MATERIALE DI SUPPORTO TURBOMACCHINE

Equazione di continuità (conservazione della massa)

$$\dot{m} = \rho C_n A = cost$$

Triangoli delle velocità

$$\vec{C} = \vec{U} + \vec{W}$$

Equazione di Eulero (conservazione del momento angolare)

$$T = \dot{m}(r_2 C_{u2} - r_1 C_{u1})$$

$$P = T\omega = \dot{m}(U_2 C_{u2} - U_1 C_{u1})$$

Primo principio della termodinamica (conservazione dell'energia)

$$P[W] = \dot{m}\left[\frac{kg}{s}\right] L\left[\frac{J}{kg}\right] \qquad L = lavoro\ specifico$$

$$P = \dot{m}(h_2^0 - h_1^0) = \dot{m}(h_2 + C_2^2/2 - h_1 - C_1^2/2)$$

Risultati utili

$$L = L_{az} + L_{reaz} = C_2^2/2 - C_1^2/2 + U_2^2/2 - U_1^2/2 + W_1^2/2 - W_2^2/2$$

$$L_{az} = C_2^2/2 - C_1^2/2$$

$$L_{reaz} = U_2^2/2 - U_1^2/2 + W_1^2/2 - W_2^2/2$$

$$h_2 - h_1 = U_2^2/2 - U_1^2/2 + W_1^2/2 - W_2^2/2$$

$$h_{2rel}^0 - h_{1rel}^0 = U_2^2/2 - U_1^2/2$$

$$h_2^0 - h_1^0 = U_2 C_{u2} - U_1 C_{u1}$$

Grado di reazione

$$R = \frac{L_{reaz}}{L} = \frac{h_2 - h_1}{h_2^0 - h_1^0}$$

Rotalpia

$$I = h + W^2/2 - U^2/2 = cost$$

$$I = h_{rel}^0 - U^2/2 = cost$$

$$I = h^0 - UC_u = cost$$

Trasformazione adiabatica reversibile (isentropica)

$$\delta Q = 0 \qquad ds = \frac{\delta Q}{T} + ds_{irr} = 0 \qquad L_{is} = \int_1^{2is} v dp \qquad \frac{p}{\rho^k} = cost$$

Trasformazione adiabatica irreversibile (reale)

$$\delta Q = 0 \qquad ds = ds_{irr} \qquad L_{irr} > L_{is} \qquad compressore$$

$$\delta Q = 0 \qquad ds = ds_{irr} \qquad L_{irr} < L_{is} \qquad turbina$$

Trasformazione reversibile politropica (equivalente)

$$\delta Q = Tds \qquad ds_{irr} = 0 \qquad L_{irr} > L_{pol} = \int_1^2 v dp > L_{is} \qquad \frac{p}{\rho^n} = cost \qquad n > k \qquad compressore$$

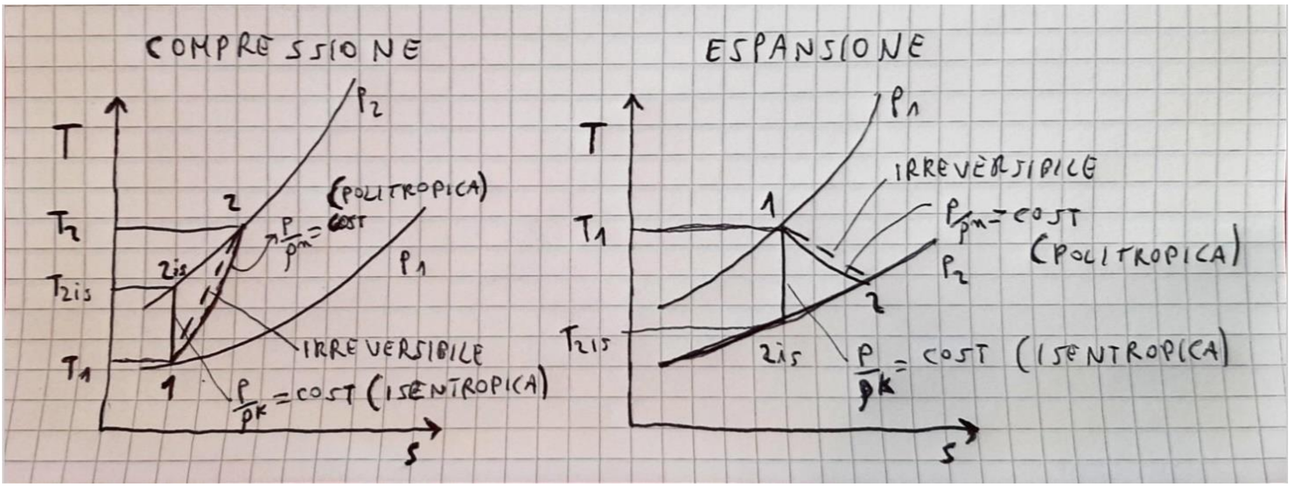
$$\delta Q = Tds \qquad ds_{irr} = 0 \qquad L_{irr} < L_{is} < L_{pol} = \int_1^2 v dp \qquad \frac{p}{\rho^n} = cost \qquad n < k \qquad turbina$$

$$\frac{n-1}{n} = \frac{k-1}{k\eta_{pol}} \quad \leftrightarrow \quad \eta_{pol} = \frac{k-1}{k}\frac{n}{n-1} \qquad compressore$$

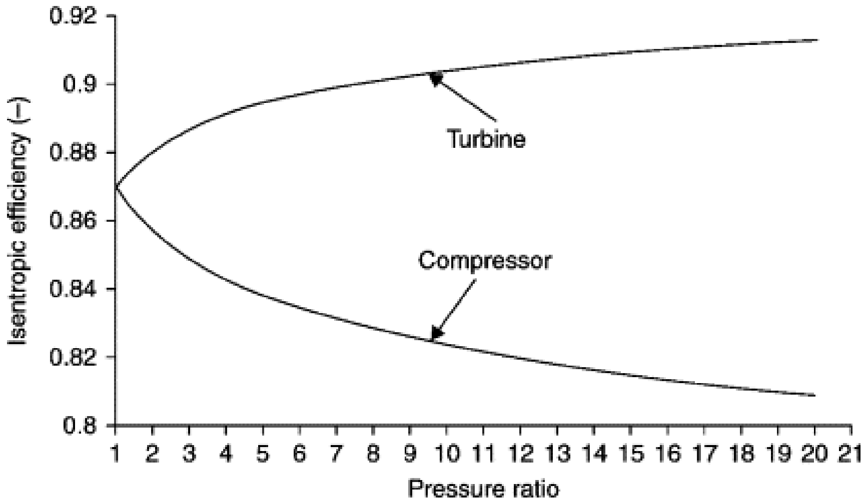
$$\frac{n-1}{n} = \frac{k-1}{k}\eta_{pol} \quad \leftrightarrow \quad \eta_{pol} = \frac{n-1}{n}\frac{k}{k-1} \qquad turbina$$

$$\eta_{pol} = \frac{L_{pol}}{L_{irr}} \quad > \quad \eta_{is} = \frac{L_{is}}{L_{irr}} \qquad \eta_{is} = \frac{\left(\pi_c^{(k-1)/k} - 1\right)}{\left(\pi_c^{(k-1)/k\eta_{pol}} - 1\right)} \qquad compressore$$

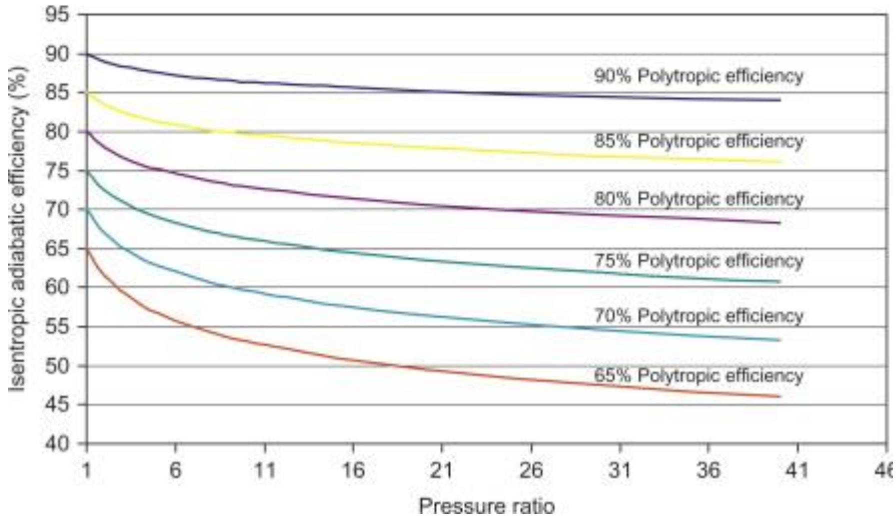
$$\eta_{pol} = \frac{L_{irr}}{L_{pol}} \quad < \quad \eta_{is} = \frac{L_{irr}}{L_{is}} \qquad \eta_{is} = \frac{\left(1 - \pi_e^{\eta_{pol}(k-1)/k}\right)}{\left(1 - \pi_e^{(k-1)/k}\right)} \qquad turbina$$



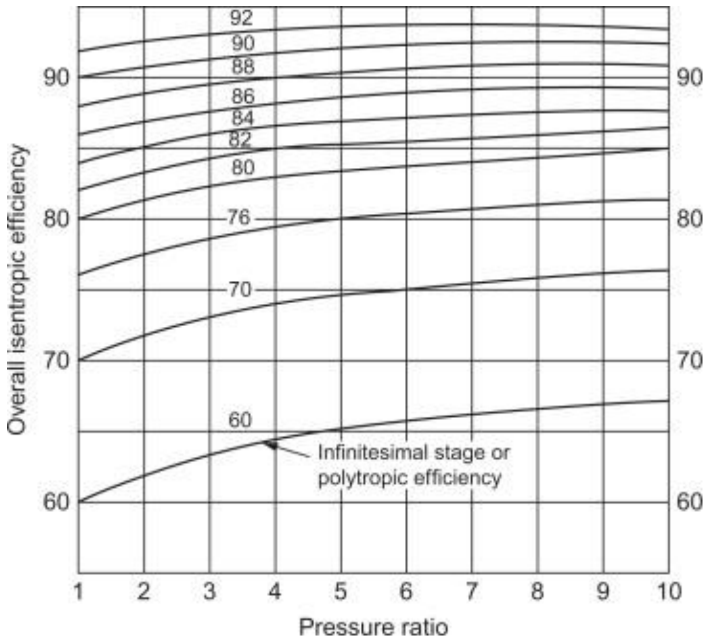
Confronto tra trasformazione isentropica, politropica reversibile e adiabatica irreversibile in compressione (sinistra) ed espansione (destra)



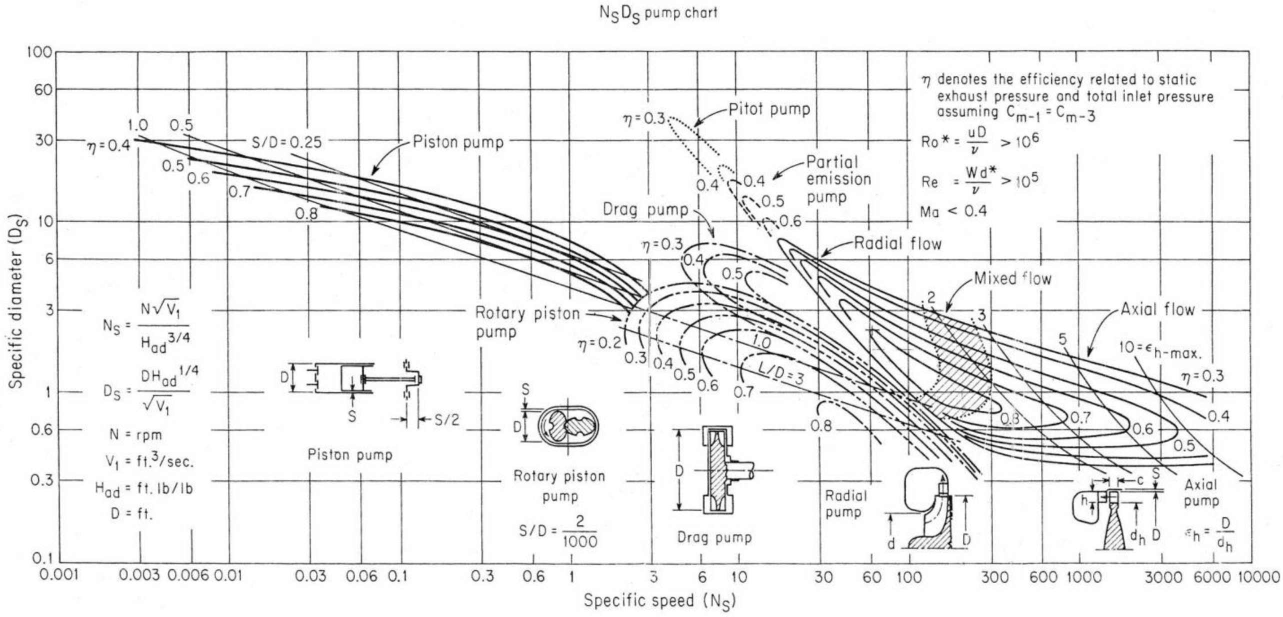
Relazione rendimento politropico vs rendimento isentropico



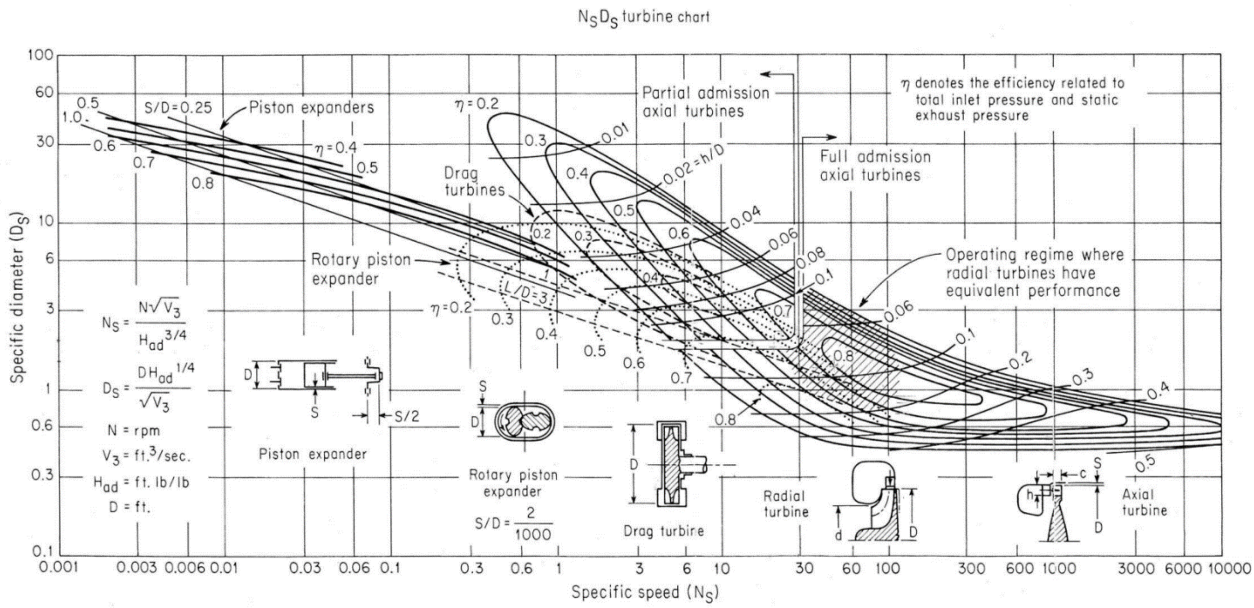
Relazione rendimento politropico vs rendimento isentropico in compressione



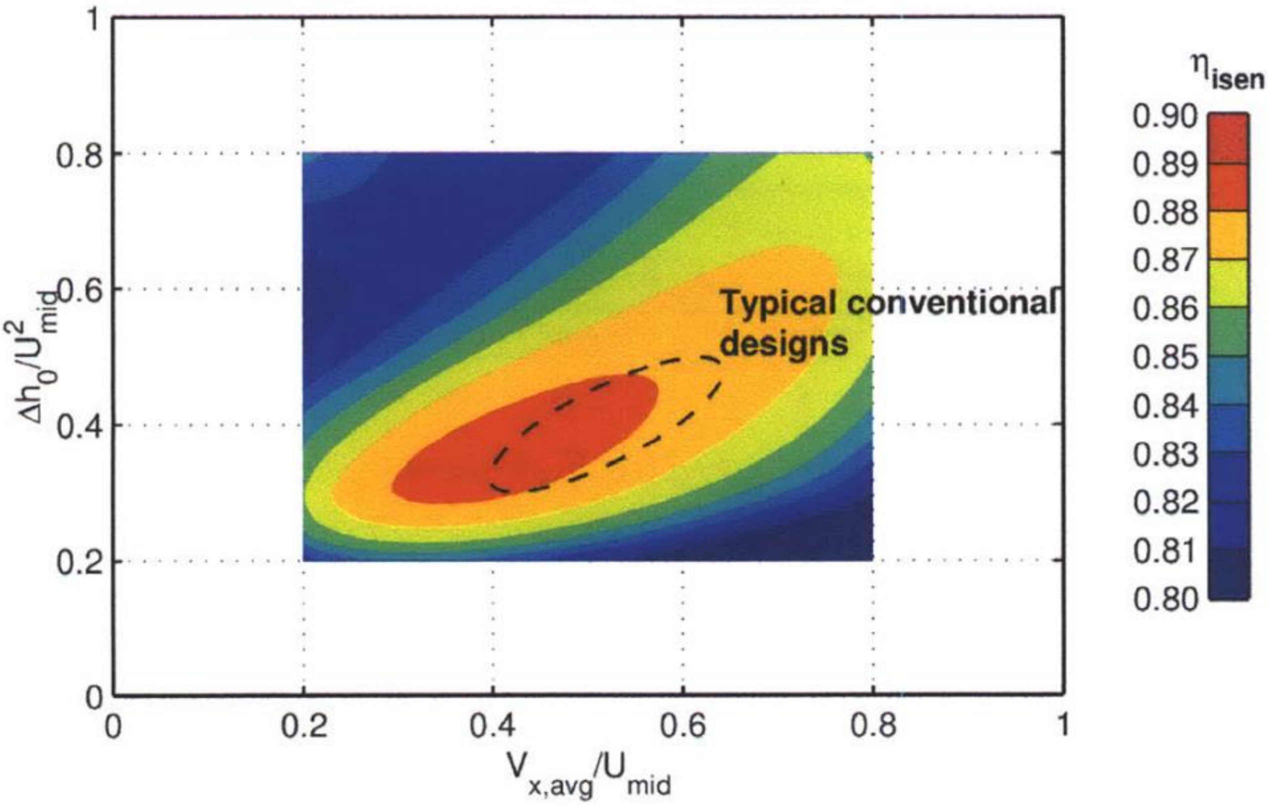
Relazione rendimento politropico vs rendimento isentropico in espansione



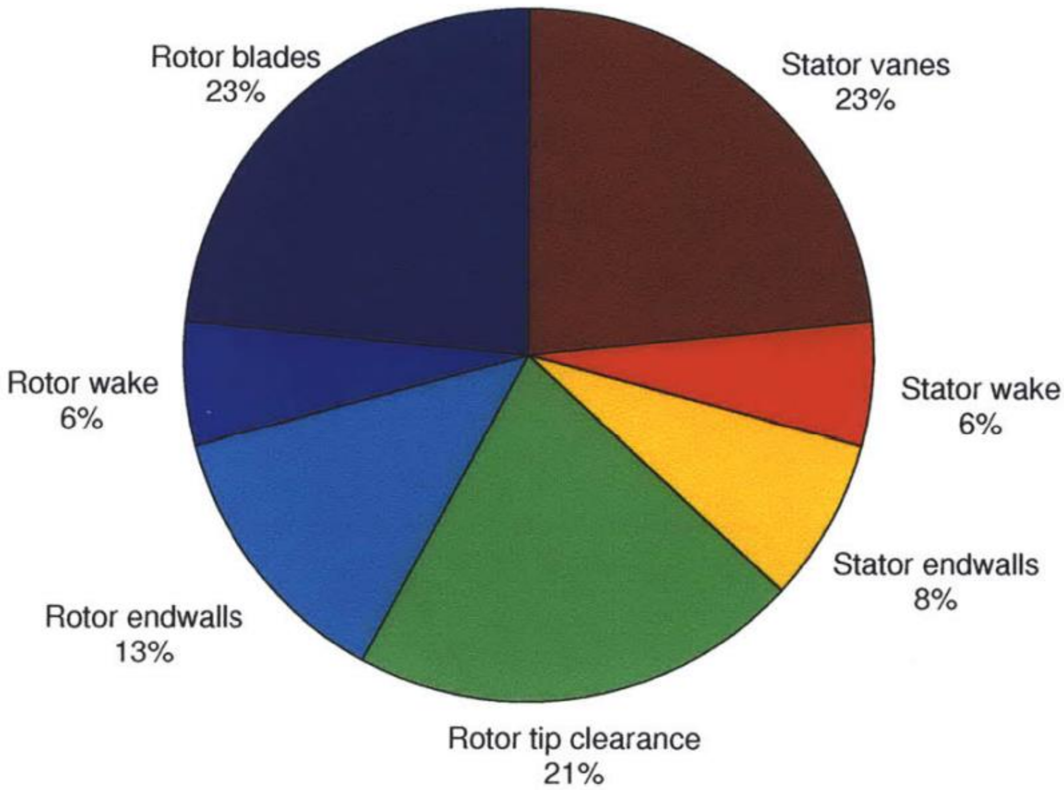
Pump selection chart



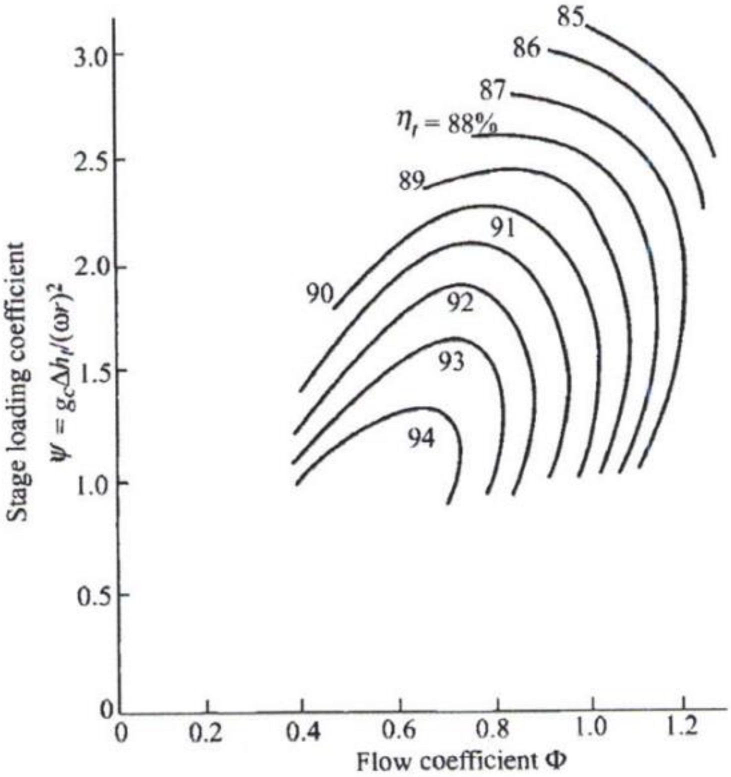
Turbine selection chart



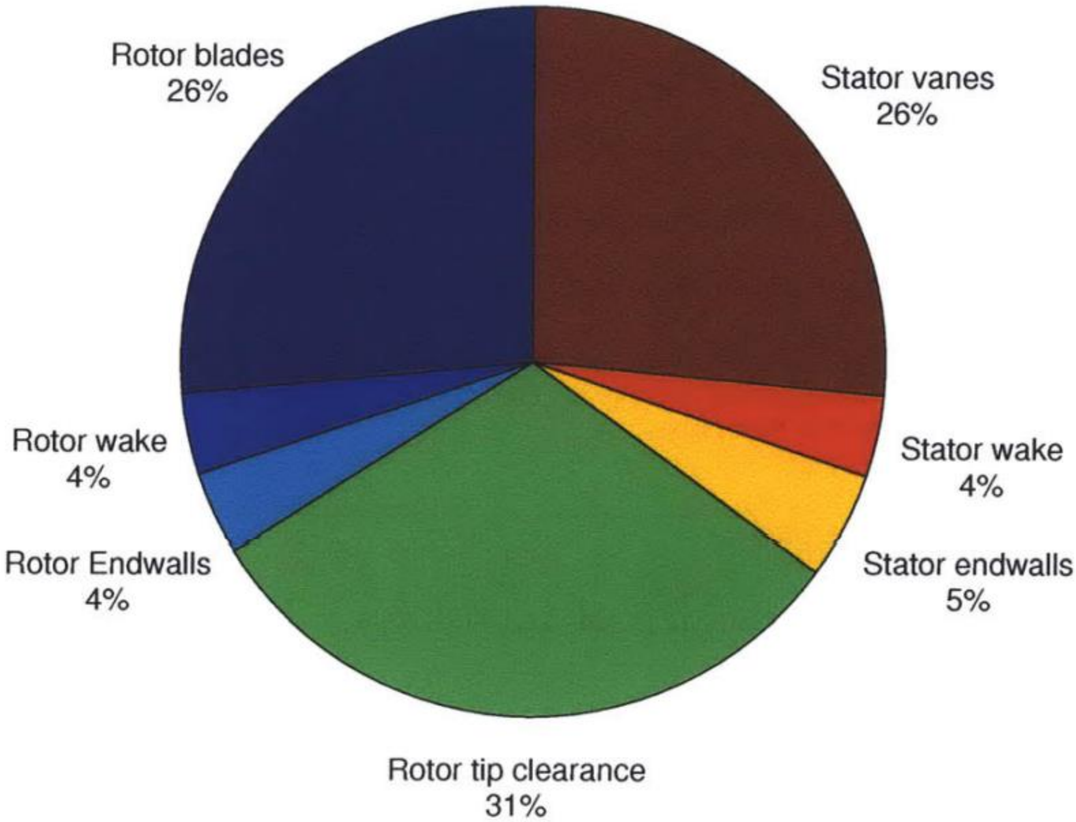
Smith chart, one-dimensional correlation of Wright & Miller, reproduced from Dickens & Day



Breakdown of losses at peak efficiency for a compressor stage



Turbine Smith chart based on experimental data, as produced in Mattingly



Breakdown of losses at peak efficiency for an uncooled turbine stage