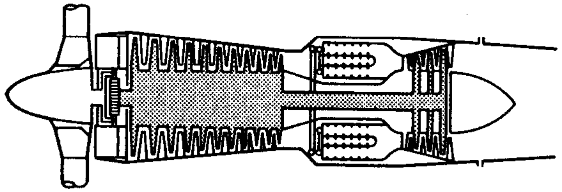




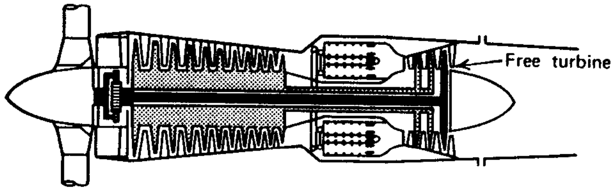
Cap.6 – Caratteristiche propulsive

Turboprop (tipo ATR42)





(d)

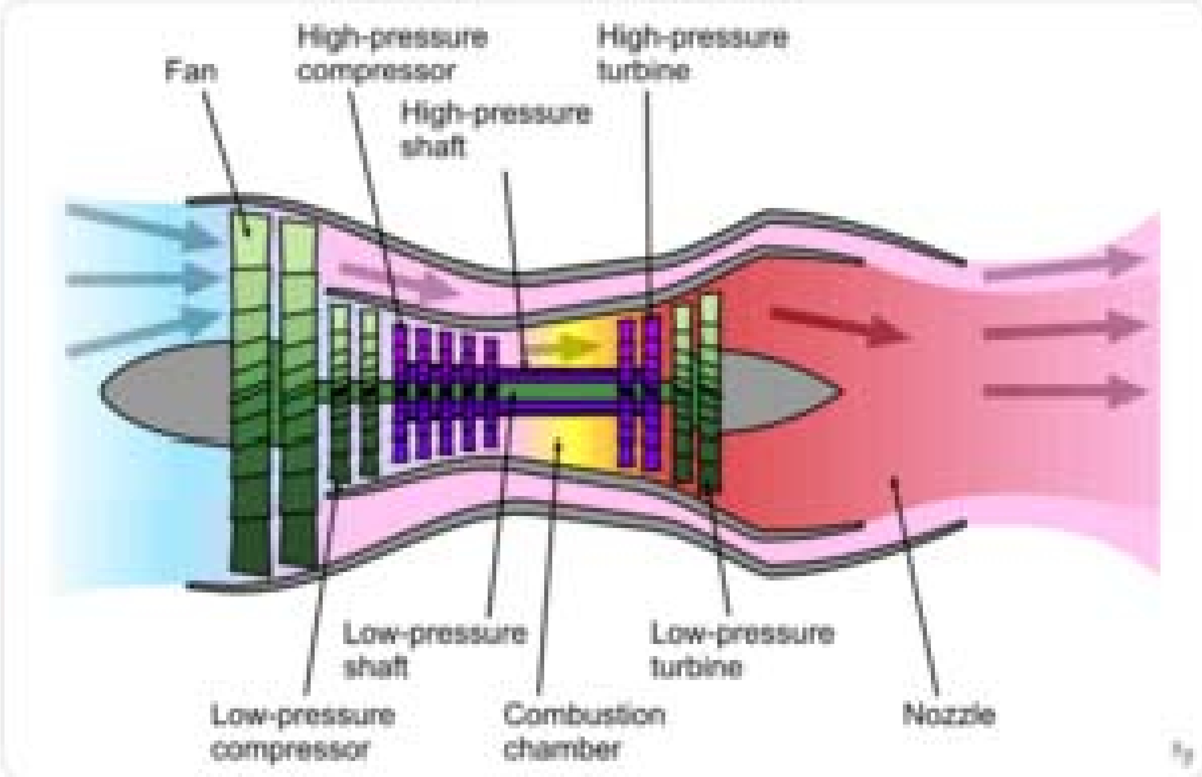


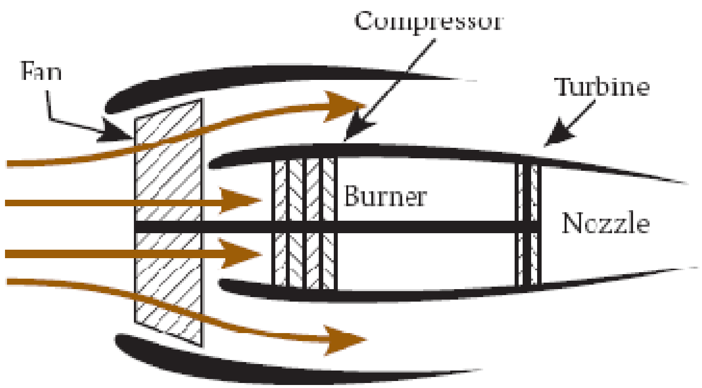
(e)

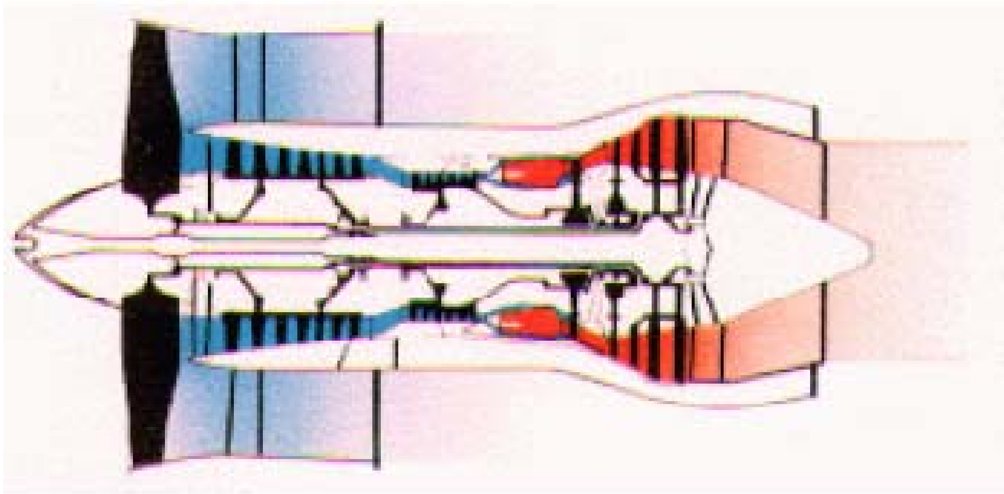
Cap.6 – Caratteristiche propulsive

<u>Turbofan</u>

BPR (By-Pass Ratio)



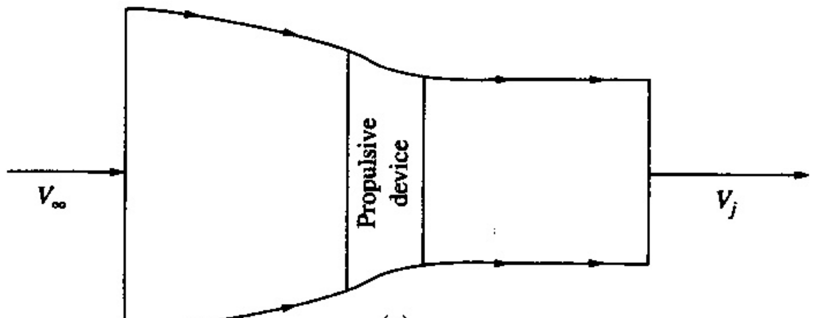




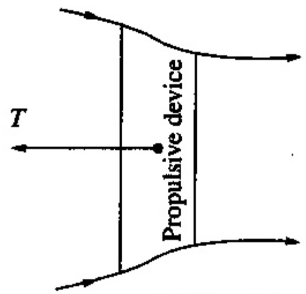
Cap.6 – Caratteristiche propulsive

Principio di funzionamento

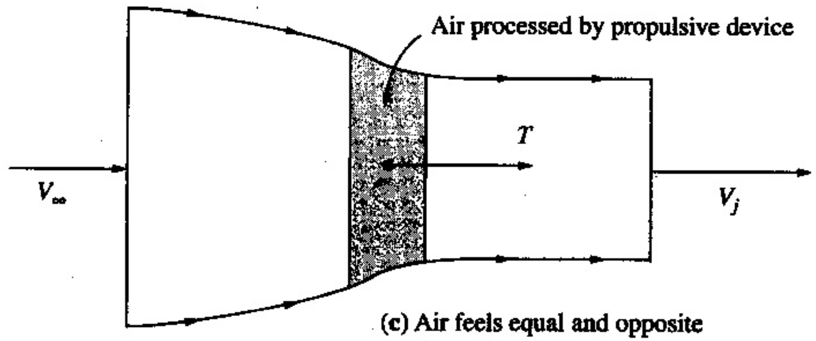
$$T = \dot{m}(V_j - V_\infty)$$



(a)



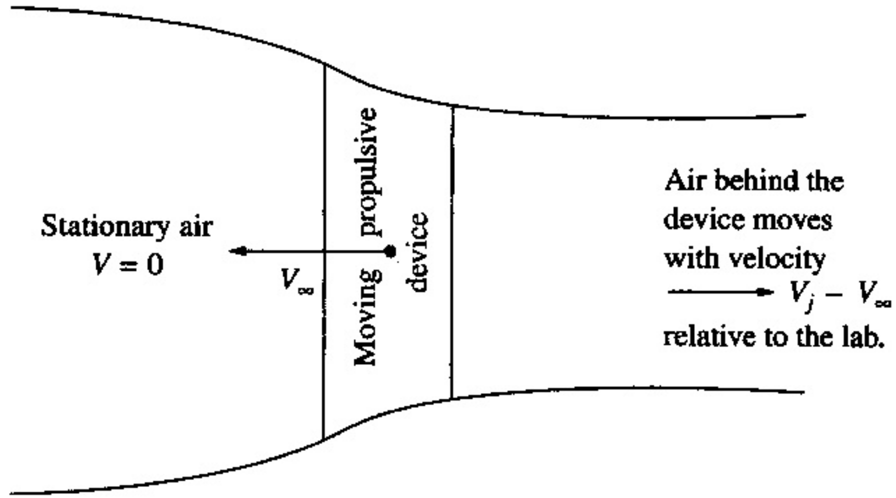
(b) Propulsive device produces thrust T acting to the left.



(c) Air feels equal and opposite force T acting to the right.

Cap.6 – Caratteristiche propulsive

Principio di funzionamento



Aria si muove a vel.

$$V_j - V_\infty$$

Energia cinetica per unità di massa

$$\frac{1}{2}(V_j - V_\infty)^2$$

<u>Quest'energia cinetica è interamente dissipata</u>

$$Potenza = forza \times velocità$$

Cap.6 – Caratteristiche propulsive

La *potenza utile*, chiamata *potenza disponibile*

$$\Pi_d = TV_\infty$$

Ma c'è anche una quantità di potenza dissipata (aria in uscita)

$$\frac{1}{2}\dot{m}(V_j - V_\infty)^2$$

=> *Potenza totale prodotta dal congegno propulsivo*

$$= TV_\infty + \frac{1}{2}\dot{m}(V_j - V_\infty)^2$$

$$\eta_j = \frac{potenza disponibile}{potenza totale prodotta}$$

Cap.6 – Caratteristiche propulsive

$$\eta_j = \frac{TV_\infty}{TV_\infty + \frac{1}{2}\dot{m}(V_j - V_\infty)^2}$$

$$\eta_j = \frac{\dot{m}(V_j - V_\infty)V_\infty}{\dot{m}(V_j - V_\infty)V_\infty + \frac{1}{2}\dot{m}(V_j - V_\infty)^2}$$

Dividendo num e denom. per $\dot{m}(V_j - V_\infty)V_\infty$

$$\boxed{\eta_j = \frac{1}{1 + \frac{1}{2}(V_j - V_\infty)/V_\infty} = \frac{1}{\frac{1}{2}(1 + \frac{V_j}{V_\infty})}}$$

$$\boxed{\eta_j = \frac{2}{1 + \frac{V_j}{V_\infty}}}$$

EFFICIENZA PROPULSIVA (Froude Efficiency)

Cap.6 – Caratteristiche propulsive

Possiamo definire anche la spinta specifica:

$$\frac{T}{\dot{m}} = \left(V_j - V_\infty\right)$$

Spinta prodotta per unità di portata di massa [N/(kg/sec)] o anche dimensione di una vel. [m/s]

$$\boxed{\eta_j = \frac{2}{2 + (V_j - V_\infty)/V_\infty} = \frac{2}{2 + \frac{T}{\dot{m}} V_\infty} = \frac{2}{2 + C_j}}$$

Abbiamo introdotto il "jet velocity coeff."

$$\boxed{C_j = \frac{T}{\dot{m}} V_\infty = \frac{V_j}{V_\infty} - 1}$$

$$\boxed{\eta_j = \frac{2}{1 + \frac{V_j}{V_\infty}}} \qquad \boxed{\eta_j = \frac{2}{2 + C_j}}$$

Cap.6 – Caratteristiche propulsive

$$\boxed{C_j = \frac{T}{\dot{m}} V_\infty = \frac{V_j}{V_\infty} - 1}$$ *jet velocity coeff.*

$$\boxed{\eta_j = \frac{2}{1 + \frac{V_j}{V_\infty}}}$$

$$\boxed{\eta_j = \frac{2}{2 + C_j}}$$

Propulsive efficiency

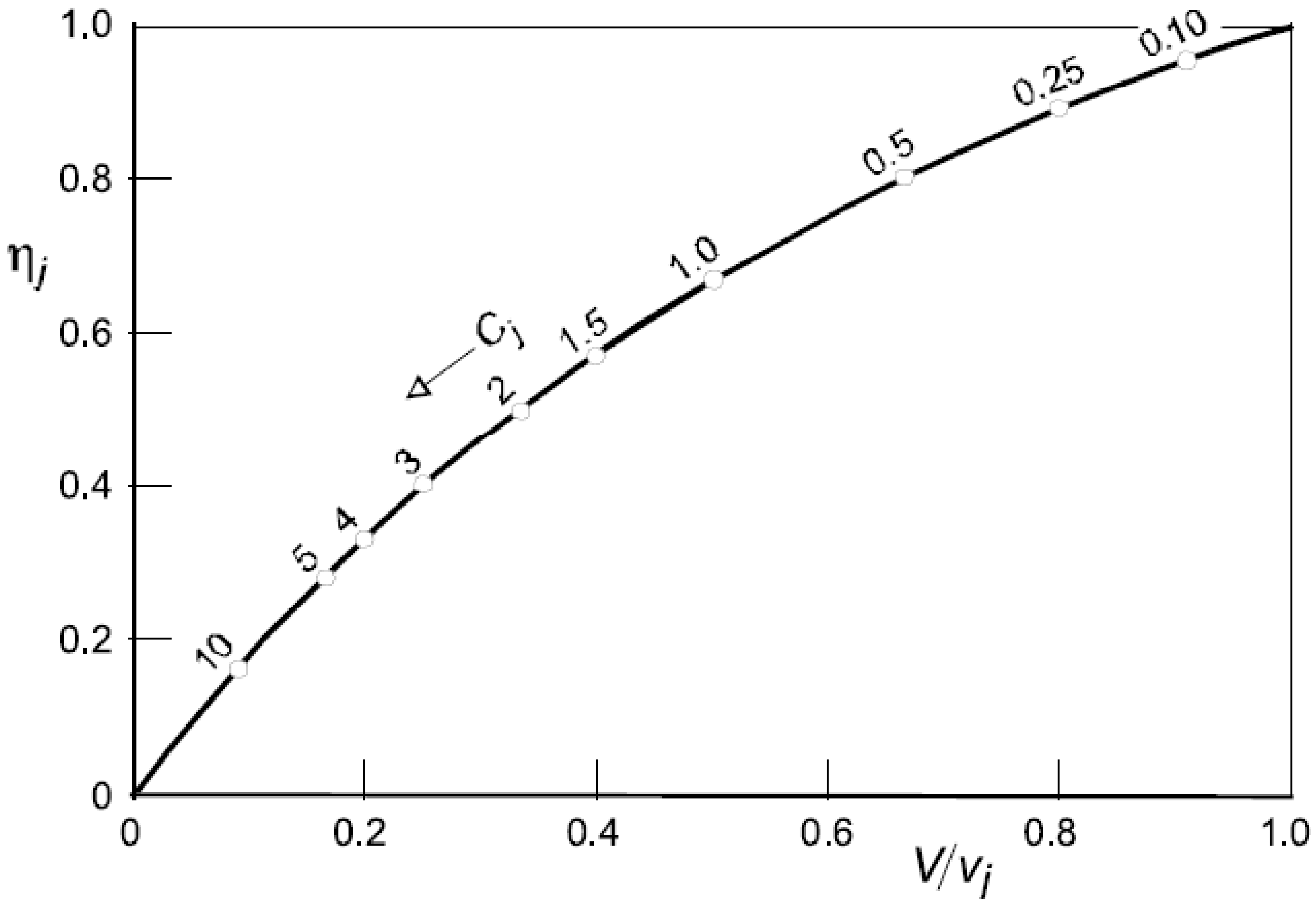


Table 5.1 Example of *propulsive efficiency* data.

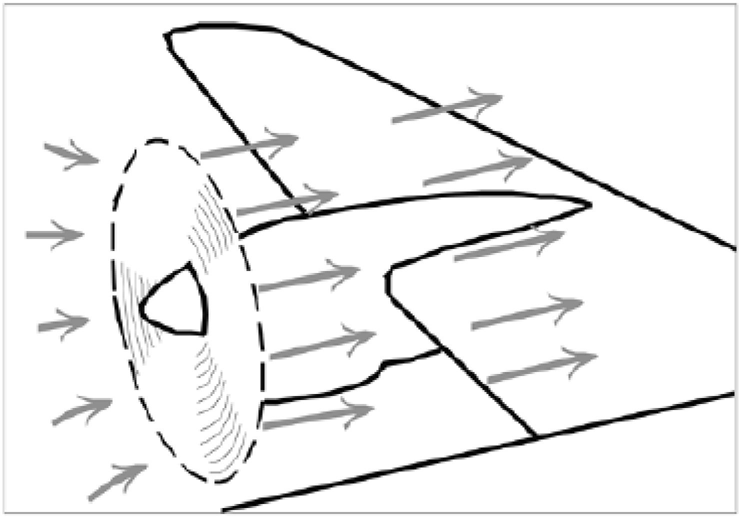
Type of propulsion	*Altitude* km	*Flight speed* V, m/s (Mach no.)	*Jet velocity* v_j, m/s	*Speed ratio* v_j/V	*Specific thrust* $T/\dot{m}_a$, m/s	*Jet coefficient* C_j	*Propulsive efficiency* η_j
propeller	6	150	160 (0.47)	1.07	10	0.067	0.97
subsonic jet engine	9	250 (0.82)	750	3.00	500	2.00	0.50
low BPR turbofan	9	250 (0.82)	582*	2.33	332	1.33	0.60
high BPR turbofan	9	250 (0.82)	418*	1.67	168	0.67	0.75
supersonic jet engine	16	600 (2.03)	1,000	1.67	400	0.67	0.75

* weighted average of primary and secondary airflow

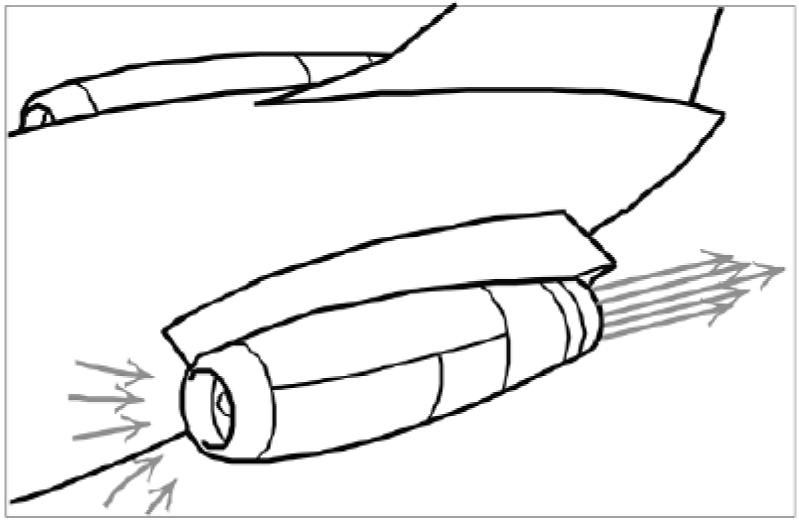
Cap.6 – Caratteristiche propulsive

L’efficienza propulsiva dell’elica è maggiore di quella del getto.

- Elica: piccolo incremento di velocità ad una grossa massa aria
- Jet: grande incremento di velocità ad una piccola quantità di aria



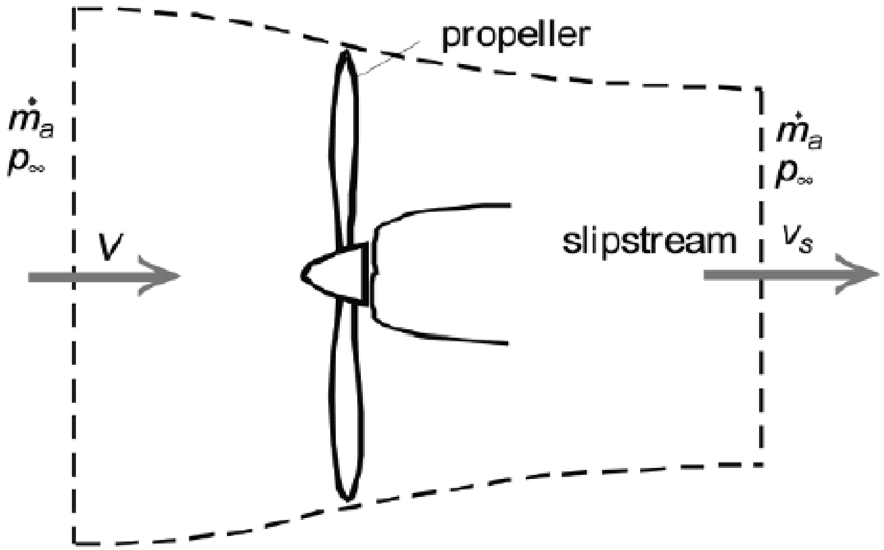
(a) A propeller imparts a small velocity increment to a large mass of air



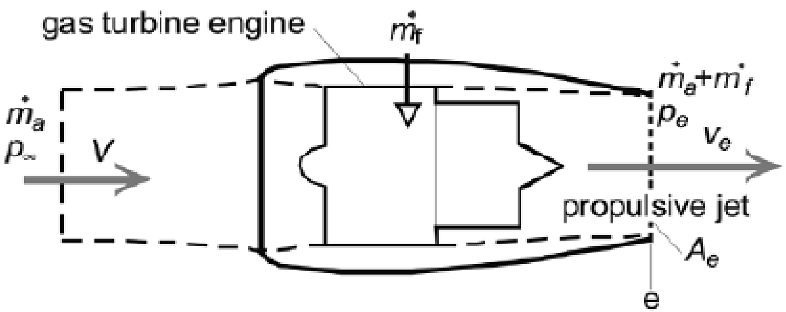
(b) A turbojet engine imparts a large velocity increment to a (relatively) small amount of air

Cap.6 – Caratteristiche propulsive

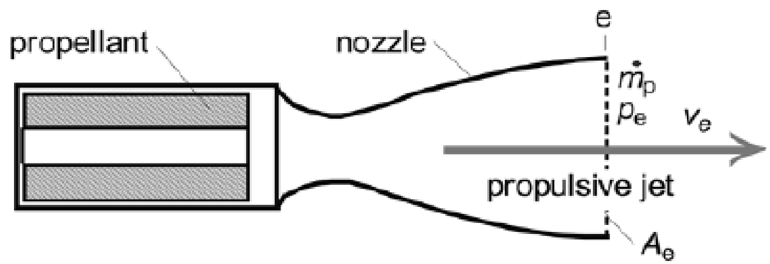
Principio di funzionamento



(a) Airflow through a propeller



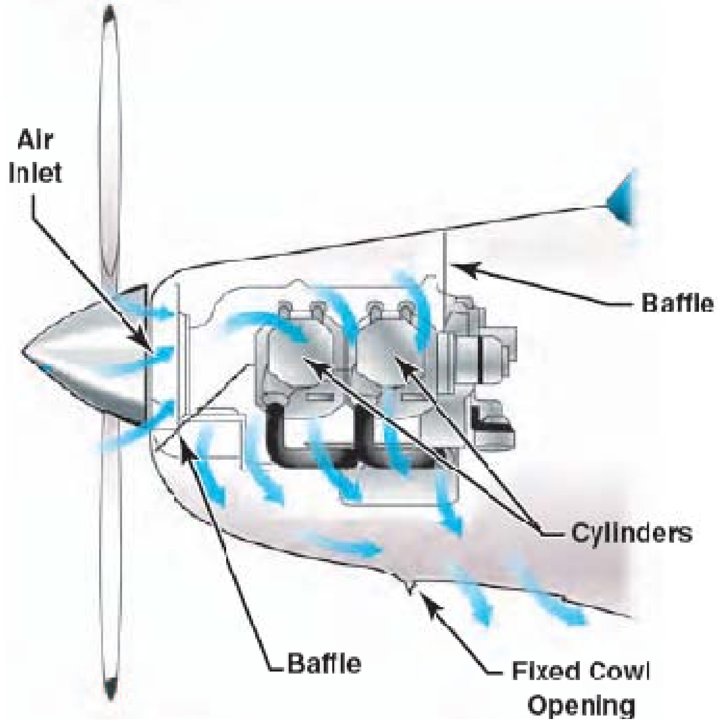
(b) Airflow through a jet engine

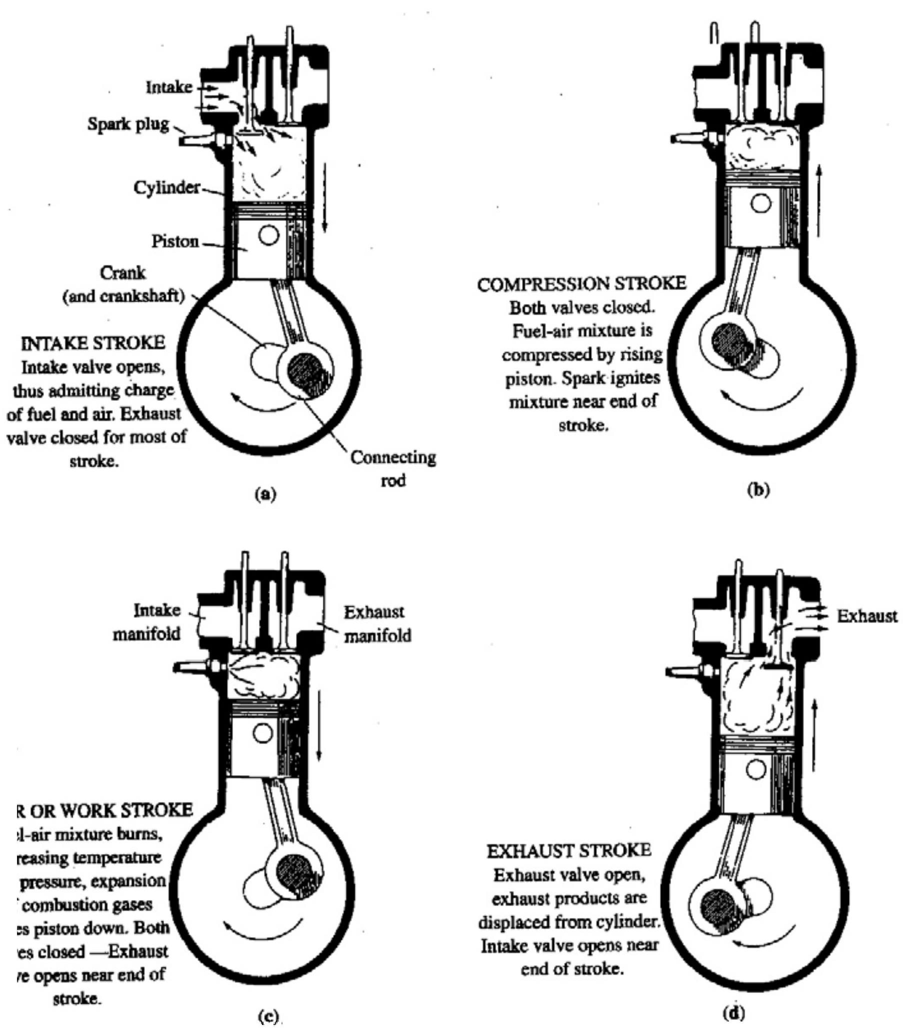


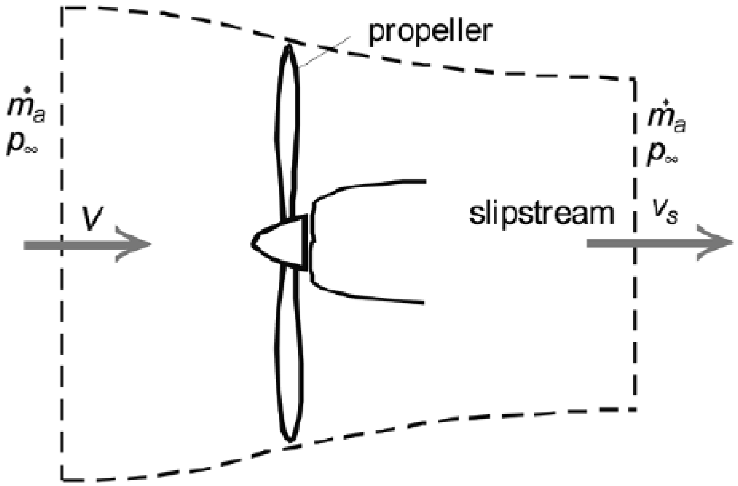
(c) Principle of a solid rocket engine

Cap.6 – Caratteristiche propulsive

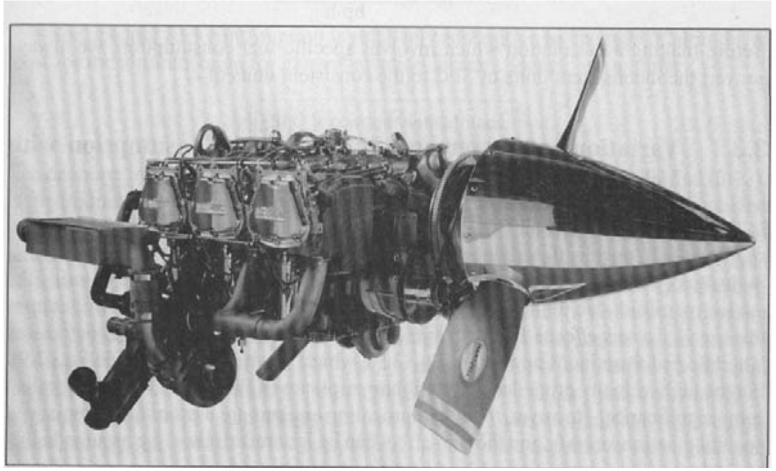
MOTOELICA







Cap.6 – Caratteristiche propulsive MOTOELICA



$$\Pi_a \propto d \cdot p_e \cdot RPM$$

- la cilindrata con *d* (dall'inglese *displacement*)
- *pressione media efficace* p_e

<u>Consumo specifico</u>

$$c = \frac{pesodicombustibileconsumatoperdatoincrementoditempo}{(potenzasviluppata)(incrementoditempo)}$$

$$[c] = \frac{lb}{(ft \cdot lb/s)(s)} \qquad [c] = \frac{N}{W \cdot s}$$

$$SFC = \frac{lb}{hp \cdot h}$$

Unità ingegneristiche

valore tipico 0.40-0.50 [lb/(hp h)].

Il che vuol dire che un motore da 100 hp in funzionamento al massimo della potenza per un’ora di volo consuma circa 50 lb di combustibile (cioè circa 25 Kg di combustibile). Teniamo anche presente che il peso specifico del combustibile è circa 0.70 Kg/l , quindi un serbatoio da 100 l di combustibile è capace di trasportare 70 Kg di combustibile.

Cap.6 – Caratteristiche propulsive MOTOELICA

Variazione di potenza e SFC con vel e quota

- Π_a è ragionevolmente costante con la velocità
- SFC è ragionevolmente costante con la velocità

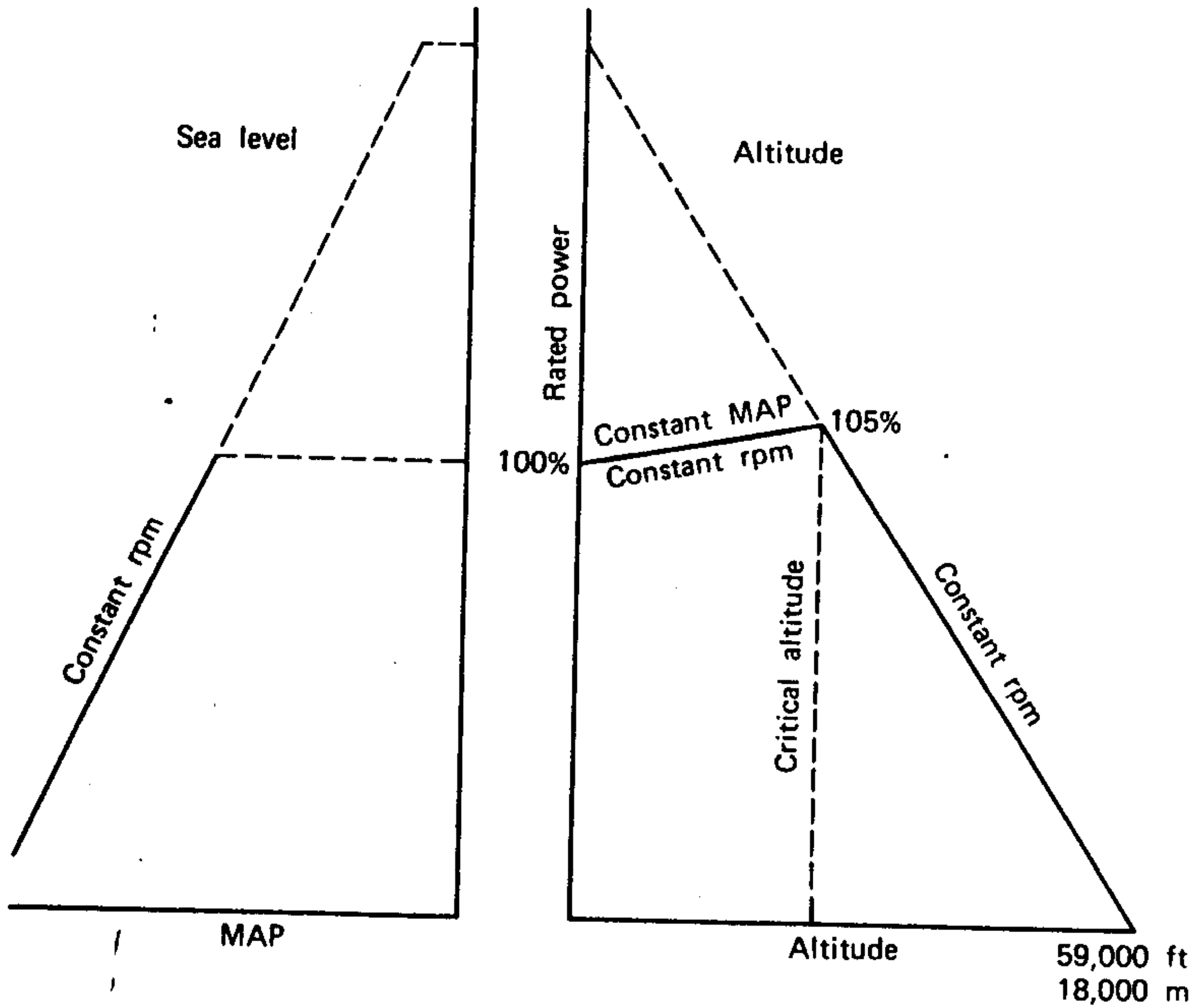
Negli Stati Uniti i due principali produttori di motori alternativi aerei sono Teledyne Continental e Textron Lycoming. I cavalli vapore a livello del mare per questi motori generalmente variano da 75 a 300 hp. Per questi motori un tipico valore di SFC è 0.4lb di carburante consumate per cavallo vapore per ora.

<u>Effetto quota</u>

$$\frac{\Pi_a}{\Pi_{a0}} = \frac{\rho}{\rho_0} \qquad \text{oppure} \qquad \frac{\Pi_a}{\Pi_{a0}} = 1.132\frac{\rho}{\rho_0} - 0.132$$

Cap.6 – Caratteristiche propulsive MOTOELICA

Motori Supercharged (turbocompressi)

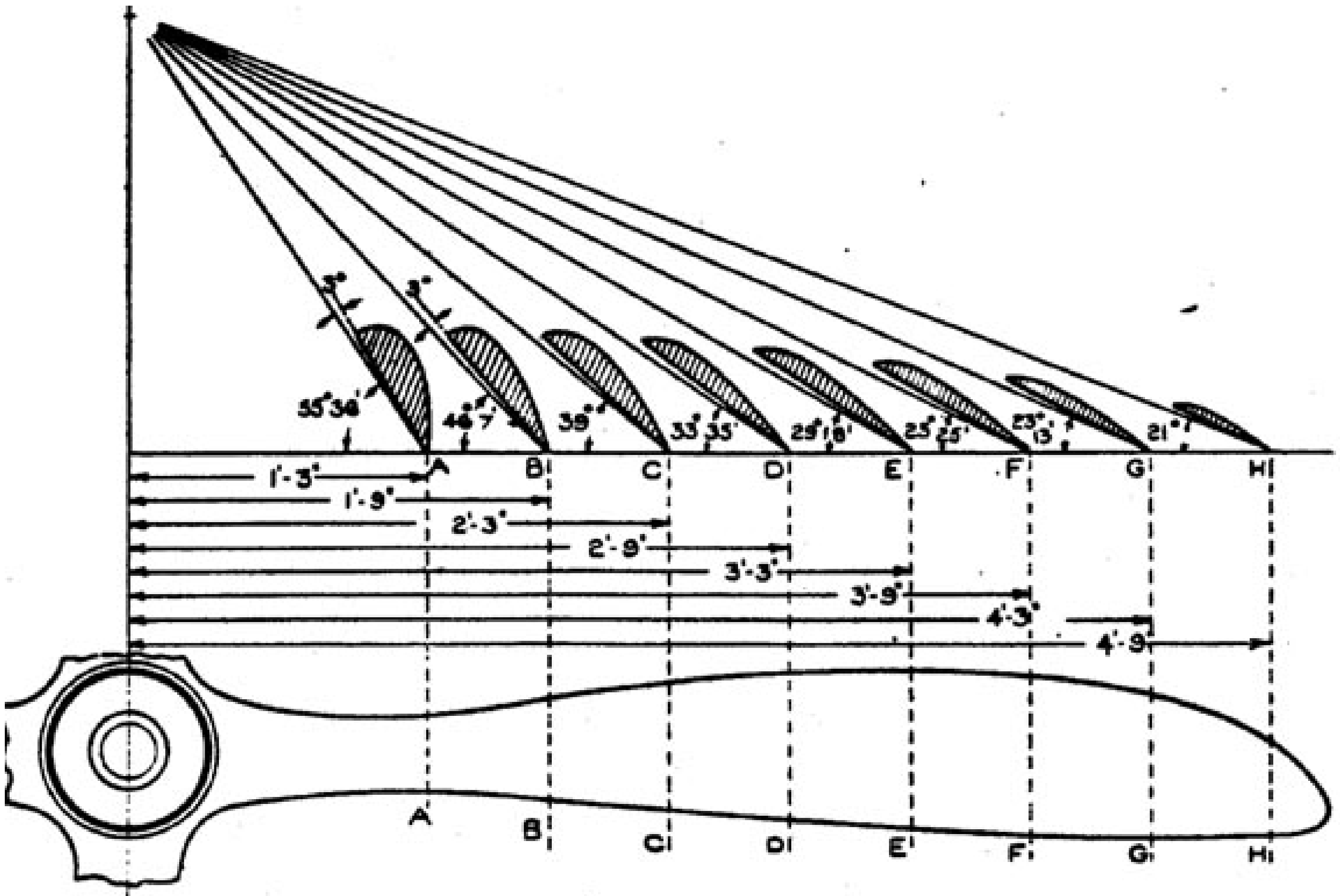


Cap.6 – Caratteristiche propulsive MOTOELICA

$$\Pi a = \Pi a_o \, \sigma \;\; \varphi$$

Quindi effetto della quota e del grado di ammissione

Cap.6 – Caratteristiche propulsive ELICHE

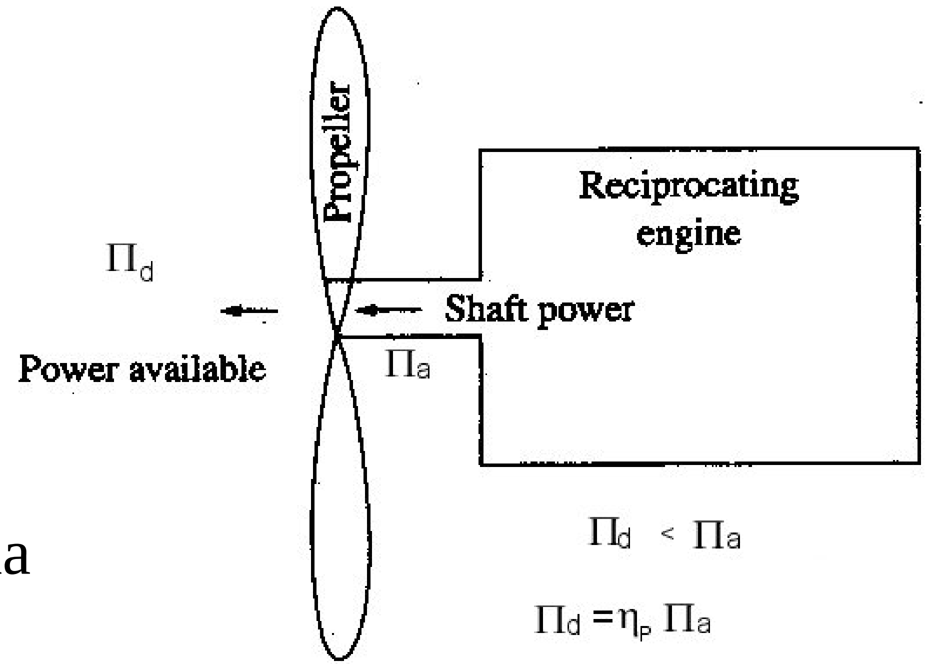


PLAN OF BLADE

FIG. 219.—Lay-out of an Airscrew.

Cap.6 – Caratteristiche propulsive ELICHE

$$\Pi_d = \eta_{pr}\Pi_a$$



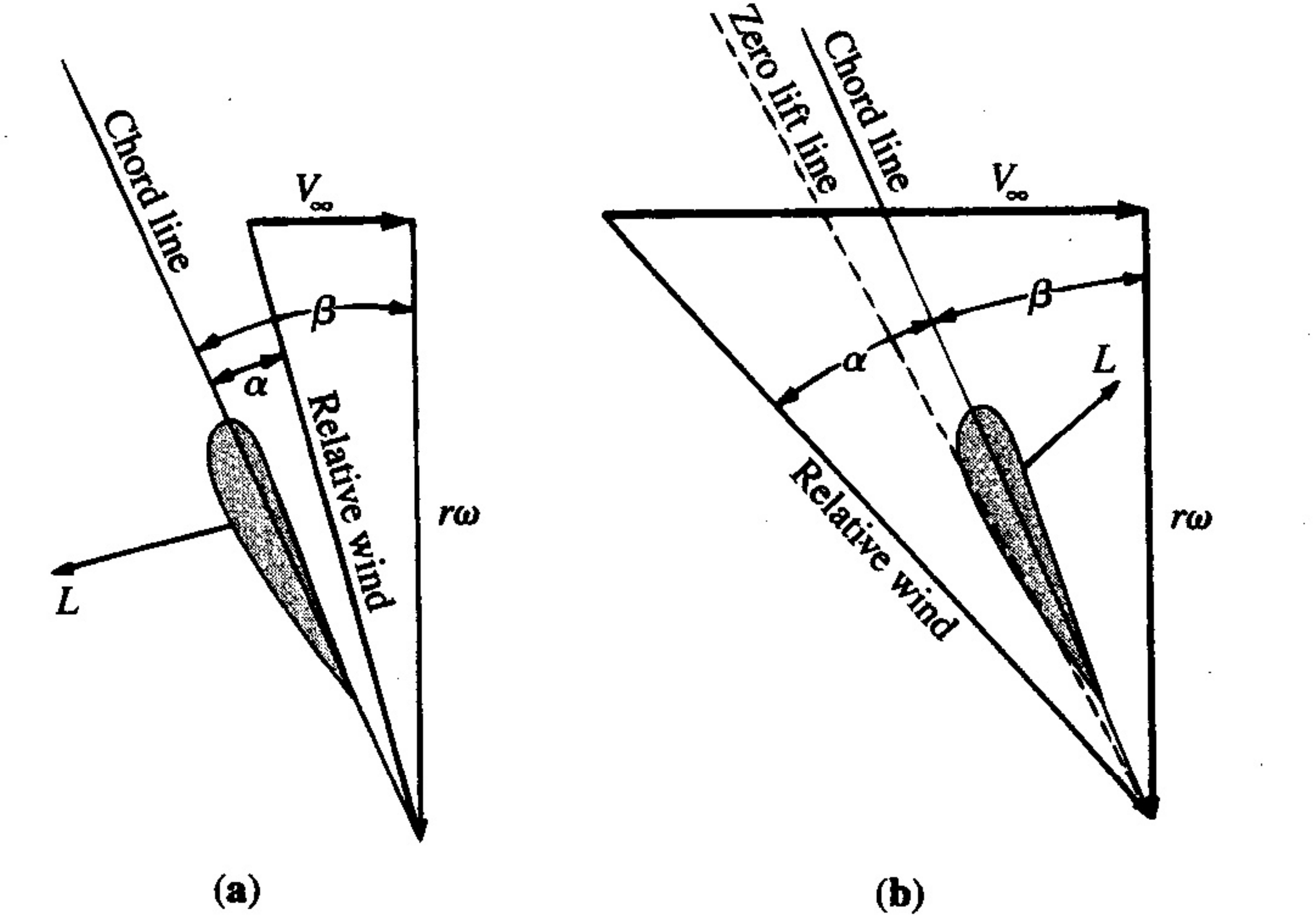
Il rendimento dell’elica è una funzione del *rapporto di avanzamento J* definito come

$$J = \frac{V_\infty}{ND}$$

Cap.6 – Caratteristiche propulsive ELICHE

$$(r\omega)_{tip} = \pi N D$$

$$\frac{V_\infty}{r\omega} = \frac{V_\infty}{r(2\pi N)}$$ (angolo vel locale) $$\left(\frac{V_\infty}{r\omega}\right)_{tip} = \frac{V_\infty}{(D/2)(2\pi N)} = \frac{V_\infty}{\pi N D} = \frac{J}{\pi}$$



Cap.6 – Caratteristiche propulsive ELICHE

$$(r\omega)_{tip} = \pi N D$$

$$\frac{V_\infty}{r\omega} = \frac{V_\infty}{r(2\pi N)} \quad \text{(angolo vel locale)} \quad \left(\frac{V_\infty}{r\omega}\right)_{tip} = \frac{V_\infty}{(D/2)(2\pi N)} = \frac{V_\infty}{\pi N D} = \frac{J}{\pi}$$

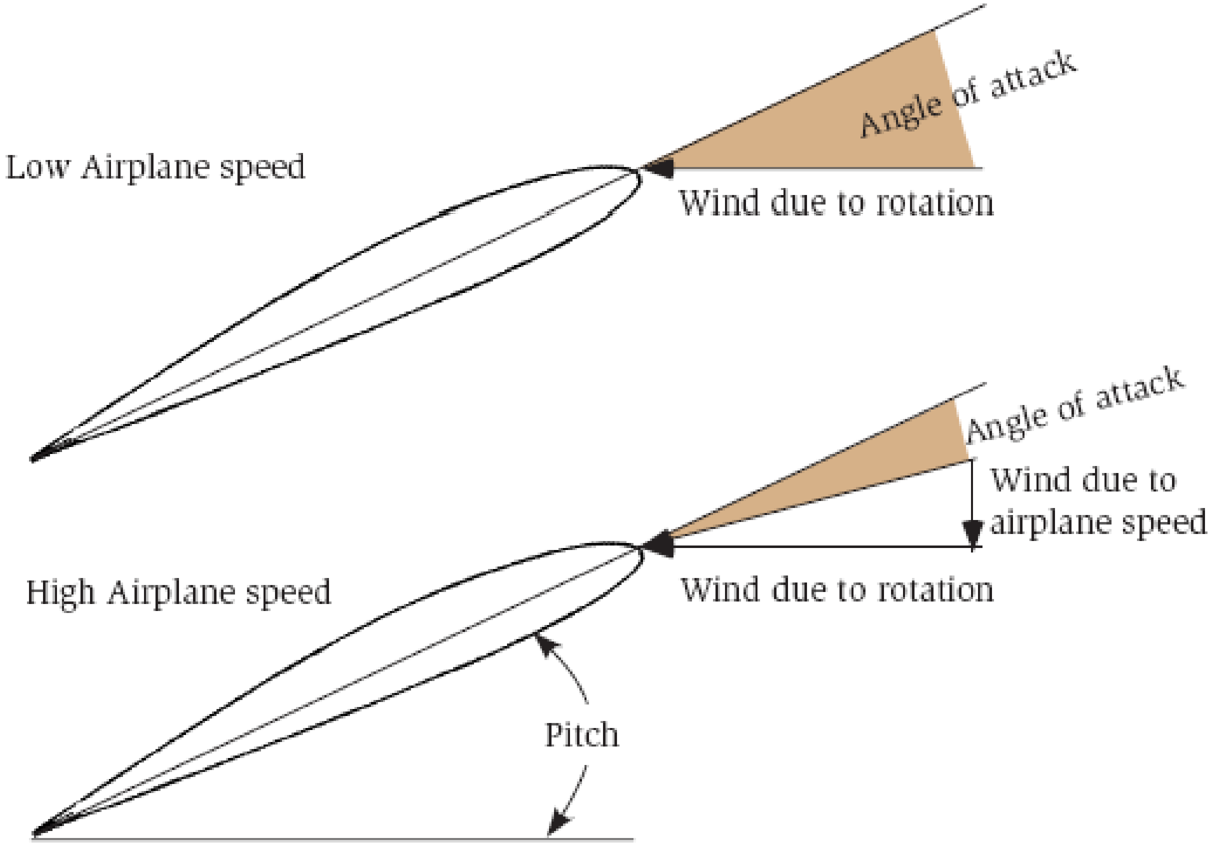
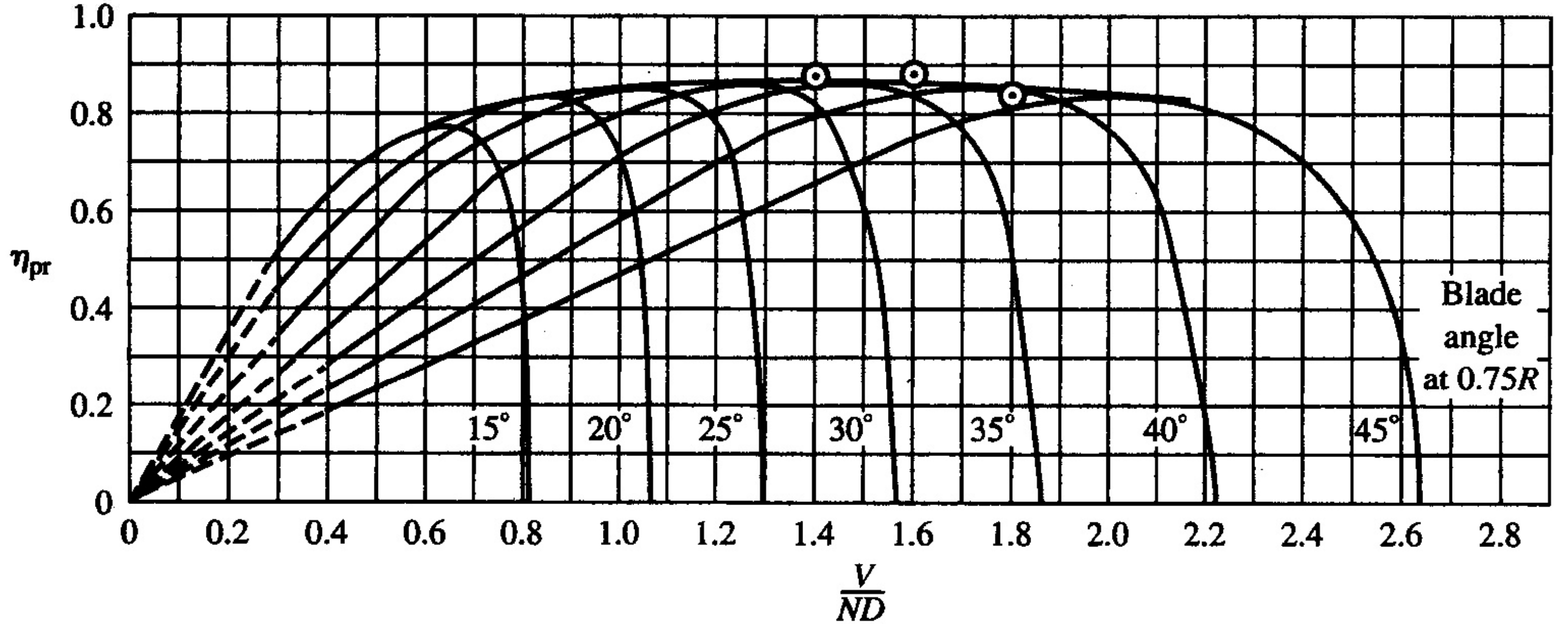
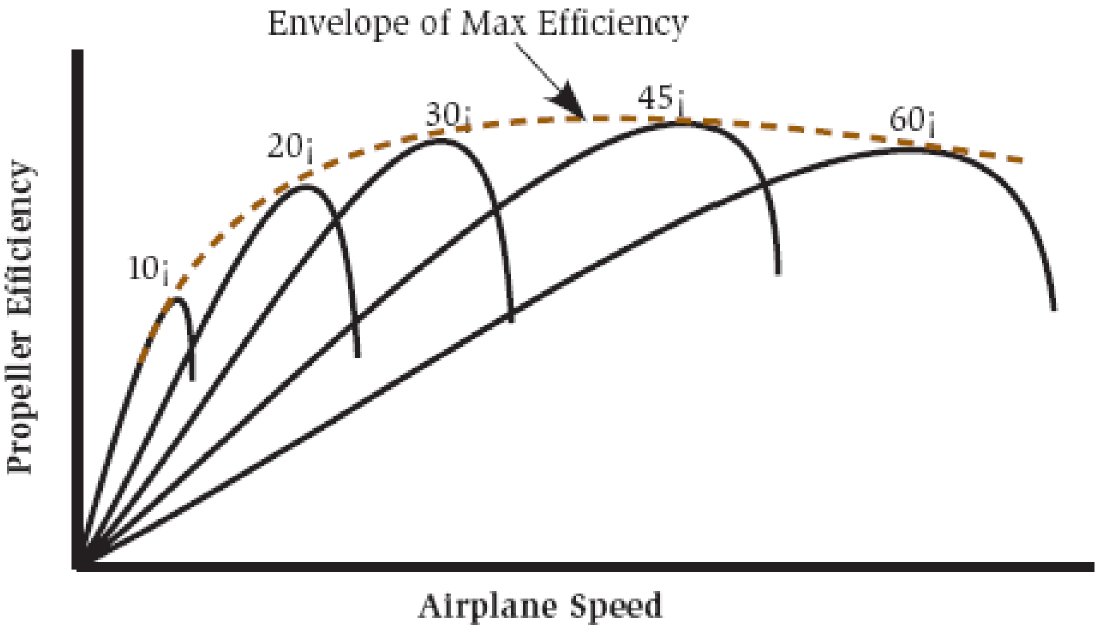


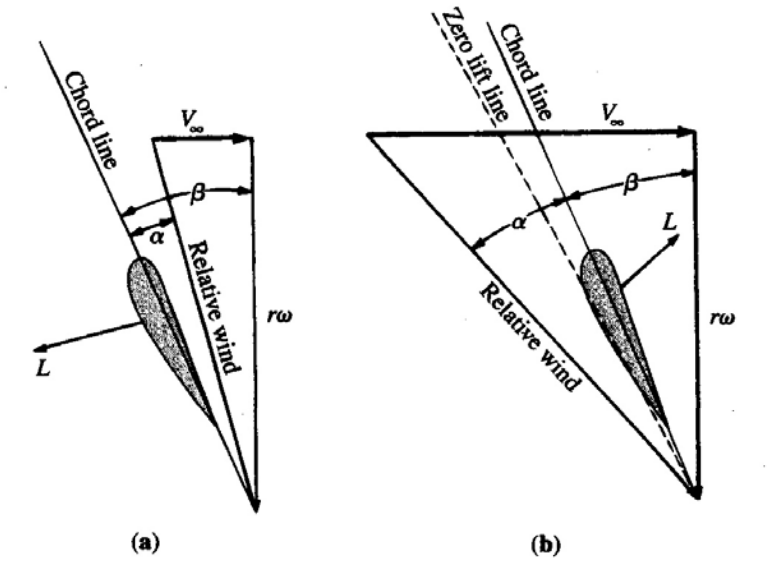
Fig. 5.5. Angle of attack of a rotating propeller.

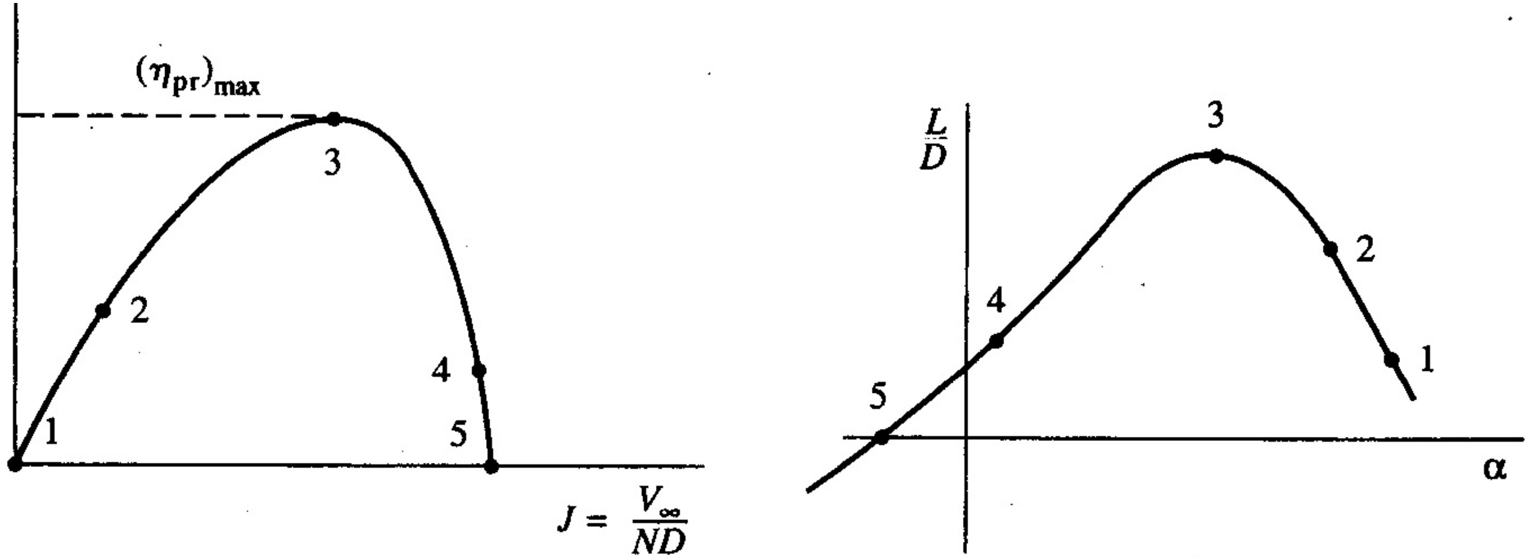
Cap.6 – Caratteristiche propulsive ELICHE





Cap.6 – Caratteristiche propulsive ELICHE

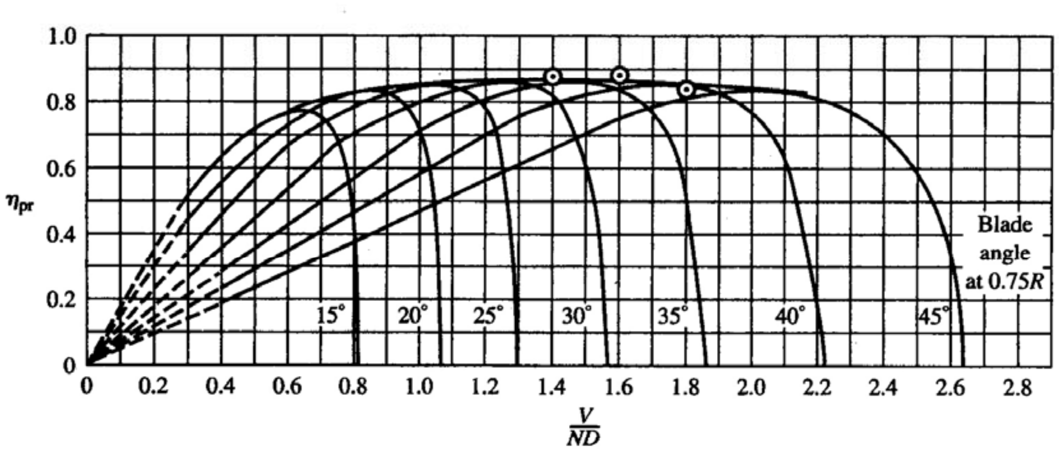


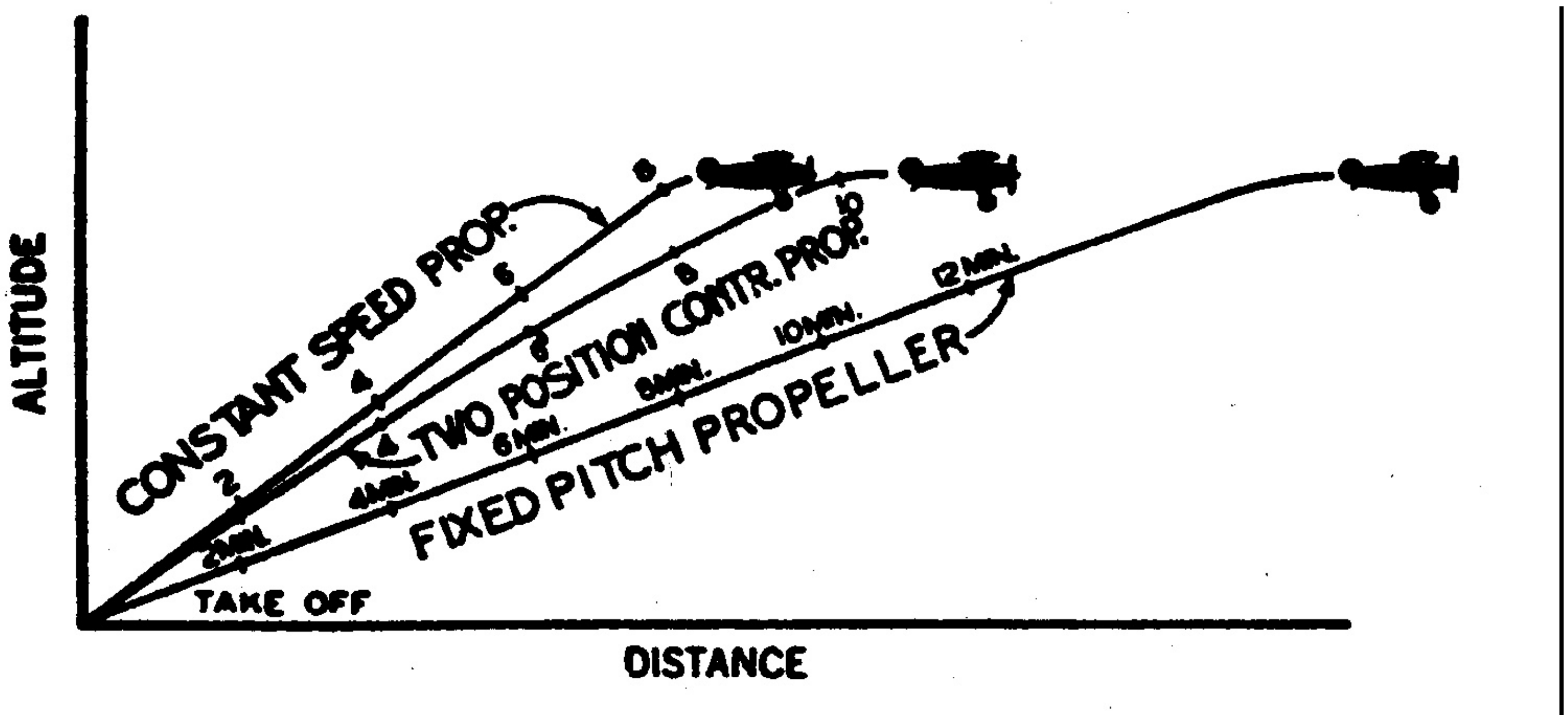


(a) Propeller efficiency

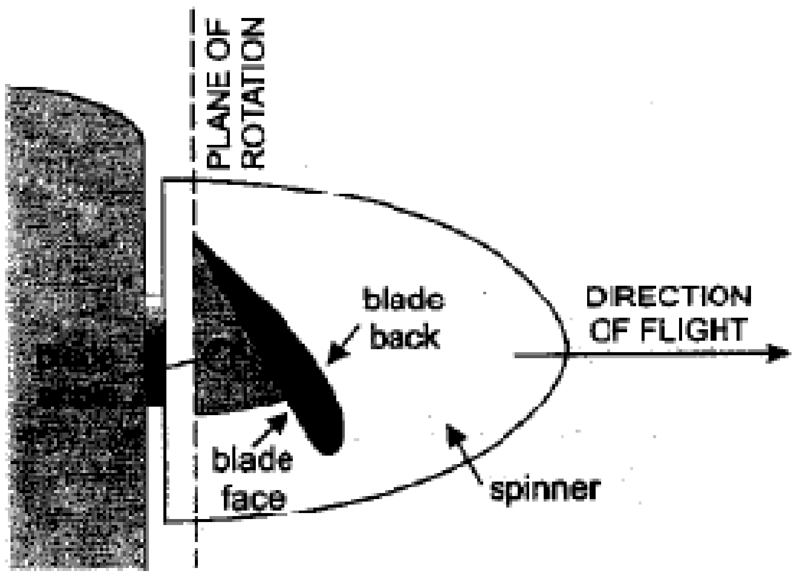
(b) Lift-to-drag ratio of a given propeller airfoil cross-section

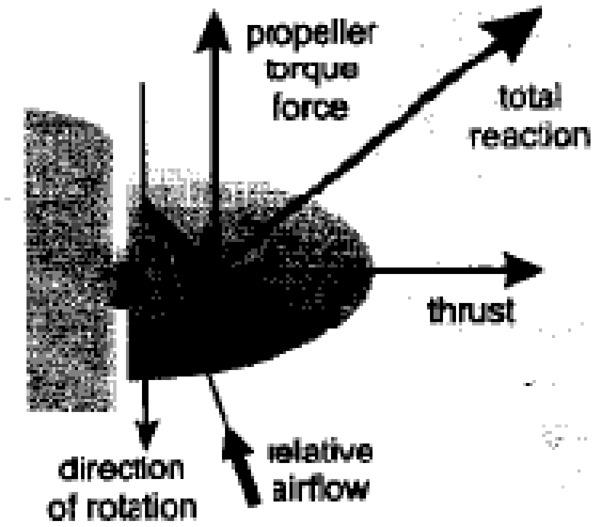
- Elica a passo variabile
- Elica a giri costanti

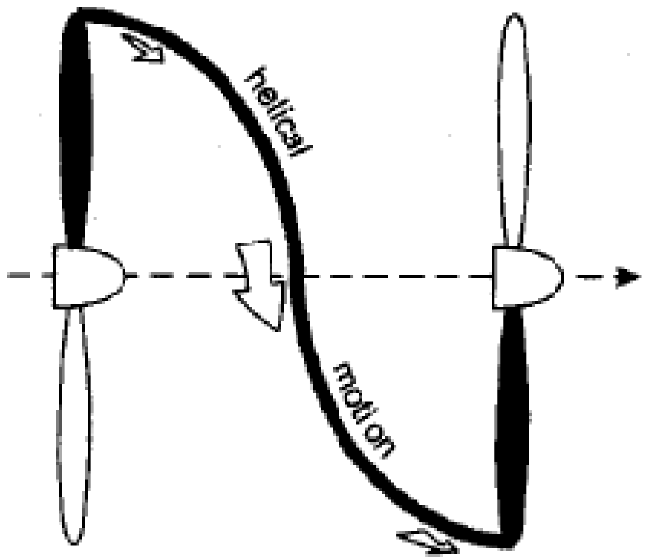


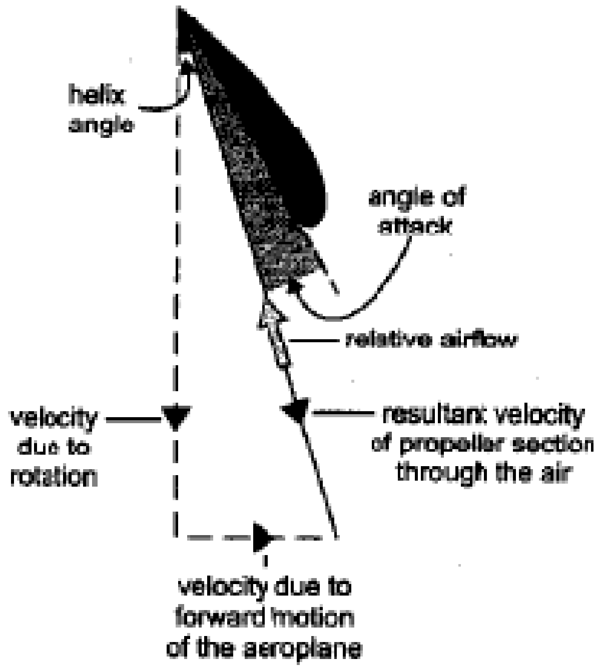


Cap.6 – Caratteristiche propulsive ELICHE

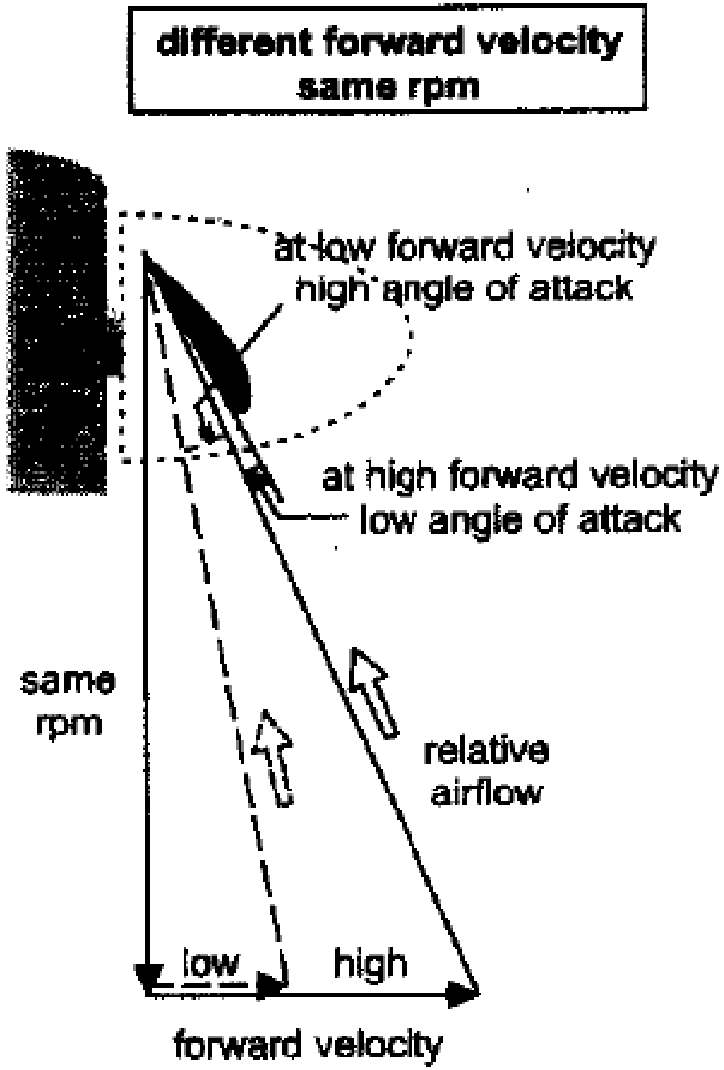


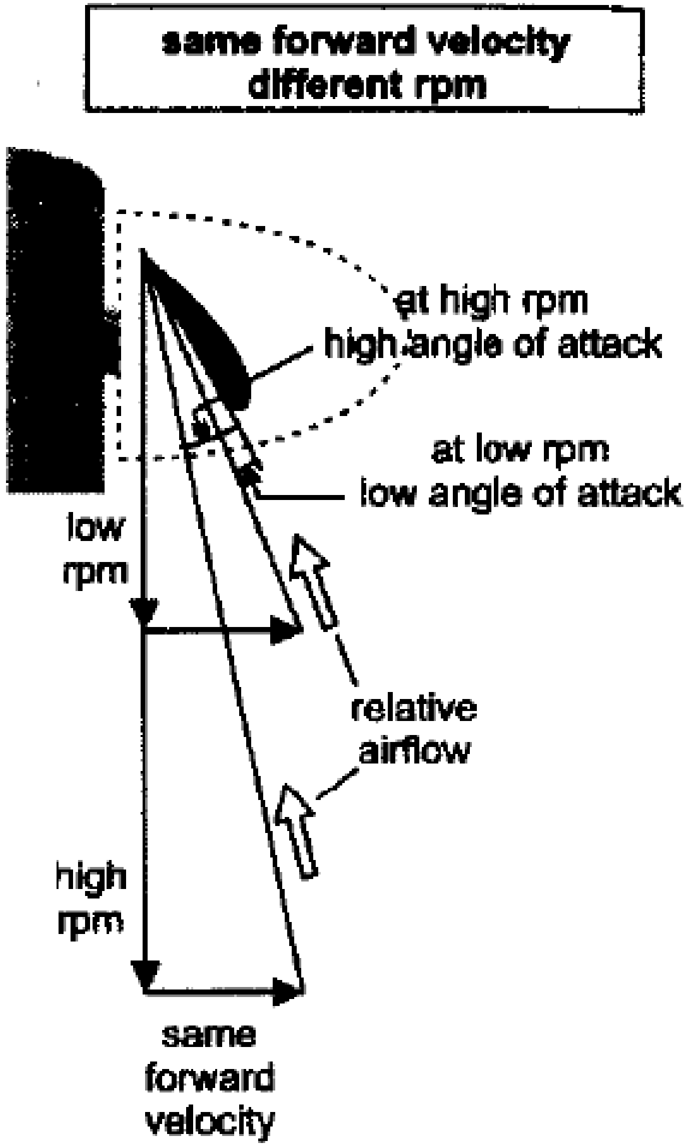




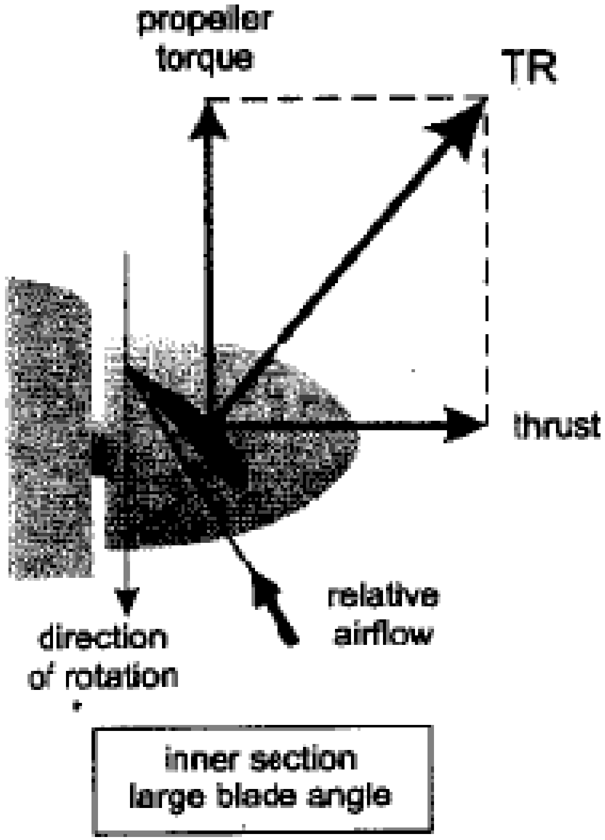


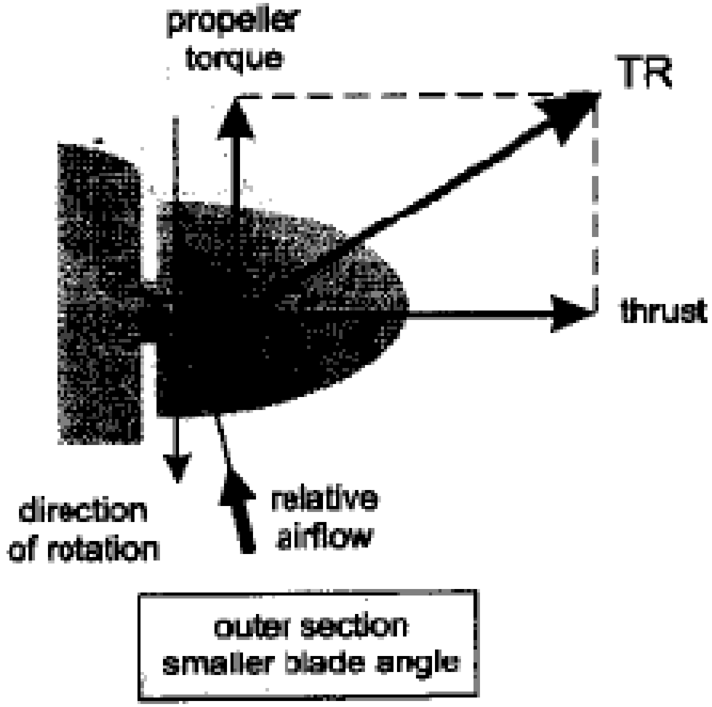
Cap.6 – Caratteristiche propulsive ELICHE



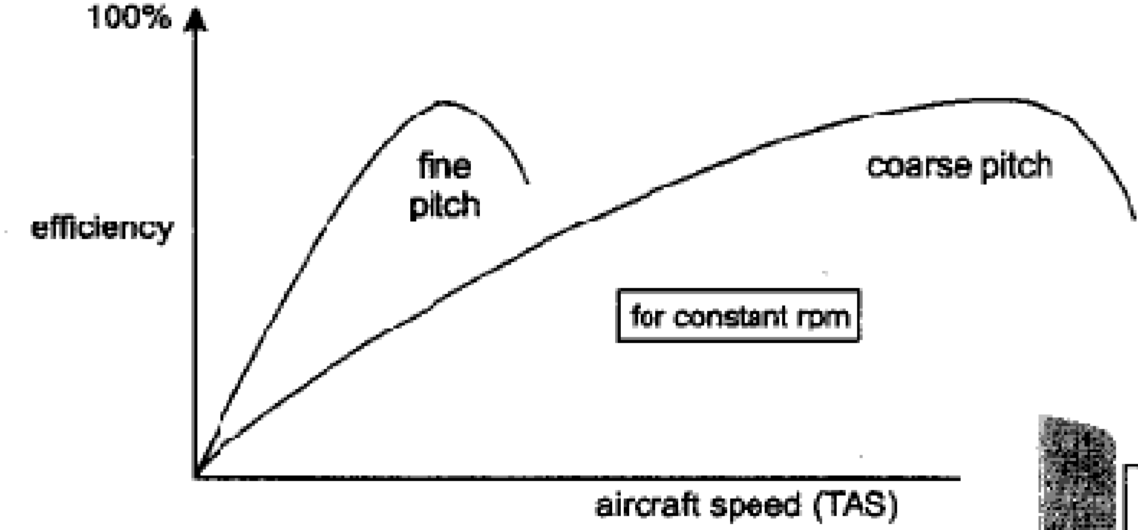


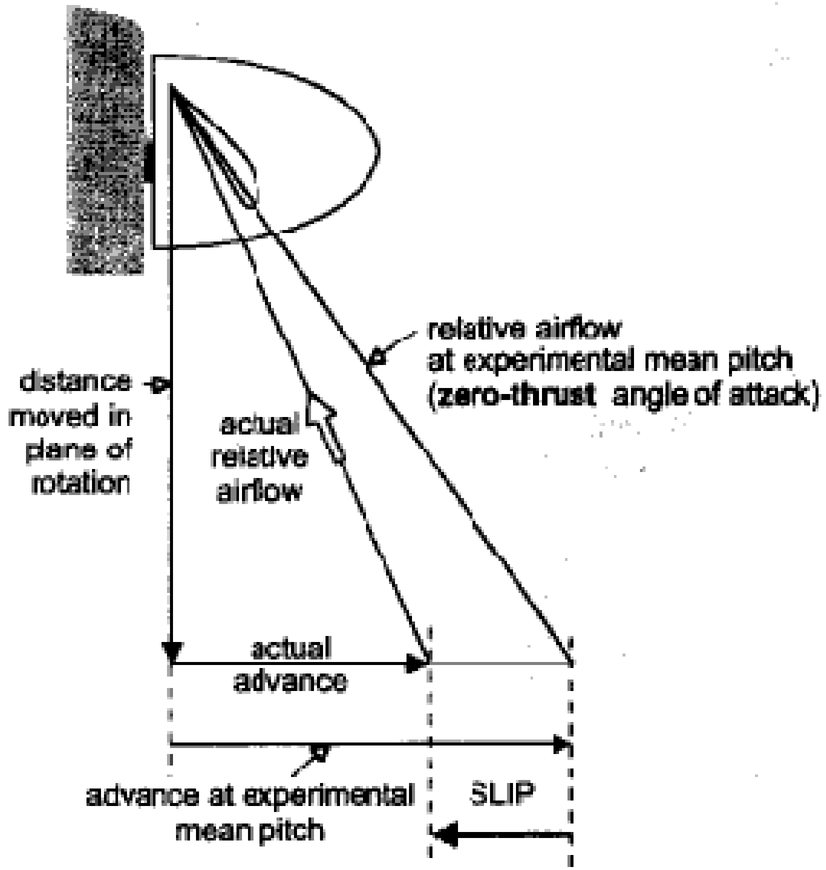
Cap.6 – Caratteristiche propulsive ELICHE



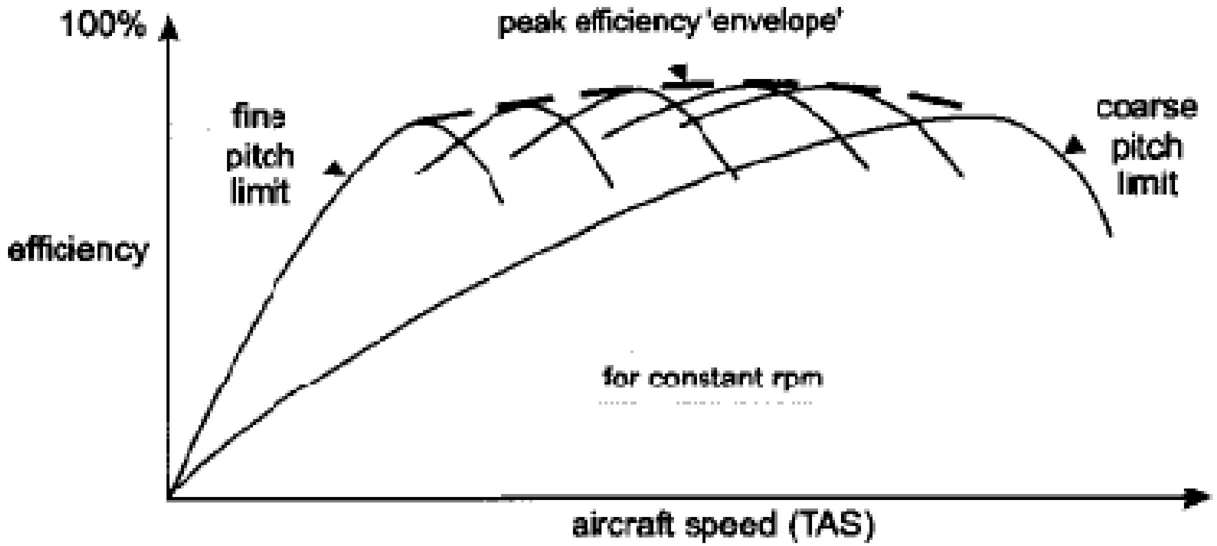


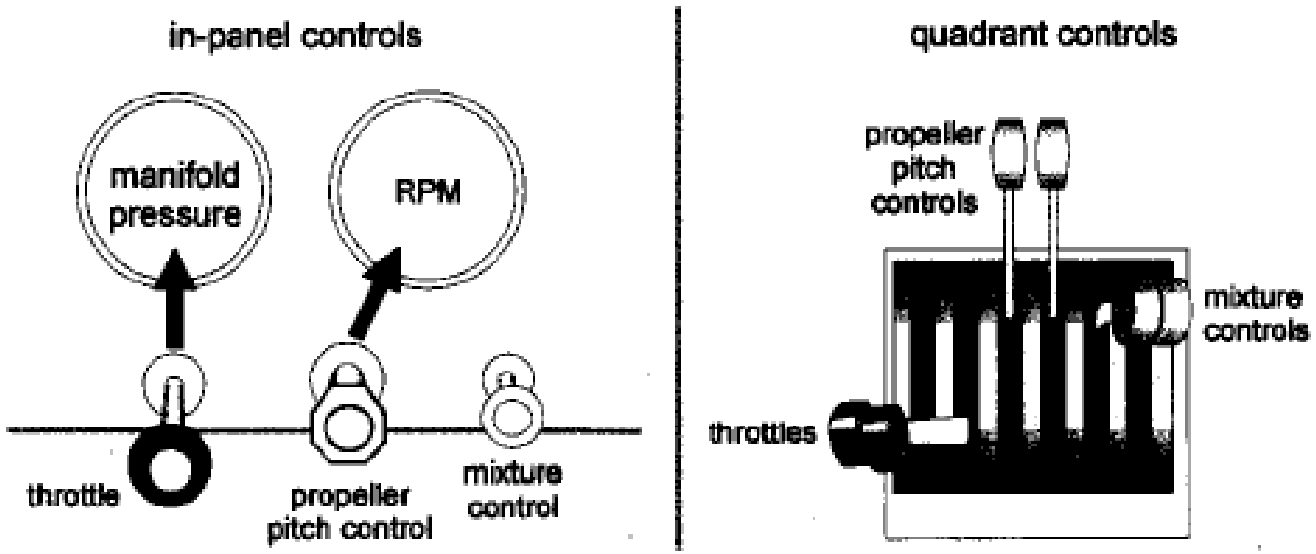
Cap.6 – Caratteristiche propulsive ELICHE



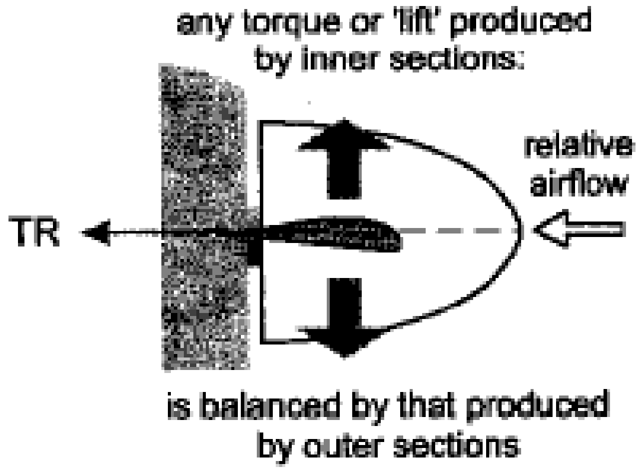


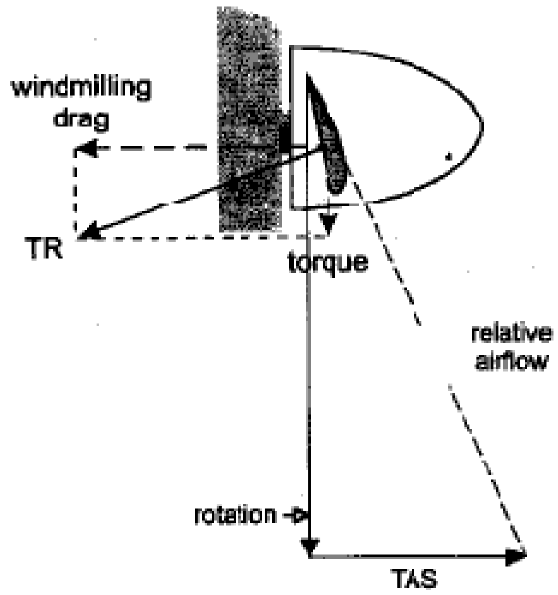
Cap.6 – Caratteristiche propulsive ELICHE

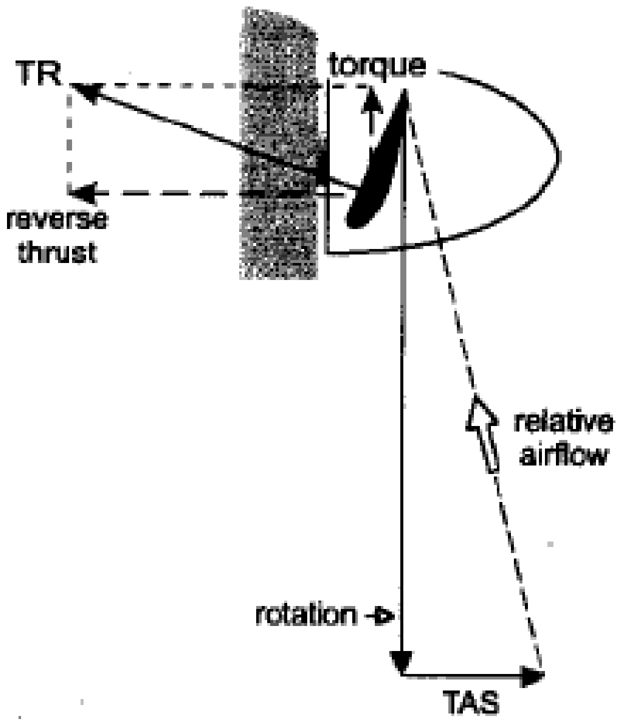




Cap.6 – Caratteristiche propulsive ELICHE



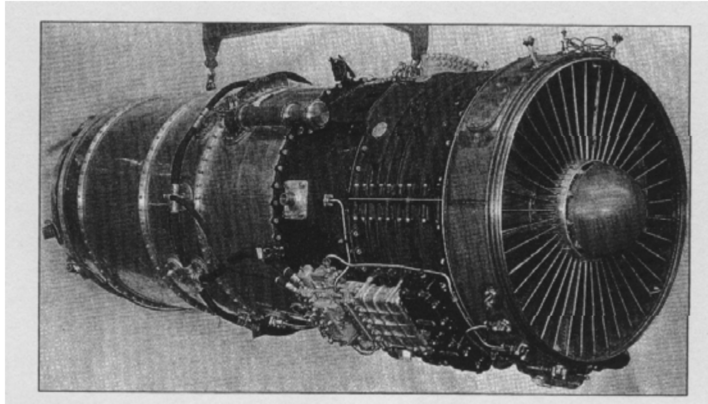


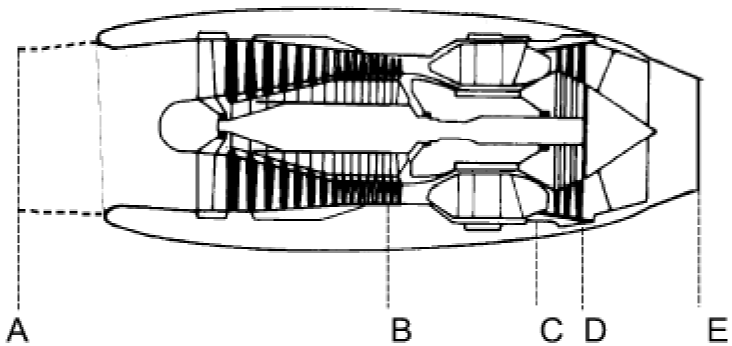


Cap.6 – Caratteristiche propulsive

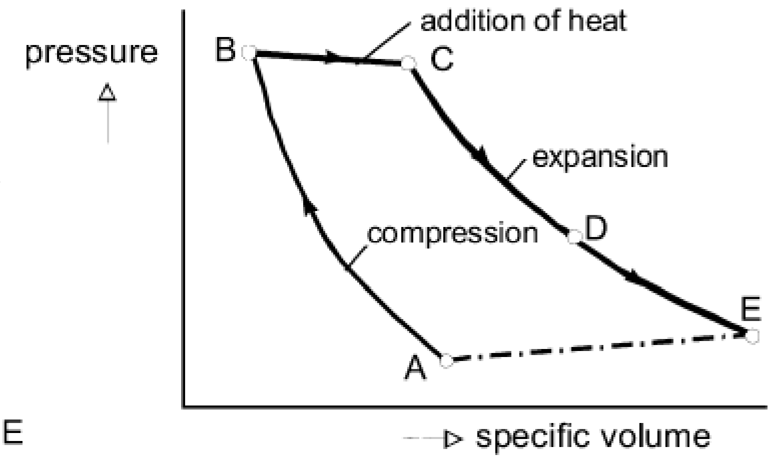
Turbojet

$$T = \left(\dot{m}_{air} + \dot{m}_{fuel}\right)V_j - \dot{m}_{air}V_\infty + \left(p_e - p_\infty\right)A_e$$





(a) Engine components



(b) Brayton cycle

Figure 5.17 Components and cycle of a jet engine.

Cap.6 – Caratteristiche propulsive

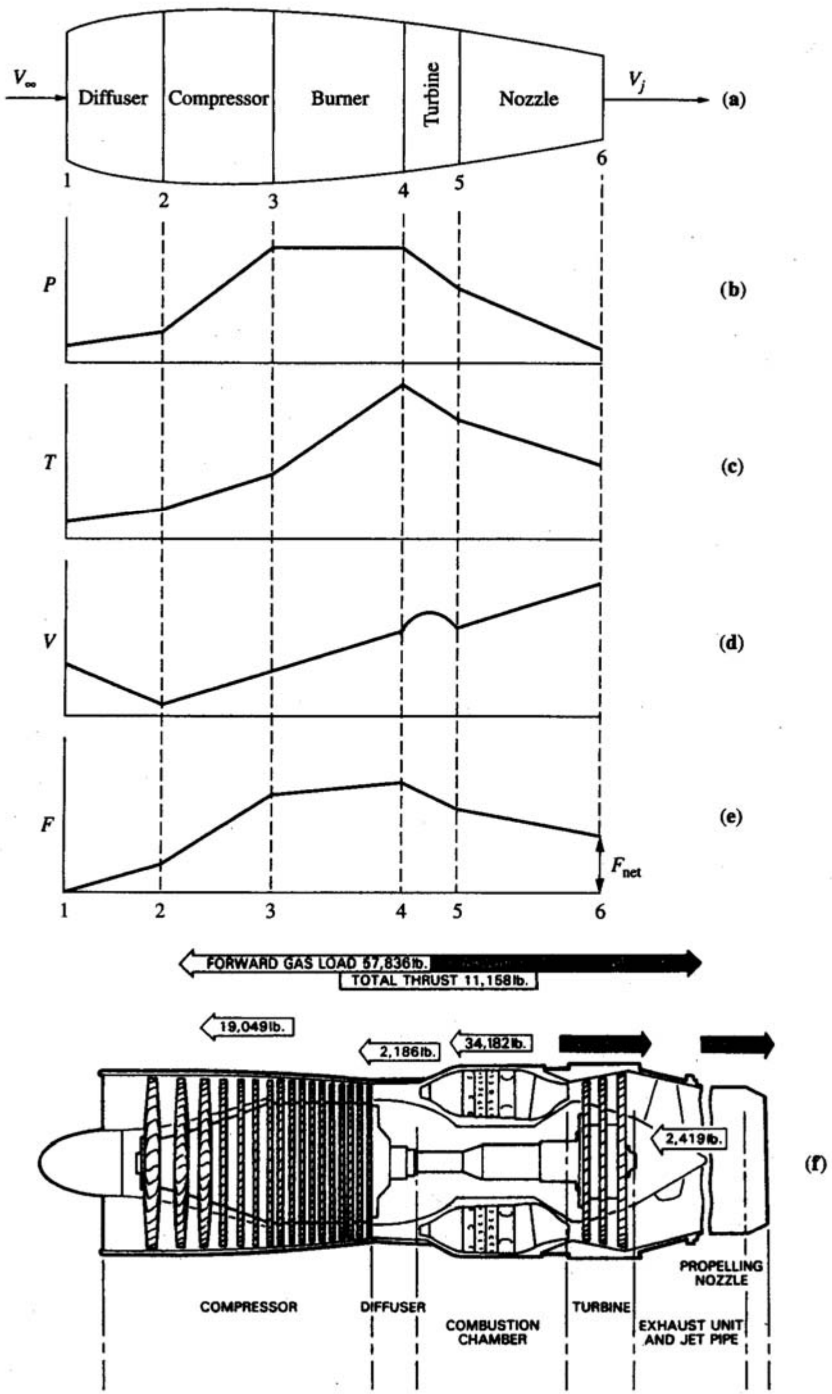
Turbojet

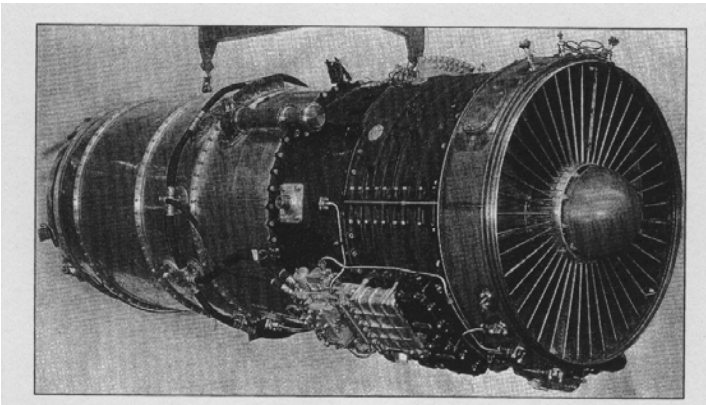
$$T = \left(\dot{m}_{air} + \dot{m}_{fuel}\right)V_j - \dot{m}_{air}V_\infty + \left(p_e - p_\infty\right)A_e$$

$$c_j = \frac{pesodelcarburanteconsumatoperdatoincrementoditempo}{(sp\,\mathrm{int}\,asviluppata)(incrementoditempo)}$$

$$\left[c_j\right] = \frac{N}{N \cdot s} = \frac{1}{s}$$

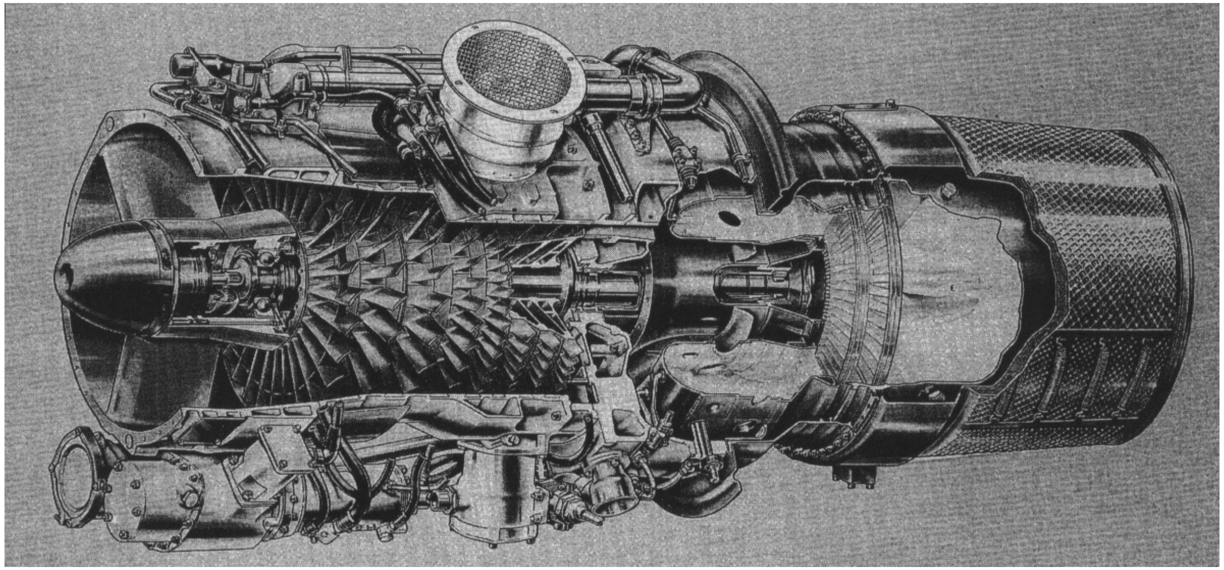
$$\left[SFCJ\right] = \frac{lb}{lb \cdot h} = \frac{1}{h}$$

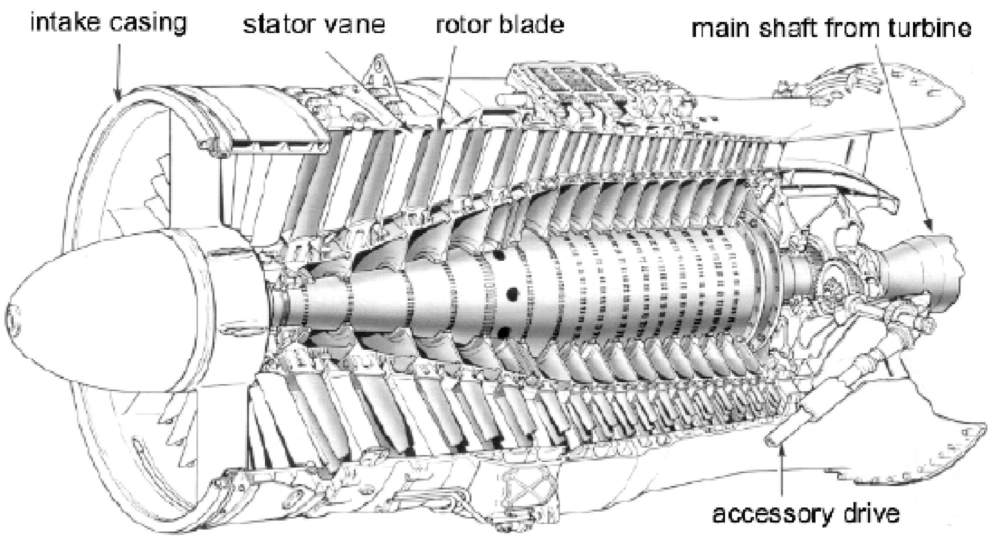


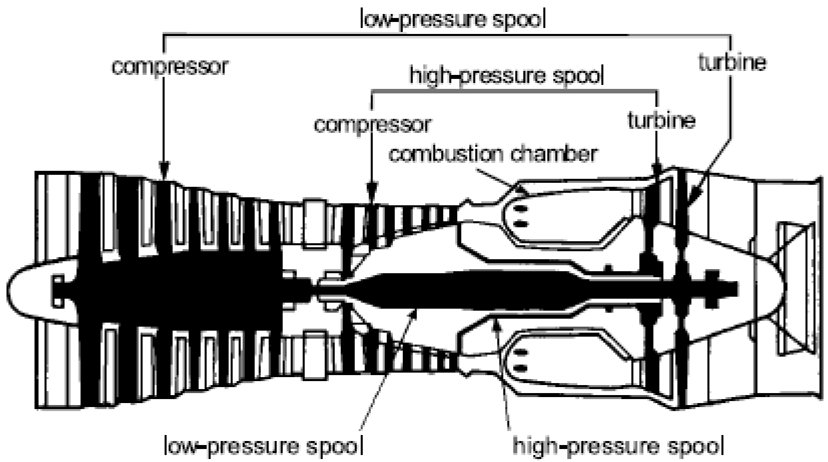


Cap.6 – Caratteristiche propulsive

Turbojet







Cap.6 – Caratteristiche propulsive

Turbojet

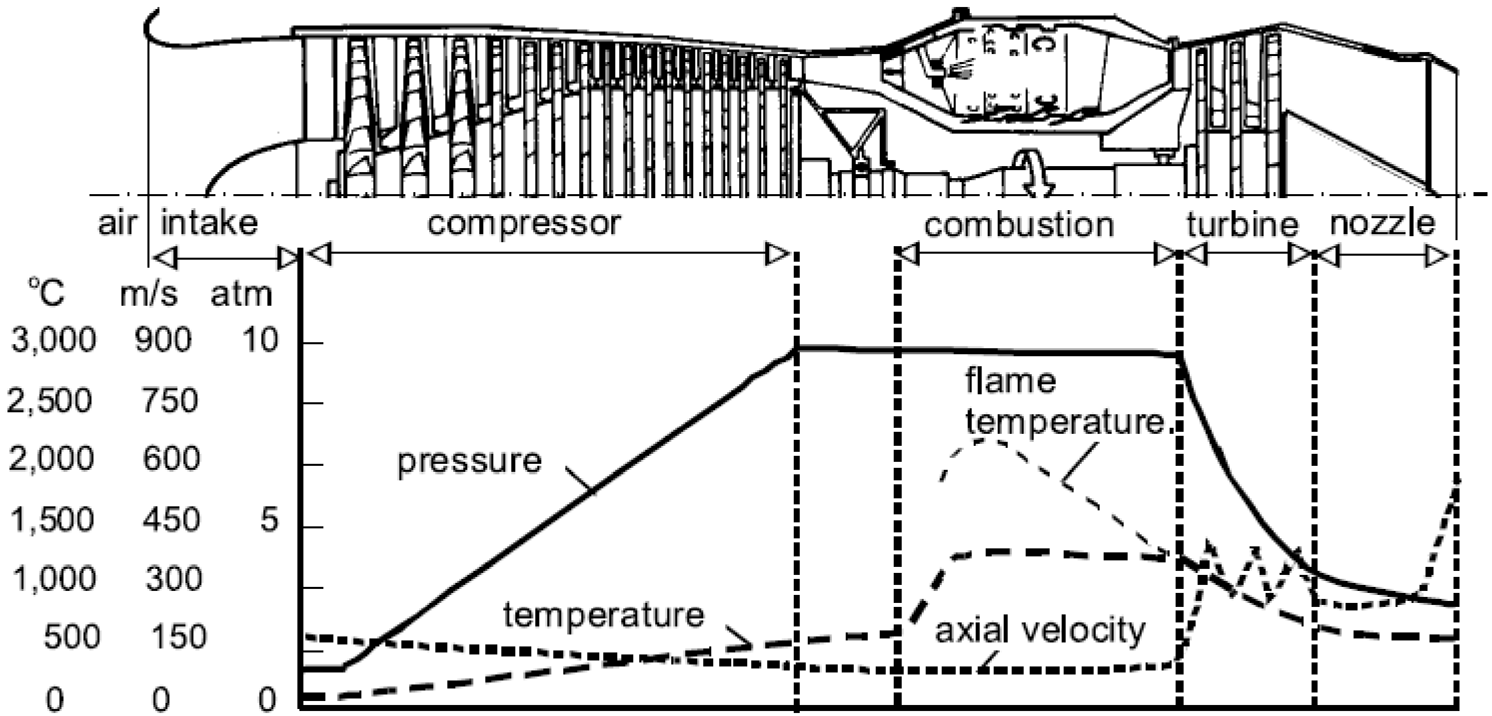


Figure 5.20 Variation of pressure, temperature and flow velocity in a jet engine (courtesy of Rolls-Royce plc).

Cap.6 – Caratteristiche propulsive

Turbojet

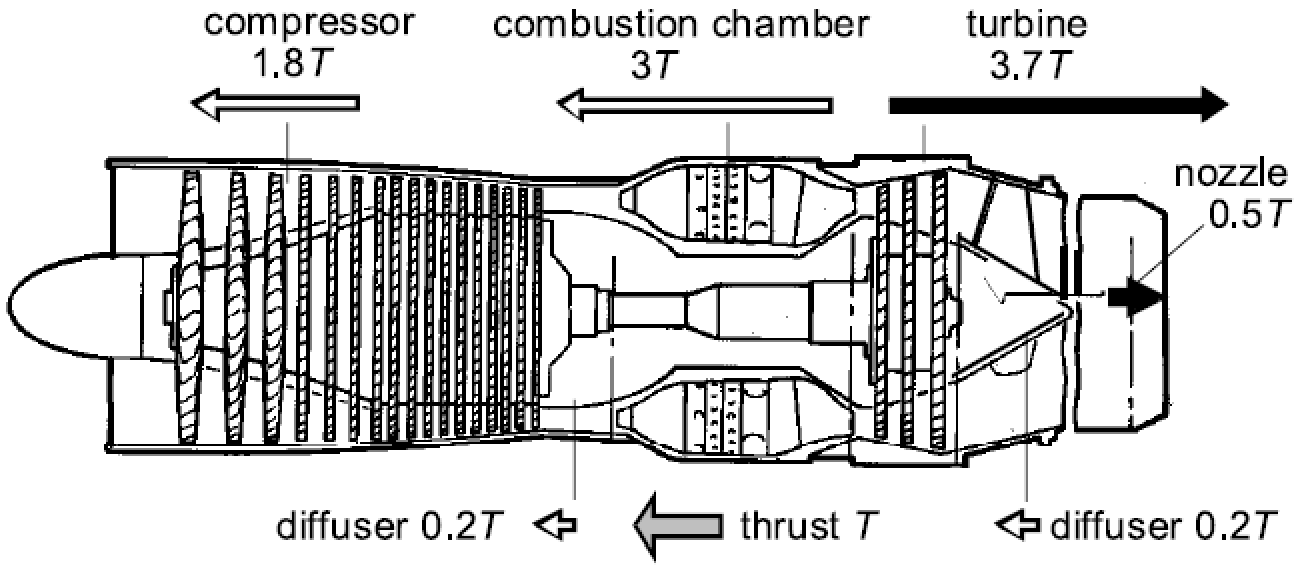
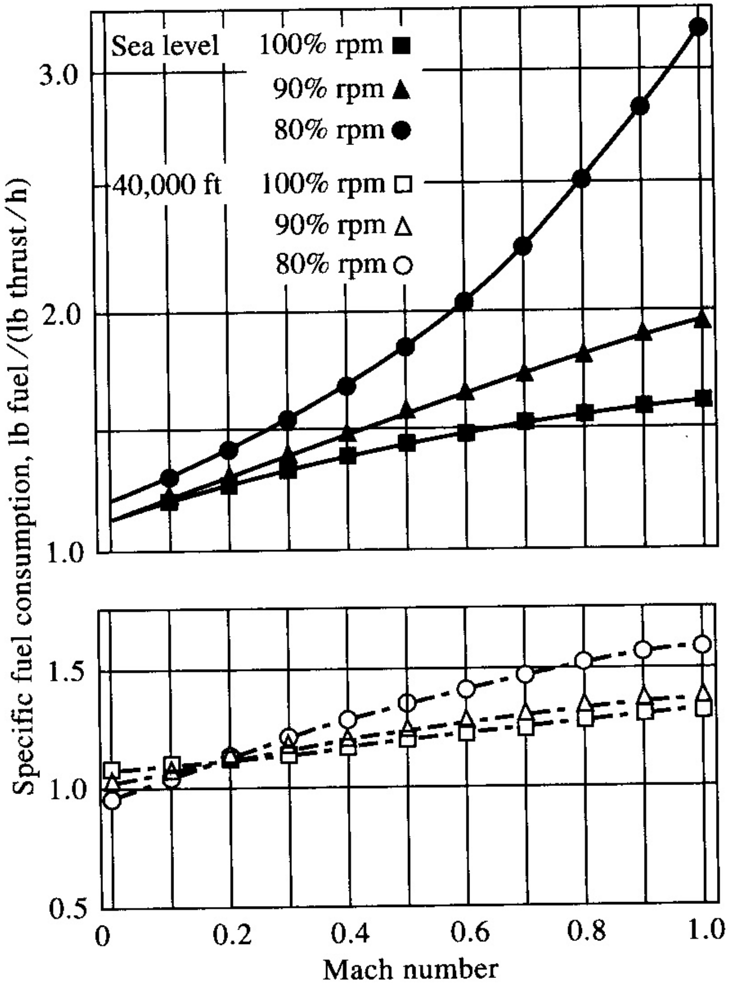


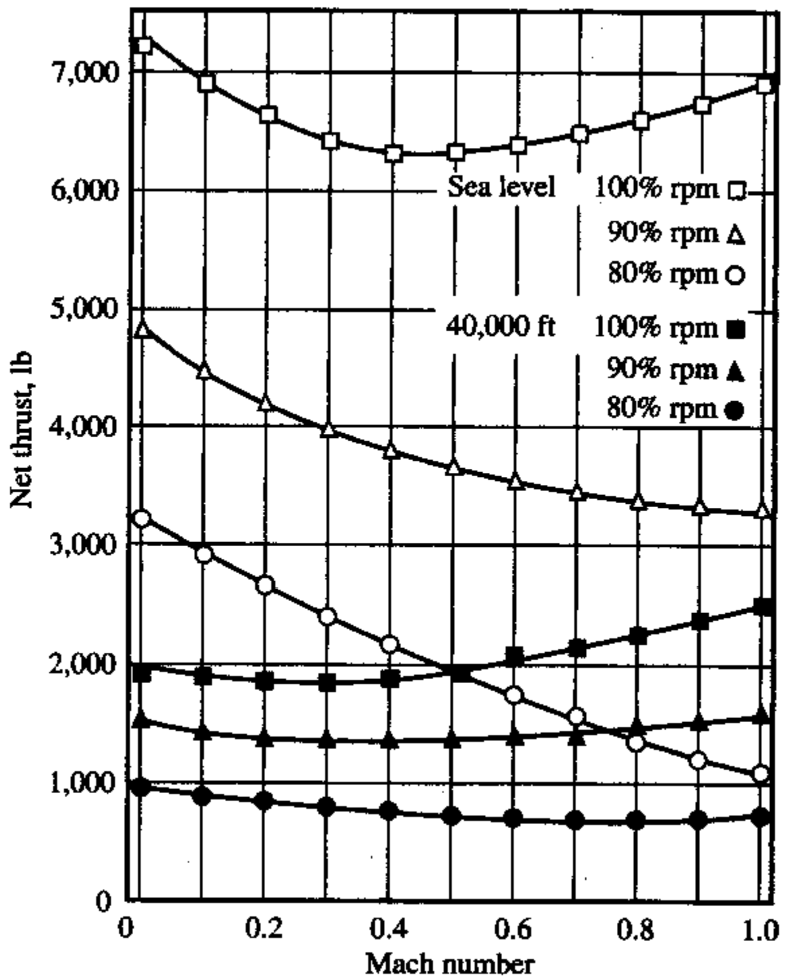
Figure 5.21 Distribution of internal thrust components for a static turbojet.

Cap.6 – Caratteristiche propulsive <u>Turbojet</u>

$$\text{TSFC} = 1.0 + kM_\infty$$

SFCJ è costante con la quota





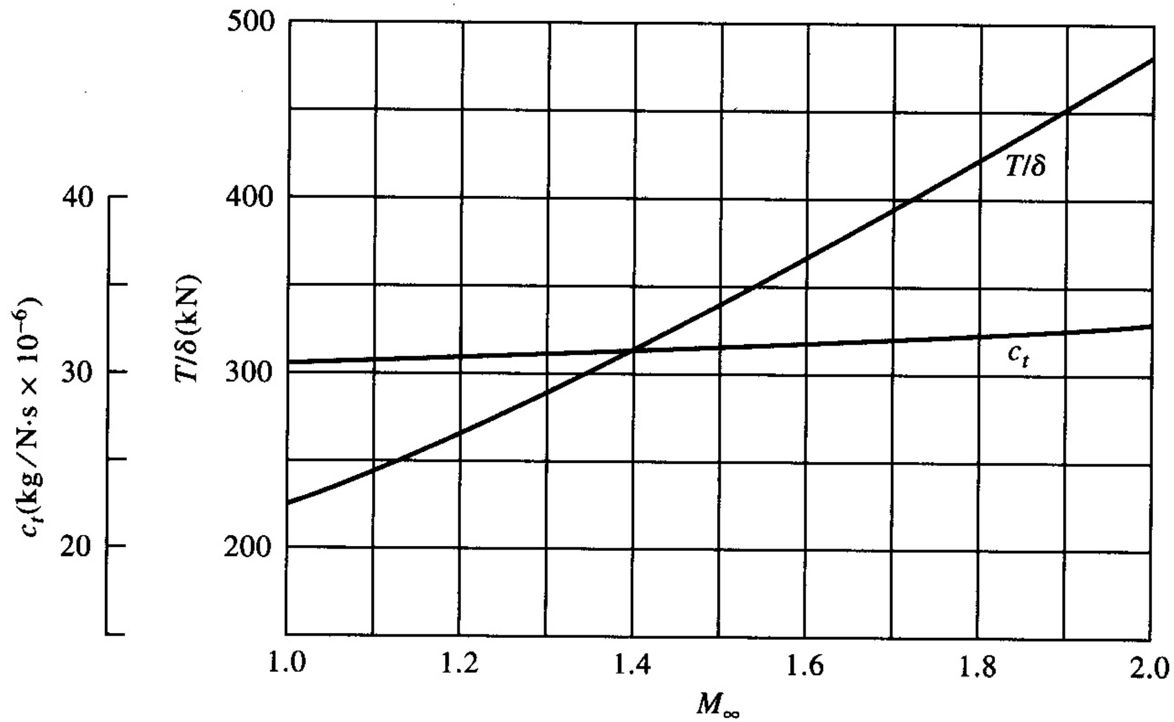
Spinta cost. con V

Effetto quota $\dfrac{T}{T_0} = \dfrac{\rho}{\rho_0}$

Cap.6 – Caratteristiche propulsive Turbojet

$$\frac{p_{total}}{p_{static}} = \left(1 + \frac{\gamma - 1}{2} M^2\right)^{\gamma/(\gamma-1)}$$

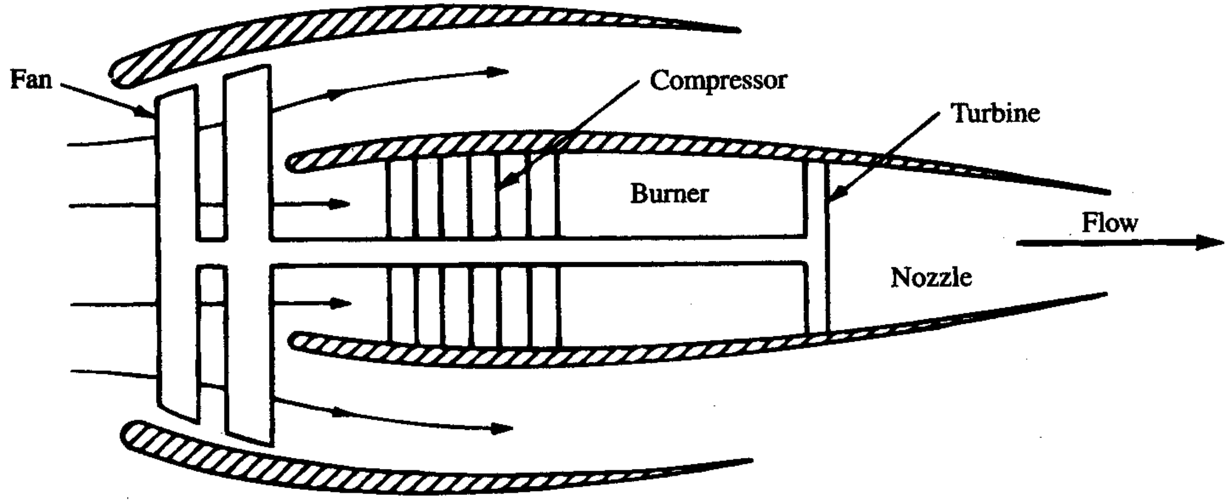
Condizioni supersoniche



$$\boxed{\frac{T}{T_{Mach1}} = 1 + 1.18(M_\infty - 1)}$$

Cap.6 – Caratteristiche propulsive

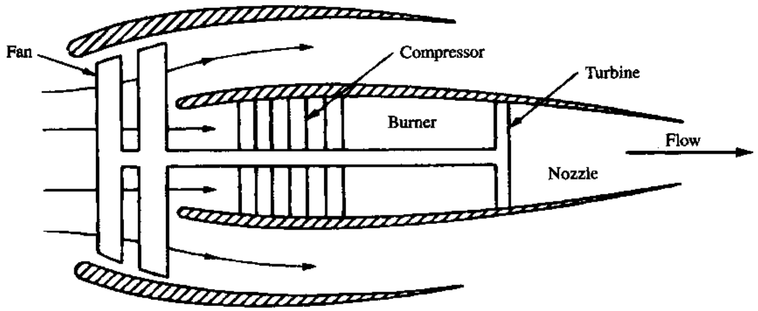
Turbofan

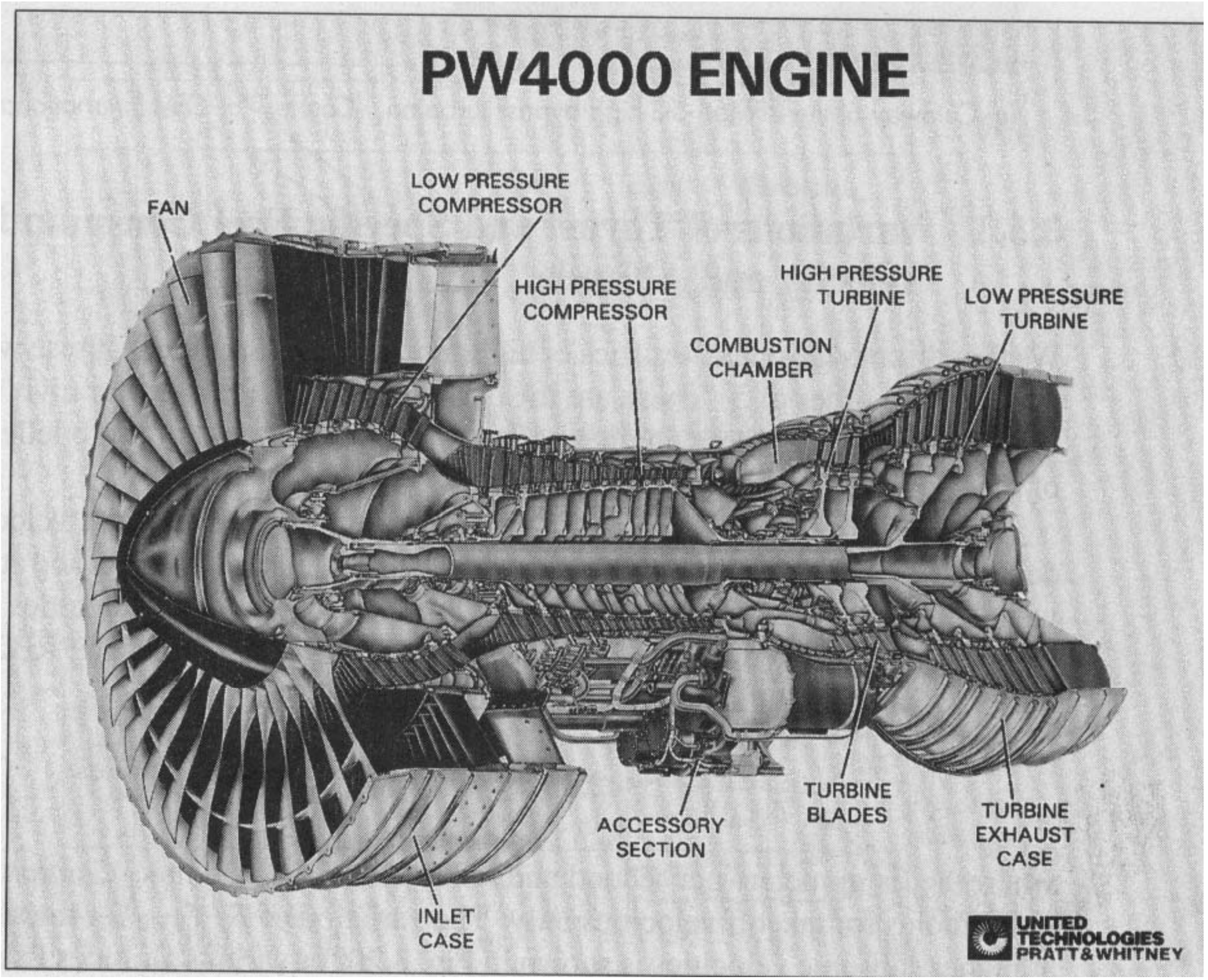


BPR : apporto di By-Pass o anche rapporto di diluizione

Cap.6 – Caratteristiche propulsive

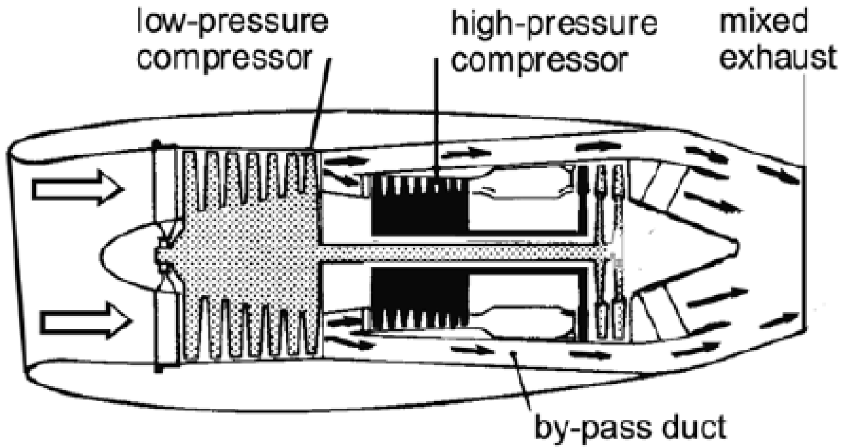
Turbofan



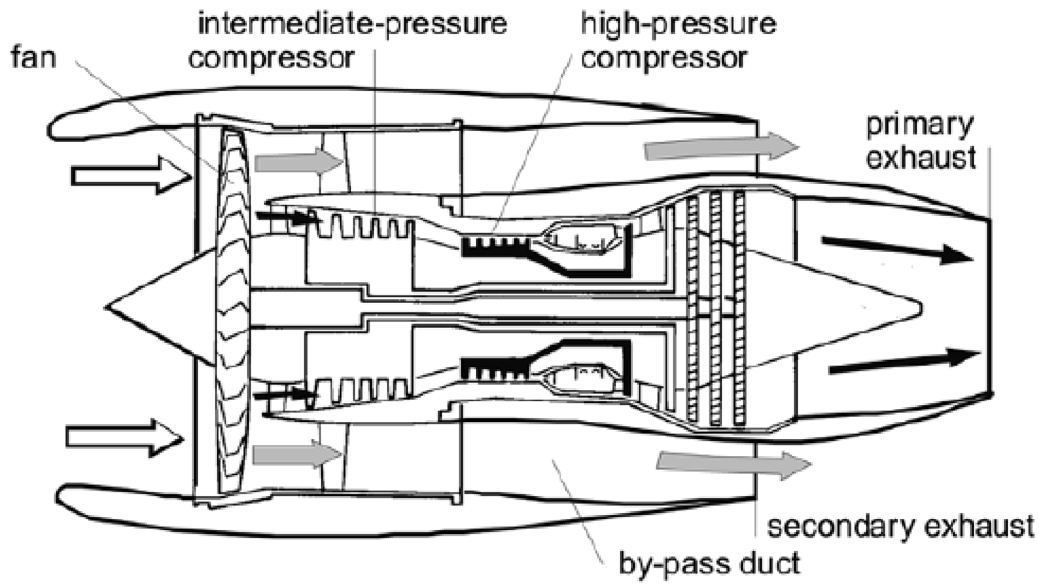


Cap.6 – Caratteristiche propulsive

Turbofan



(a) Low by-pass ratio turbofan



(b) Three-shaft high by-pass ratio turbofan

Cap.6 – Caratteristiche propulsi

Turbofan

- Low BPR

- HIGH BPR

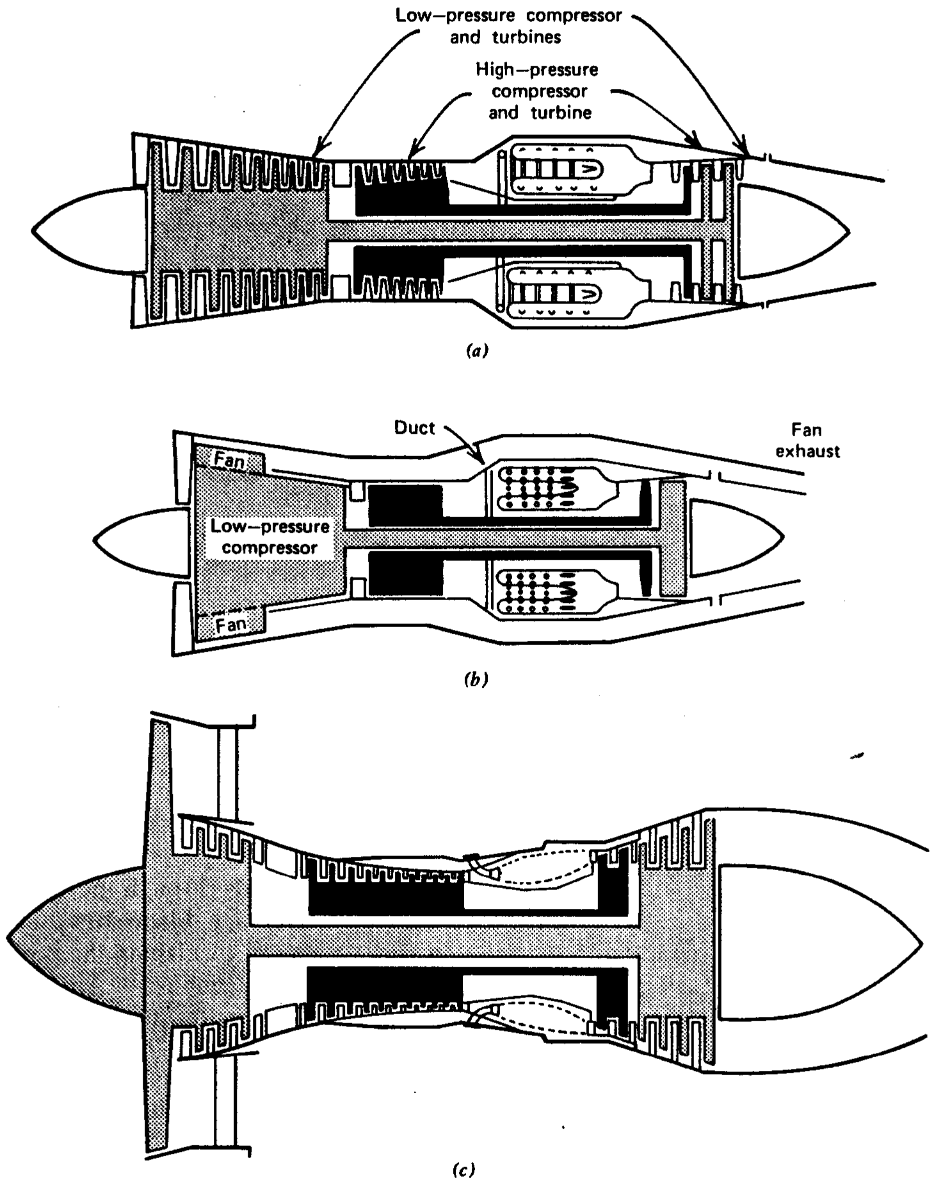
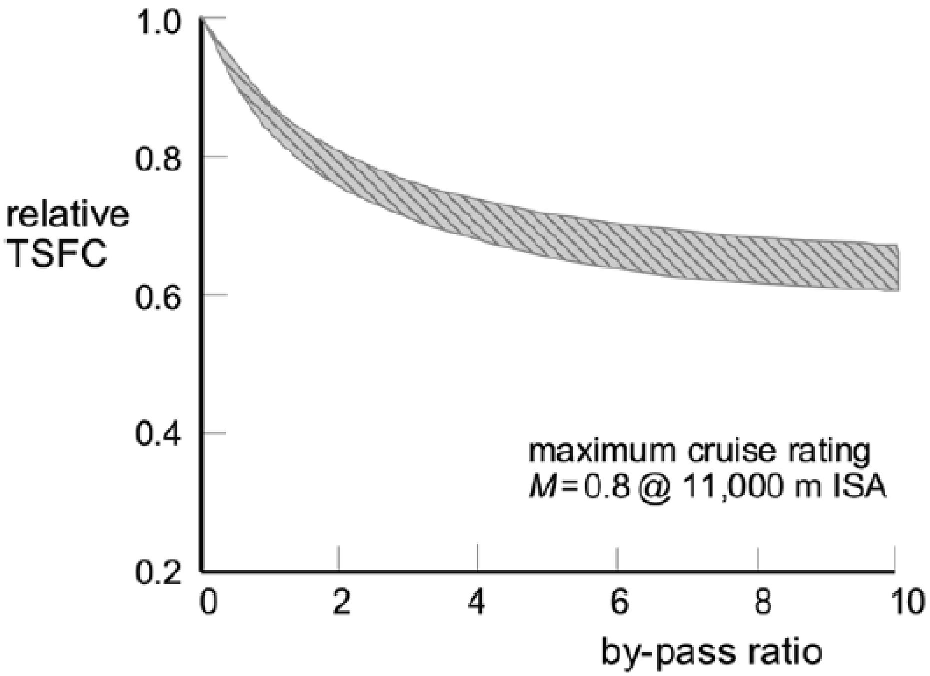
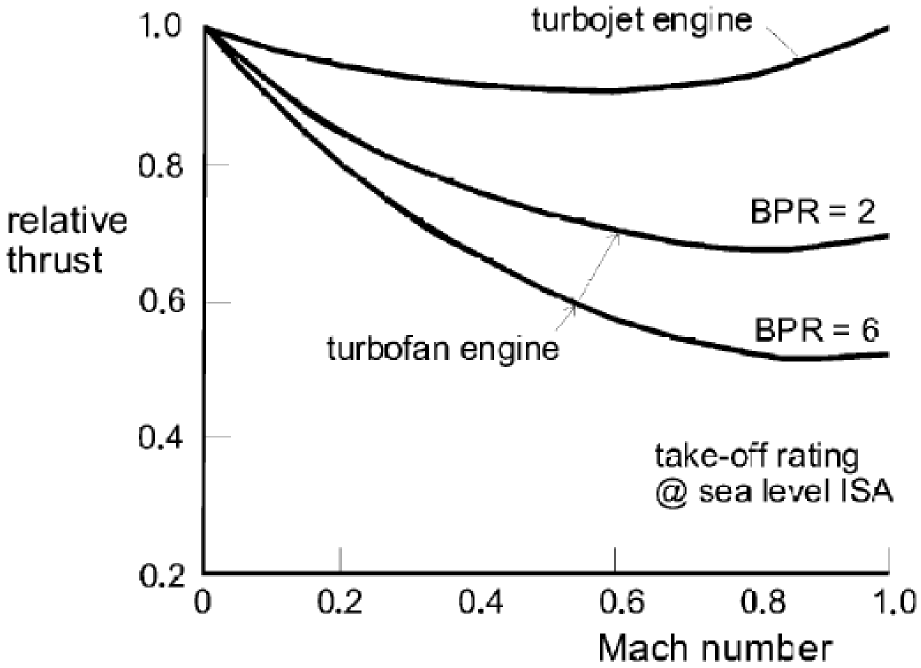


Figure 6.26 Variations on the gas turbine. (*a*) Dual axial-flow compressor turbojet. (*b*) Dual axial-flow compressor, forward fan engine with long ducts. (*c*) High bypass ratio turbofan with short ducts. (*d*) Single axial-flow compressor, direct propeller drive turboprop. (*e*) Single axial-flow compressor, free turbine propeller drive turboprop. (*f*) Dual axial-flow compressor, turbojet with afterburner. (*g*) Dual axial-flow compressor, industrial turboshaft engine.

Cap.6 – Caratteristiche propulsive



(a) Specific fuel consumption



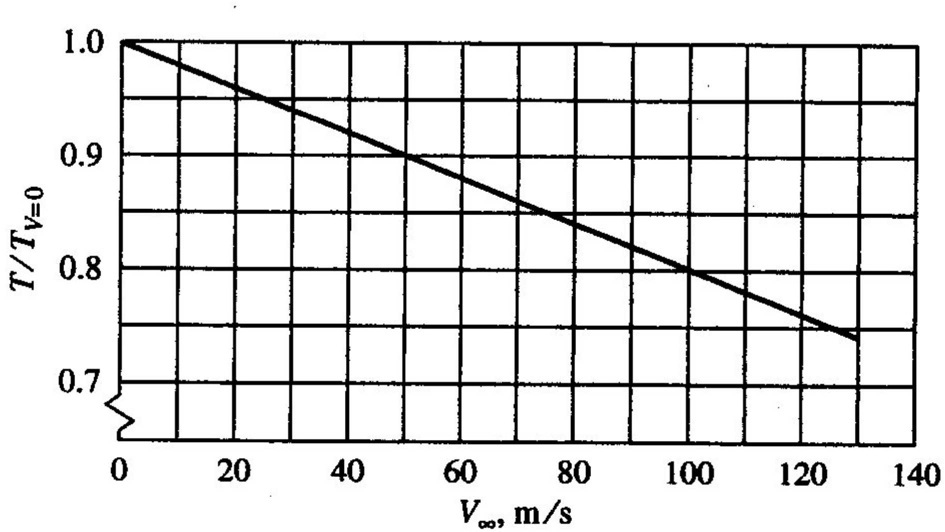
(b) Thrust lapse with speed

Cap.6 – Caratteristiche propulsive Turbofan

Variazione Spinta con Vel e quota

Condizioni di decollo

$$\frac{T}{T_{V=0}} = 1 - 2.52\times10^{-3}V_\infty + 4.34\times10^{-6}V_\infty^2$$

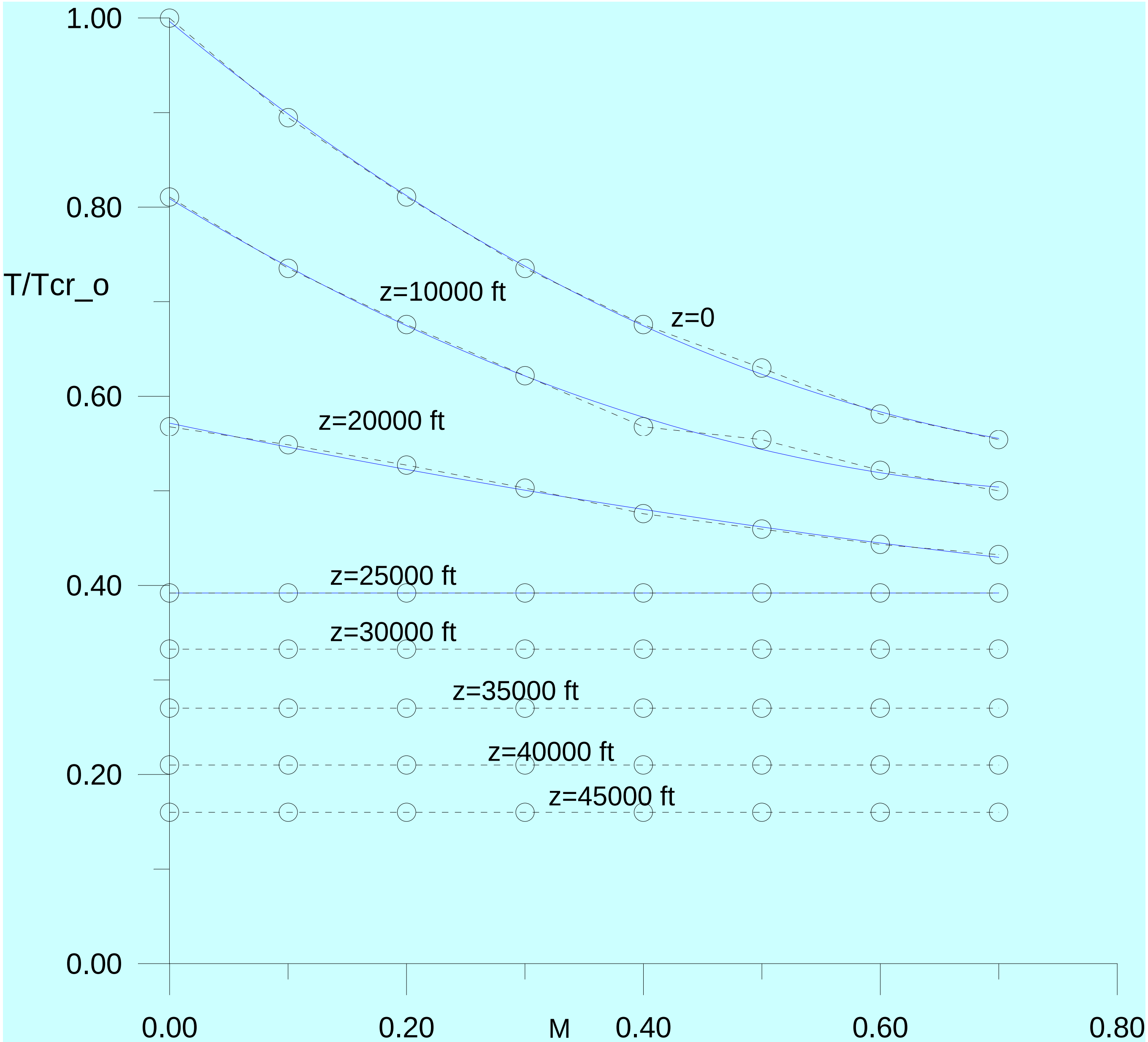


Cap.6 – Caratteristiche propulsive Turbofan

Variazione Spinta con Vel e quota

Condizioni di crociera e salita

$$T_{o}\_cr = T_{o} \cdot 0.80$$



Variazione Spinta con Vel e quota

Condizioni di crociera e salita

$$K_{MZ} = \frac{T}{T_{o\_}cr}$$

z=0 ft (S/L) KMZ=T/Tcr_o = 1.00 –1.037 M + 0.582 M2
z= 10000 ft KMZ=T/Tcr_o = 0.81 –0.768 M + 0.474 M2
z= 20000 ft KMZ=T/Tcr_o = 0.57 –0.261 M + 0.084 M2
z= 25000 ft KMZ=T/Tcr_o = 0.39
z= 30000 ft KMZ=T/Tcr_o = 0.33
z= 35000 ft KMZ=T/Tcr_o = 0.27
z= 40000 ft KMZ=T/Tcr_o = 0.21
z= 45000 ft KMZ=T/Tcr_o = 0.16

$$\boxed{T = K_{MZ} \cdot 0.80 \cdot T_o \cdot \varphi}$$

Variazione Spinta con Vel e quota

Condizioni di crociera e salita

E' abbastanza valida

$$\frac{T}{T_0} = \left(\frac{\rho}{\rho_0} \right)^m$$

Alle alte quote :

$$\boxed{T = T_o \cdot 0.80 \cdot \sigma \cdot \varphi = T_{o}\_cr \cdot \sigma \cdot \varphi}$$

Cap.6 – Caratteristiche propulsive Turbofan

Variazione Consumo specifico con Vel e quota

$$c_t = B\left(1 + kM_{\infty}\right)$$

SFCJ=0.50-0.70 lb/(lb h)

Cap.6 – Caratteristiche propulsive Turbofan

Table 6.1 Weight and Performance Data for Turbojet and Turbofan Engines

Manuf./Type/ Config./B.P.R.	Weight (lbs)	Thrust at take–off s.l.s. (lbs)	s.f.c. at take–off s.l.s. (lbs/hr/lbs)	Massflow take–off s.l.s. (lbs/sec)	Alt./ M	Thrust at altitude/M (lbs)	s.f.c. at altitude/M (lbs/hr/lbs)
(1)/CF6–6D/ TBF/5.72	7,896	40,000	0.346	1,303	35K/ 0.8	7,160 (80% max)	0.616
(1)/CF6–32/ TBF/4.90	7,140	36,500	0.357	1,104	35K/ 0.8	6,630 (80% max)	0.609
(1)/CF6–50/ TBF/4.26	8,731	51,000	0.390	1,450	35K/ 0.8	8,720 (80% max)	0.628
(1)/CF6–80/ TBF/4.66	8,435	48,000	0.344	1,433	35K/ 0.8	8,260 (80% max)	0.592
(1)/CF34/ TBF/6.30	1,580	8,650	0.362	332	40K/ 0.8	1,420 (max)	0.728
(1)/CFM56–2/ TBF/6.00	4,610	24,000	???	817	35K/ 0.8	5,188 (max)	0.661
(1)/CJ610–5/ TBJ/1.00	402	2,950	0.980	44	36K/ 0.8	870 (max)	1.150
(1)/CF700/ TBF/1.93	725	4,200	0.660	126	36K/ 0.8	1,060 (max)	0.980
(1)/J79–17/ TBJ/0	3,873	17,820	1.980	170	35K/ 0.9 35K/ 2.0	2,600 (max) 18,600 (max)	0.980 2.070
(1)/TF34–400/ TBF/6.2	1,478	9,275	0.363	338	36K/ 0.8	1,896 (intermediate)	0.682
(1)/F404–402/ TBF/0.27	2,282	17,700	???	146	???	???	???
(2)/CFE738/ TBF/5.3	1,325	5,725	0.372	210	40K/ 0.8	1,464 (max)	0.640
(3)/535E4/ TBF/4.3	7,264	42,000	???	1,150	35K/ 0.8	8,700 (max)	0.598
(3)/RB211/ TBF/4.3	9,814	60,600	???	1,604	35K/ 0.85	11,813 (max)	0.570
(3)/Trent800/ TBF/???	13,133	90,000	???	???	35K/ 0.83	13,000 (max)	0.557

Type: (1) = G.E.
(2) = G.E./Allied Signal
(3) = Rolls Royce

Manuf./Type/ Config./B.P.R. = Manufacturer/Type/ Configuration/By–pass Ratio

Cap.6 – Caratteristiche propulsive Turbofan

Table 6.2 Weight and Performance Data for Turbojet and Turbofan Engines

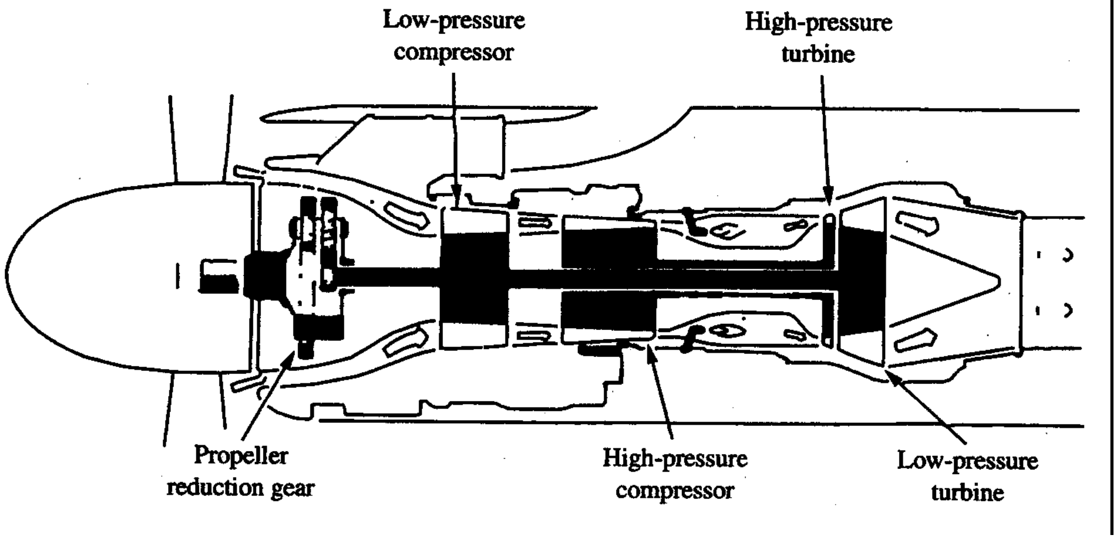
Manuf./Type/ Config./B.P.R.	Weight (lbs)	Thrust at take–off s.l.s. (lbs)	s.f.c. at take–off s.l.s. (lbs/hr/lbs)	Massflow take–off s.l.s. (lbs/sec)	Alt./ M	Thrust at altitude/M (lbs)	s.f.c. at altitude/M (lbs/hr/lbs)
(4)/TFE731–2/ TBF/2.66	743	3,500	???	113	40K/ 0.8	755 (max)	0.815
(4)/TFE731–5/ TBF/3.48	890	4,600	???	143	40K/ 0.8	1,000 (max)	0.760
(4)/ALF502L/ TBF/5.0	1,311	7,500	0.428	???	???	???	???
(5)/JT8D–219/ TBF/1.77	4,612	21,000	???	488	35K/ 0.8	5,250 (max)	0.737
(5)/PW4000/ TBF/4.85	9,400	56,000	???	1,705	35K/ 0.8	???	0.537
(5)/PW2000/ TBF/6.00	7,300	38,250	???	1,340	35K/ 0.8	???	0.563
(5)/PW300/ TBF/4.3	993	4,679	0.388	???	40K/ 0.8	1,155 (max)	0.681
(6)/CFM56–2A2/ TBF/6.0	4,820	24,000	???	817	35K/ 0.8	5,188 (max)	0.661
(7)/IAEV2500/ TBF/4.6	5,224	30,000	???	848	35K/ 0.8	5,752 (max)	0.575
(8)/Larzac 04/ TBF/1.13	639	2,966	0.710	63	35K/ 0.8	772 (max)	???
(9)/FJ44/ TBF/3.28	447	1,900	0.475	???	36K/ 0.7	506 (max. cont.)	0.758
(10)/Adour 871/ TBF/0.80	1,330	5,900	0.740	???	39K/ 0.8	???	0.955

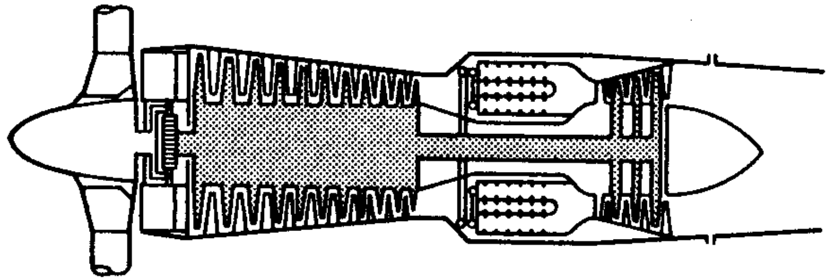
Type: (4) = Allied Signal
(5) = Pratt & Whitney
(6) = CFM International (G.E./SNECMA)
(7) = International Aero Engines
(8) = Turbomeca
(9) = Williams/Rolls Royce
(10) = Rolls Royce/Turbomeca

Manuf./Type/ Config./B.P.R. = Manufacturer/Type/ Configuration/By–pass Ratio

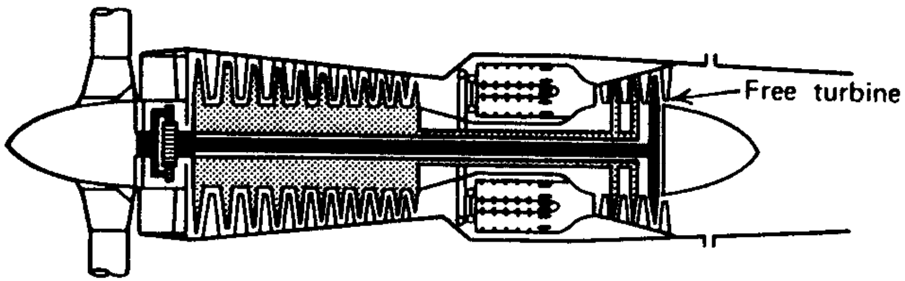
Cap.6 – Caratteristiche propulsive

Turboelica





(d)



(e)

Cap.6 – Caratteristiche propulsive

Turboelica

$$\Pi_d = (T_p + T_j) V_\infty$$

$$\Pi_d = \eta_p \Pi_a + T_j V_\infty$$

Equivalent Shaft Horsepower (Pot all'albero equivalente)

$$\Pi_d = \eta_p \Pi_{ea}$$

$$\eta_p \Pi_{ea} = \eta_p \Pi_a + T_j V_\infty$$

$$\boxed{\Pi_{ea} = \Pi_a + \frac{T_j V_\infty}{\eta_p}}$$

In ultimo forniamo una utile regola basata sull'esperienza pratica: in condizioni statiche (motore che opera con l'aeroplano a velocità nulla al suolo) una turboelica produce circa 2.5 lb di spinta per cavallo vapore all'albero. Questa osservazione va utilizzata se dobbiamo considerare la spinta di un motore turboelica in decollo.

EFFETTO RAM !!

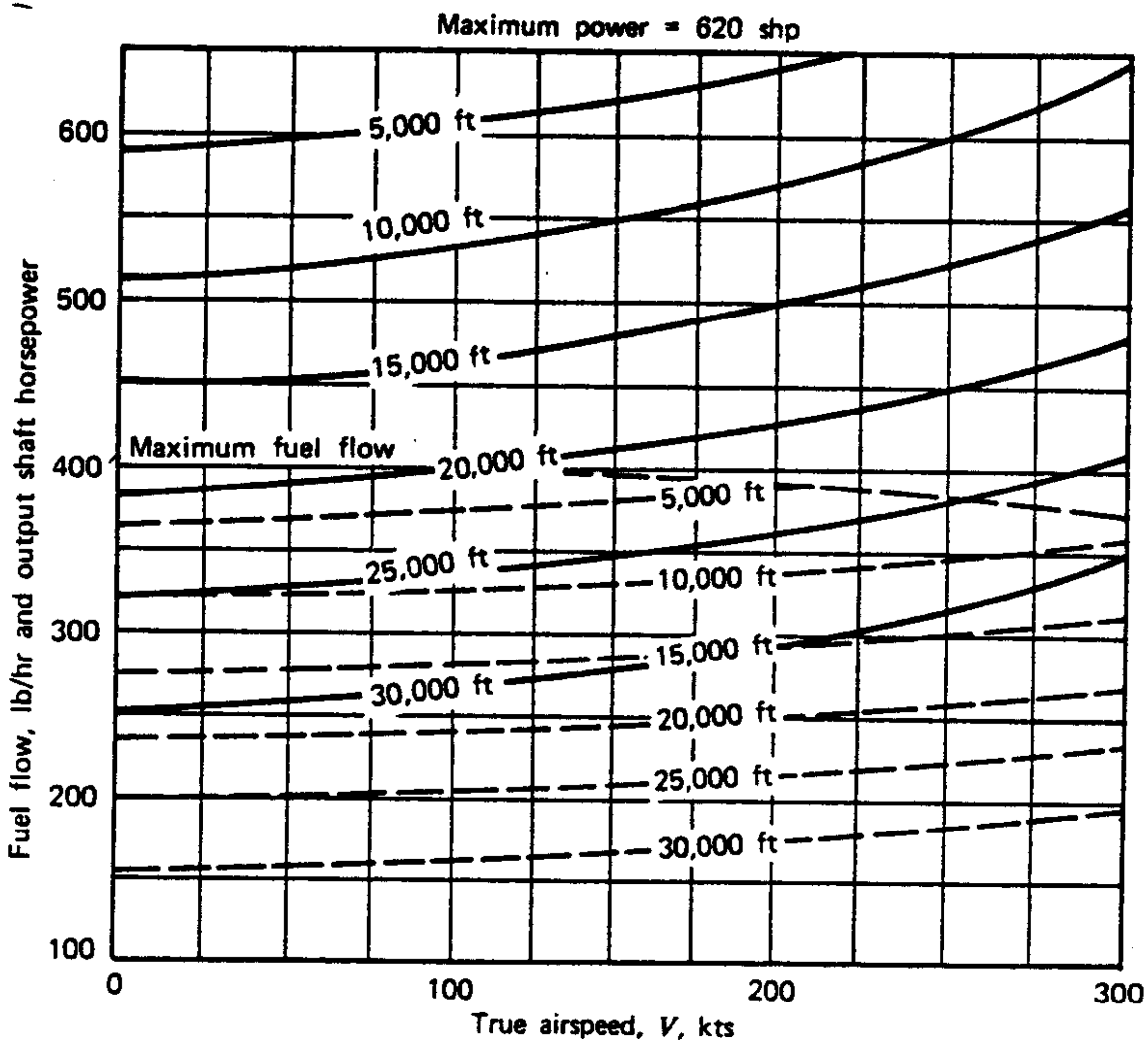
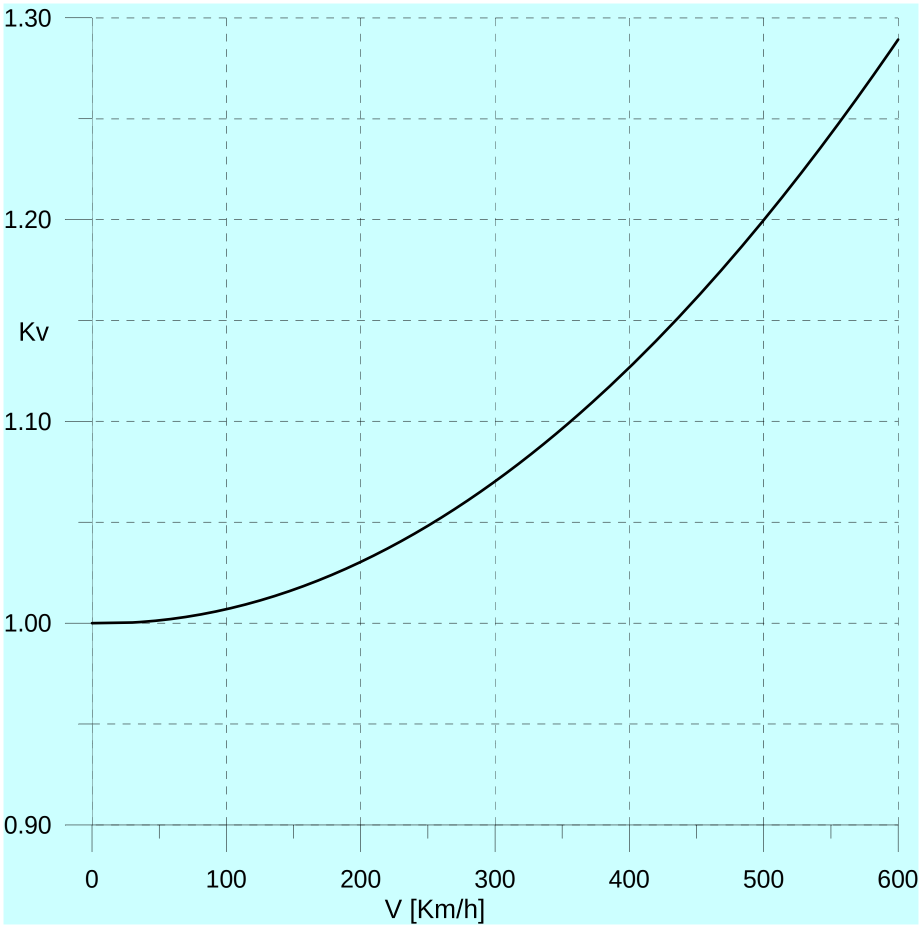


Figure 6.46a PT6A-27 maximum cruise performance. Prop speed—2200 rpm. (Courtesy, Pratt & Whitney of Canada.)

EFFETTO RAM !!

$$Kv = 1.00 - 0.0014 * (V/100) + 0.00827 * (V/100)^2$$

con V espressa in Km/h



EFFETTO Quota

$$\frac{\Pi_a}{\Pi_{a,0}} = \left(\frac{\rho}{\rho_0}\right)^n \qquad n = 0.7$$

O anche …
$$\frac{\Pi_a}{\Pi_{ao}} = \left(\frac{\rho}{\rho_0}\right) = \sigma$$

$$\boxed{\Pi_a = \Pi_{ao} \cdot \varphi \cdot \sigma \cdot Kv}$$

Cap.6 – Caratteristiche propuls

Turboelica

Consumo specifico

SFC=0.6-0.7 $\dfrac{\text{lb}}{\text{hp}\cdot\text{h}}$

Table 6.3 Weight and Performance Data for Turboprop Engines

Manufacturer/ Type	Weight (lbs)	ESHP/SHP/Prop RPM at maximum take–off setting, s.l.s.* (hp)	s.f.c. at take–off s.l.s. (lbs/hr/eshp)	ESHP/SHP/Prop RPM at maximum cruise setting, s.l.s.* (hp)	Massflow take–off s.l.s. (lbs/sec)
(1)/PT6A–11	328	528/500/2,200	0.647	528/500/2,200	???
(1)/PT6A–27	328	715/680/2,200	0.602	715/680/2,200	6.8
(1)/PT6A–34	331	783/750/2,200	0.595	783/750/2,200	???
(1)/PT6A–65B	481	1,174/1,100/1,700	0.536	1,174/1,100/1,700	9.5
(1)/PW118	861	1,892/1,800/1,300	0.498	1,593/1,513/1,300	???
(1)/PW123B	992	2,626/2,500/1,200	0.463	2,136/2,030/1,200	???
(1)/PW115	841	1,580/1,500/1,300	0.544	1,580/1,500/1,300	???
(2)/TPE331–1	336	705/665/???	0.605	690/650/???	6.2
(2)/TPE331–10	380	???/1,000/???	0.560	???	???
(3)/CT7–5	676	1,685/1,630/???	0.466	1,465/1,417/???	???
(3)/CT64–820–4	1,145	3,133/3,133/1,160	0.486	2,745/2,745/1,015	???
(4)/Dart RDa7 Mk535–2/TS1637	1,369	????/2,080/????	0.760	????/1,835/????	23.5
(5)/250–B17C	195	420/420/????	0.657	369/369/????	3.45
(5)/250–C30	240	650/650/????	0.592	557/557/????	5.6
(5)/T56–A–15	1,825	4,910/4,591/1,106	0.501	4,365/4,061/1,106	32.4

Type: (1) = Pratt & Whitney, Canada (3) = General Electric

(2) = Allied Signal (4) = Rolls Royce

(5) = Allison

* In calculating ESHP from SHP it is usually assumed, that 2.5 lbs of axial jet thrust is equivalent to 1 hp.

Cap.6 – Caratteristiche propulsive

PISTONI /ELICA

Potenza all'albero $\Pi_a = \Pi_{ao} \cdot \sigma \cdot \varphi$

Potenza disponibile $\boxed{\Pi_d = T \cdot V = \Pi_a \cdot \eta_p = \Pi_{ao} \cdot \sigma \cdot \varphi \cdot \eta_p}$

Spinta disponibile $\boxed{T_d = \Pi_d / V}$

Potenza all'albero sempre costante con la velocità di volo e dipendente dalla potenza di targa e dalla quota e dal grado di ammissione.
Potenza disponibile costante con V nell'ipotesi di considerare un'elica a passo variabile (o giri costanti).

Consumo specifico

$$\boxed{SFC = 0.40 \div 0.50 \frac{\mathrm{lb}}{\mathrm{hp} \cdot \mathrm{h}}}$$

Consumo specifico costante con la quota e la velocità di volo e dipendente solo dal motore.

Cap.6 – Caratteristiche propulsive

TURBOELICA /ELICA

Potenza all'albero $\Pi_a = \Pi_{ao} \cdot \sigma \cdot \varphi \cdot Kv$

Kv effetto *ram* Kv = 1.00 – 0.0014 * (V/100) +0.00827 * $(V/100)^2$ [V in Km/h] fig. 6.24

Potenza disponibile $\boxed{\Pi_d = T \cdot V = \Pi_a \cdot \eta_p = \Pi_{ao} \cdot \sigma \cdot \varphi \cdot Kv \cdot \eta_p}$

Spinta disponibile $\boxed{T_d = \Pi_d / V}$

Potenza all'albero variabile con la velocità di volo e dipendente dalla potenza di targa e dalla quota e dal grado di ammissione. Sempre accoppiato con elica a passo variabile(giri costanti), quindi η_p costante con la velocità di volo.

NB : Per analisi di prestazioni di velocità non al calcolatore anziché assumere la legge per il Kv data sopra, si può semplicemente assumere un valore di potenza all'albero incrementata di :

+ 5% per V all'incirca di 250 Km/h
+ 7% per V all'incirca di 300 Km/h (monorotori veloci)
+ 10% per V all'incirca di 350 Km/h
+ 13% per V all'incirca di 400 Km/h (velivoli bimotori tipo Cessna)
+ 17% per V all'incirca di 450 Km/h
+ 20% per V all'incirca di 500 Km/h (velivoli tipo ATR 42)

Consumo specifico

$$\boxed{SFC = 0.60 \div 0.70 \frac{lb}{hp \cdot h}}$$

Consumo specifico costante con la quota e la velocità di volo e dipendente solo dal motore.

Cap.6 – Caratteristiche propulsive

TURBOGETTO

Spinta disponibile $$\boxed{T_d = 0.80 \cdot T_o \cdot \sigma \cdot \varphi}$$

Potenza disponibile $$\boxed{\Pi_d = T_d \cdot V}$$

Spinta disponibile costante con la velocità (con il Mach) di volo.
Variazione con la quota data da σ. Dipendenza dal grado di ammissione φ.
Solo l'80% della spinta T_o (spinta massima al decollo del motore) può essere utilizzata in volo (crociera o salita, cioè condizioni continuative).

Consumo specifico

$$\boxed{SFCJ = 1.00 \div 2.00 \frac{lb}{lb \cdot h}}$$

Consumo specifico costante con la quota e la velocità di volo e dipendente solo dal motore.

TURBOFAN

Spinta disponibile $\boxed{T_d = 0.80 \cdot T_o \cdot K_{MZ} \cdot \varphi}$

Con K_{MZ} variazione della spinta massima utilizzabile in volo in funzione di Mach e quota di volo, cioè K_{MZ}=funzione di (Mach, quota)

Relazione più semplice da utilizzare nell'analisi di prestazioni

$$\boxed{T_d = 0.80 \cdot T_o \cdot \sigma \cdot \varphi}$$

Potenza disponibile $\boxed{\Pi_d = T_d \cdot V}$

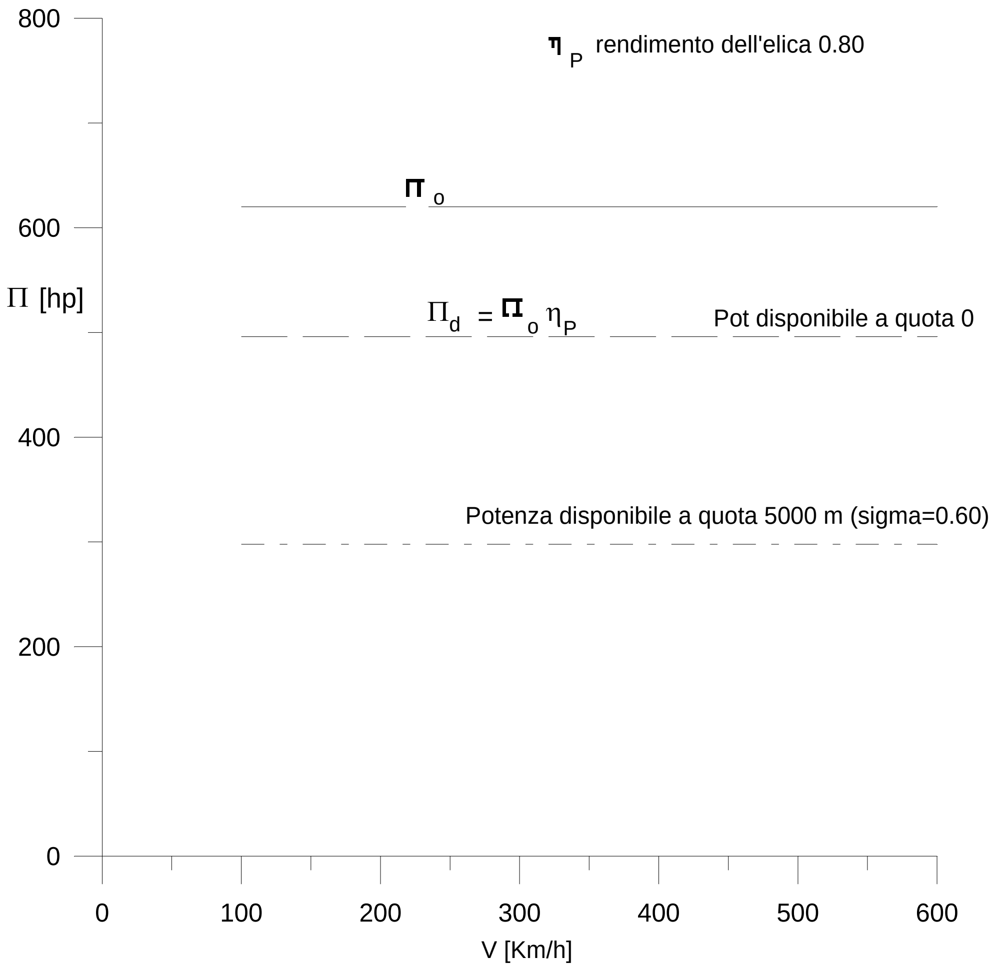
La relazione approssimata fornisce una spinta disponibile costante con la velocità (con il Mach) di volo e variazione con la quota data da σ. Dipendenza dal grado di ammissione φ.
Solo l'80% della spinta T_o (spinta massima al decollo del motore) può essere utilizzata in volo (crociera o salita , cioè condizioni continuative).

Consumo specifico

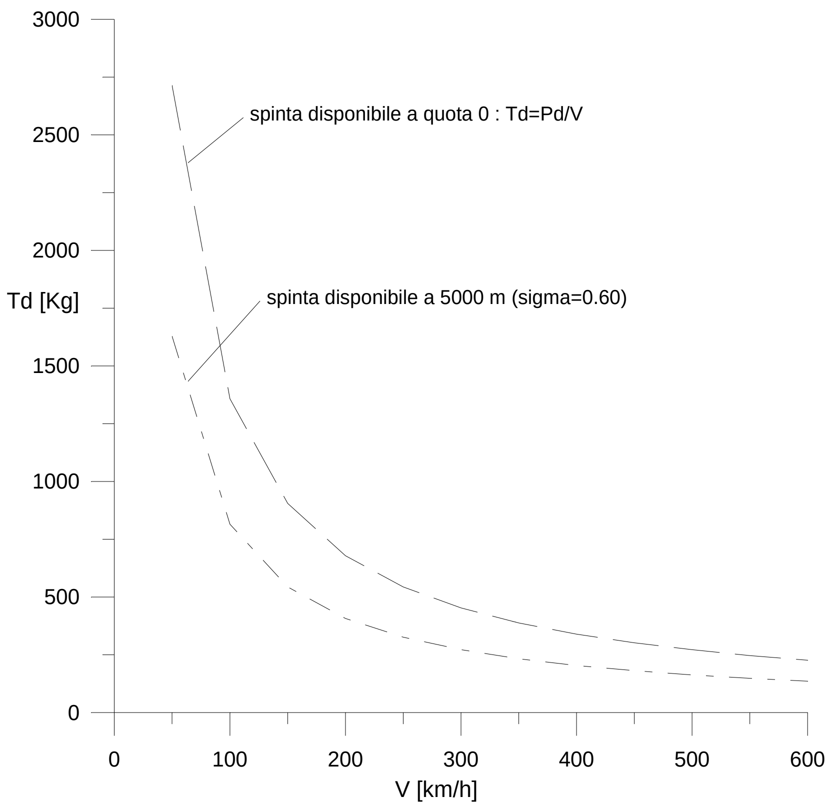
$$\boxed{SFCJ = 0.60 \div 0.70 \frac{lb}{lb \cdot h}}$$

Consumo specifico costante con la quota e la velocità di volo e dipendente solo dal motore.

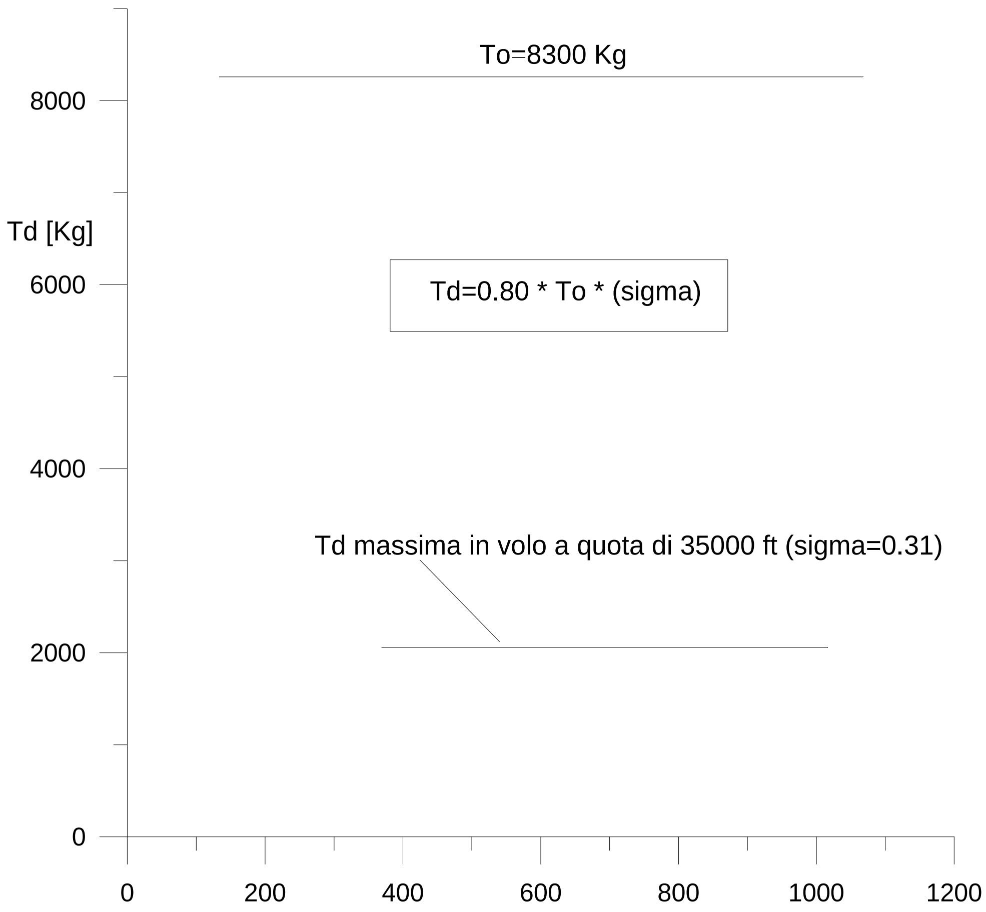
Cap.6 – Caratteristiche propulsive ELICA



Motore Pratt&Whitney PT6A-27. (Potenza di targa, cioè potenza al decollo, o anche massima a quota 0=620 hp). Rendimento dell'elica a passo variabile ηP =0.80. Tener presente che Td=Pd/V fornisce Td in [N] se Pd è in [Watt] e V in [m/s].

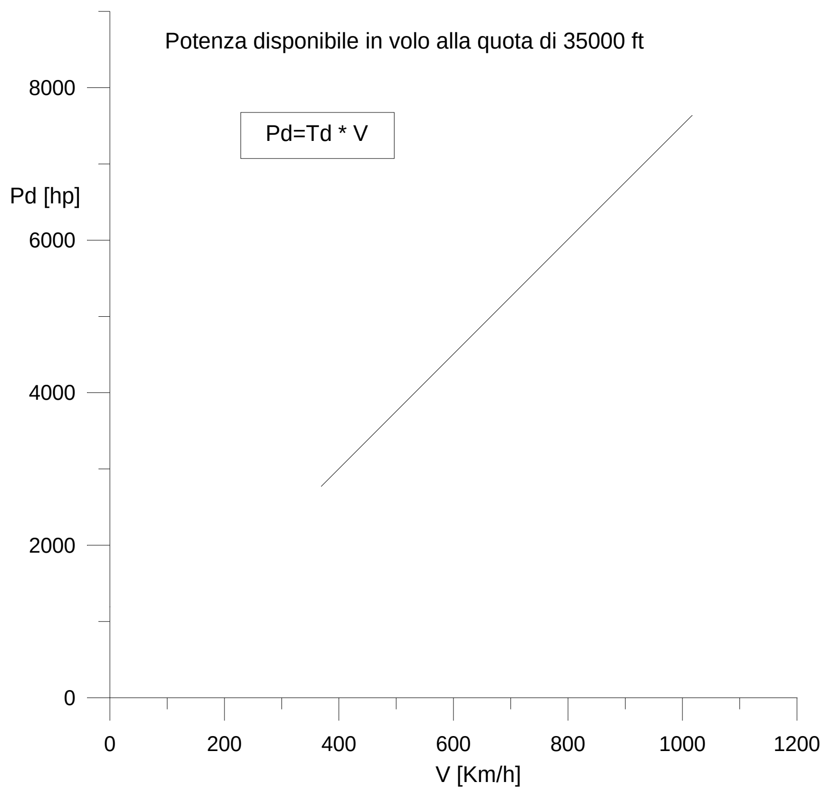


Cap.6 – Caratteristiche propulsive



TURBOFAN

Motore turbofan JT9-D (Motore del velivolo MD-80). Spinta massima al decollo To=8300 Kg.



Cap.6 – Caratteristiche propulsive