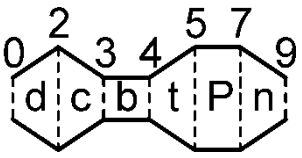
| | 2 | 3 | 4 | 5 | 7 | 9 | |
|---|---|---|---|---|---|---|---|
| | diff | comp | CC | Tur | AB | No | |
| $c_p$ | 1004 | | | 1152 | | 1243 | J/kgs |
| $\gamma$ | 1.4 | | | 1.33 | | 1.3 | |
| $\pi$ | 0.96 | 10 | 0.95 | | 0.98 | 0.97 | |
| $\eta$, $e_{c,t}$ | | 0.9 | 0.99 | 0.9 | 0.99 | | |
| Tt | | | | 1750 | | 2250 | |
| M0 | 2 | | po/p9 | 1 | QR | 42800 | kJ/kgK |
| T0 | 250 | K | p0 | 101,300 | Pa | $\eta_m$ | 0.99 |
| k | 0.28571 | | | 0.24812 | | 0.23077 | |
| R | 286.857 | | | 285.835 | | 286.846 | kJ/kgK |
| a0 | 316.86 | m/s | V0 | 633.719 | m/s | | |
| $\tau_r$=$\psi$ | 1.8 | | | | | | |
| Section | c | t | $\lambda$ | | | | t |
| $\tau$ | 2.07711 | 0.76251 | 8.03187 | | | $\pi$ | 0.29696 |
| Section | 0 | 2 | 3 | 4 | 5 | 7 | 9 |
| Tt | 450 | 450 | 934.701 | 1750 | 1334.4 | | 1334.4 |
| pt | 792,617 | 760,912 | 7.61E+06 | 7.23E+06 | 2.15E+06 | | 2.08E+06 |
| Section | f | Pt9/p9 | M9 | Tt9/T9 | T9/T0 | a9 | |
| 3 | 0.0267 | 2.06E+01 | 2.60209 | 2.11719 | 2.52107 | 489.492 | m/s |
| 5 | 0 | V9 | | V9/a0 | V9/a0 eff | F/ma0 | Num |
| | | 1273.7 | m/s | 4.01977 | 4.01977 | 2.1271 | 1.26E+06 |
| Section | t | th | p | 0 | TSFC*1e3 | | |
| $\eta$ | 0.913 | 0.55303 | 0.67581 | 0.37374 | 0.039617 | | |




$$k = \frac{\gamma - 1}{\gamma} = \frac{0.4}{1.4} = 0.2867 \quad k_5 = \frac{\gamma_5 - 1}{\gamma_5} = \frac{0.33}{1.33} = 0.2481$$

$$k_9 = \frac{\gamma_9 - 1}{\gamma_9} = \frac{0.3}{1.3} = 0.2308 \quad R_9 = 0.2308 \cdot 1243 = 286.8 J/kgK$$

$$R = kc_p = 0.2867 \cdot 1004 = 286.9 J/kgK \quad R_5 = 0.2481 \cdot 1152 = 285.8 J/kgK$$

$$a_0 = \sqrt{\gamma R T_0} = 1.4 \cdot 286.9 \cdot 250 = 316.9 m/s$$

$$V_0 = M_0 \cdot a_0 = 2.00 \cdot 316.9 = 633.7 m/s$$

## Presa d'aria

$$\tau_r = \psi_0 = 1 + \frac{\gamma - 1}{2} M_0^2 = 1 + 0.2 \cdot 4 = 1.800$$

$$T_{t0} = T_{t2} = T_0 \tau_r = 250 \cdot 1.800 = 450 K$$

$$p_{t0} = \tau_r^{\frac{1}{k}} p_0 = 1.800^{\frac{1}{0.2867}} 1.013 \cdot 10^5 = 792.6 kPa$$

$$p_{t2} = p_{t0} \pi_d = 792.6 \cdot 0.96 = 760.9 kPa$$

**Compressore**

$\tau_c = \pi_c^{\frac{k}{e_c}} = 10^{\frac{0.2867}{0.90}} = 2.077$

$p_{t3} = p_{t2}\pi_c = 760.9 \cdot 10 = 7609kPa$

$T_{t3} = T_{t2}\tau_c = 450 \cdot 2.077 = 934.7K$

**Camera di combustione**

$p_{t4} = p_{t3}\pi_b = 7609 \cdot 0.95 = 7229kPa$

$\tau_\lambda = \frac{c_{p5}T_{t4}}{c_pT_0} = \frac{1152 \cdot 1750}{250 \cdot 1004} = 8.032$

$f = \frac{\tau_\lambda - \tau_c\tau_r}{Q_R\eta_b/(c_pT_0) - \tau_\lambda} = \frac{8.032 - 2.077 \cdot 1.8}{42.8 \cdot 10^6 \cdot 0.99/(250 \cdot 1004) - 8.032} = 0.02670$

**Turbina**

$\tau_t = 1 - \frac{\tau_r(\tau_c - 1)}{\eta_m(1+f)\tau_\lambda} = 1 - \frac{1.8 \cdot 1.077}{0.99 \cdot 1.027 \cdot 8.032} = 0.7625$

$\pi_t = \tau_t^{\frac{1}{k_5 e_t}} = 0.7625^{\frac{1}{0.2481 \cdot 0.900}} = 0.2970$

$p_{t5} = p_{t4}\pi_t = 7229 \cdot 0.2970 = 2147kPa$

$T_{t5} = T_{t4}\tau_t = 1750 \cdot 0.7625 = 1334K$

**Ugello (AB Off)**

$p_{t9} = p_{t5}\pi_n = 2147 \cdot 0.97 = 2082kPa$

$\frac{p_{t9}}{p_9} = \frac{p_{t9}}{p_9}\frac{p_9}{p_0} = \frac{2082}{101.3} \cdot 1 = 20.55$

$\psi_9 = \left(\frac{p_{t9}}{p_9}\right)^{k_5} = 20.55^{0.2481} = 2.117$

$M_9 = \sqrt{\frac{2}{\gamma_5 - 1}[\psi_9 - 1]} = \sqrt{\frac{2}{.33}[1.117]} = 2.602$

$M_9 > 1 \rightarrow p_9 = p_0$ (Si dovrebbe verificare rapporto aree)

$T_9 = T_{t9}/\psi_9 = T_{t5}/\psi_9 = 1334/2.117 = 630.3K$

$a_9 = \sqrt{\gamma_5 R_5 T_9} = \sqrt{1.33 \cdot 285.8 \cdot 630.3} = 489.5m/s$

$V_9 = M_9 \cdot a_9 = 2.602 \cdot 489.5 = 1274m/s$

$\frac{V_9}{a_0} = \frac{1274}{316.9} = 4.020$

**Spinta**

$$V_{9.e} = V_9\left[1 + \frac{1 - \frac{p_0}{p_9}}{\gamma_9 M_9^2}\right] = V_9$$

$$\frac{F_u}{\dot{m}_0 a_0} = (1+f)\frac{V_{9.e}}{a_0} - M_0 = 1.027 \cdot 4.020 - 2.00 = 2.127$$

$$TSFC = \frac{f}{F_u/\dot{m}_0} = \frac{0.02670 \cdot 10^3}{2.127 \cdot 316.9} = 0.03962 \frac{g}{s}\frac{1}{N}$$

$$\eta_{th} = \frac{\mathrm{a}_0^2[(1+f)V_{9.e}^2/\mathrm{a}_0^2 - M_0^2]}{2fQ_R} =$$

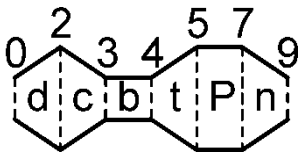
$$\eta_{th} = \frac{316.9^2[1.027 \cdot 4.020^2 - 2.000^2]}{2 \cdot 0.02670 \cdot 42.8 \cdot 10^6} = \frac{1.264 \cdot 10^6}{2.286 \cdot 10^6} = 0.553 = 55.3\%$$

$$\eta_p = \frac{2\frac{F_u}{\dot{m}_0 a_0} a_0 V_0}{\mathrm{a}_0^2[(1+f)V_{9.e}^2/\mathrm{a}_0^2 - M_0^2]} = \frac{2 \cdot 2.127 \cdot 316.9 \cdot 633.7}{1.264 \cdot 10^6} = 0.675 = 67.5\%$$

$$\eta_0 = \eta_{th}\eta_p = 0.553 \cdot 0.675 = 0.374 = 37.4\%$$

**AB ON**

| Section | 0 | 2 | 3 | 4 | 5 | 7 | 9 |
|---|---|---|---|---|---|---|---|
| Tt | 450 | 450 | 934.701 | 1750 | 1334.4 | | 1334.4 |
| pt | 792,617 | 760,912 | 7.61E+06 | 7.23E+06 | 2.15E+06 | | 2.08E+06 |
| Section | f | Pt9/p9 | M9 | Tt9/T9 | T9/T0 | a9 | |
| 3 | 0.0267 | 2.06E+01 | 2.60209 | 2.11719 | 2.52107 | 489.492 | m/s |
| 5 | 0 | V9 | | V9/a0 | V9/a0 eff | F/ma0 | Num |
| | | 1273.7 | m/s | 4.01977 | 4.01977 | 2.1271 | 1.26E+06 |
| Section | t | th | p | 0 | TSFC*1e3 | | |
| $\eta$ | 0.913 | 0.55303 | 0.67581 | 0.37374 | 0.039617 | | |




$$k_9 = \frac{\gamma_9 - 1}{\gamma_9} = \frac{0.3}{1.3} = 0.2308 \quad R_9 = 0.2308 \cdot 1243 = 286.8 J/kgK$$

**Post Bruciatore**

$$p_{t7} = p_{t5}\pi_{AB} = 2147 \cdot 0.98 = 2104 kPa$$

$$\tau_{\lambda.AB} = \frac{c_{p9}T_{t7}}{c_p T_0} = \frac{1243 \cdot 2250}{250 \cdot 1004} = 11.14$$

$$f_{AB} = \frac{(1+f)(\tau_{\lambda.AB} - \tau_\lambda \tau_t)}{Q_{R.AB}\eta_{b.AB}/(c_p T_0) - \tau_{\lambda.AB}} = \frac{1.027(11.14 - 8.032 \cdot 0.7625)}{\frac{42.8 \cdot 10^6 \cdot 0.99}{250 \cdot 1004} - 11.14} = 0.03268$$

**Ugello**

$p_{t9} = p_{t7}\pi_n = 2104 \cdot 0.97 = 2041kPa$

$\frac{p_{t9}}{p_9} = \frac{p_{t9}}{p_9}\frac{p_9}{p_0} = \frac{2041}{101.3} \cdot 1 = 20.14$

$\psi_9 = \left(\frac{p_{t9}}{p_9}\right)^{k_5} = 20.14^{0.2308} = 2.000$

$M_9 = \sqrt{\frac{2}{\gamma_9 - 1}[\psi_9 - 1]} = \sqrt{\frac{2}{.30}[1.000]} = 2.582$

$M_9 > 1 \rightarrow p_9 = p_0$ (Si dovrebbe verificare rapporto aree)

$T_9 = T_{t9}/\psi_9 = 2250/2.000 = 1125K$

$a_9 = \sqrt{\gamma_9 R_9 T_9} = \sqrt{1.30 \cdot 286.8 \cdot 1125} = 647.6m/s$

$V_9 = M_9 \cdot a_9 = 2.582 \cdot 647.6 = 1672m/s$

$\frac{V_9}{\mathrm{a}_0} = \frac{1672}{316.9} = 5.277$

**Spinta**

$V_{9.e} = V_9\left[1 + \frac{1 - \frac{p_0}{p_9}}{\gamma_9 M_9^2}\right] = V_9$

$\frac{F_u}{\dot{m}_0 a_0} = (1 + f + f_{AB})\frac{V_{9.e}}{a_0} - M_0 = (1 + 0.0267 + 0.0327) \cdot 5.277 - 2.00 = 3.591$

$TSFC = \frac{f + f_{AB}}{F_u/\dot{m}_0} = \frac{0.05938 \cdot 10^3}{3.591 \cdot 316.9} = 0.05219\frac{g}{s}\frac{1}{N}$

$\eta_{th} = \frac{\mathrm{a}_0^2[(1 + f + f_{AB})V_{9.e}^2/\mathrm{a}_0^2 - M_0^2]}{2(f + f_{AB})Q_R} =$

$\eta_{th} = \frac{316.9^2[1.059 \cdot 5.277^2 - 2.000^2]}{2 \cdot 0.05938 \cdot 42.8 \cdot 10^6} = \frac{2.561 \cdot 10^6}{5.083 \cdot 10^6} = 0.504 = 50.4\%$

$\eta_p = \frac{2\frac{F_u}{\dot{m}_0 a_0}a_0 V_0}{\mathrm{a}_0^2[(1 + f + f_{AB})V_{9.e}^2/\mathrm{a}_0^2 - M_0^2]} = \frac{2 \cdot 2.127 \cdot 316.9 \cdot 633.7}{1.264 \cdot 10^6} = 0.563 = 56.3\%$

$\eta_0 = \eta_{th}\eta_p = 0.504 \cdot 0.563$=0.284=28.4%