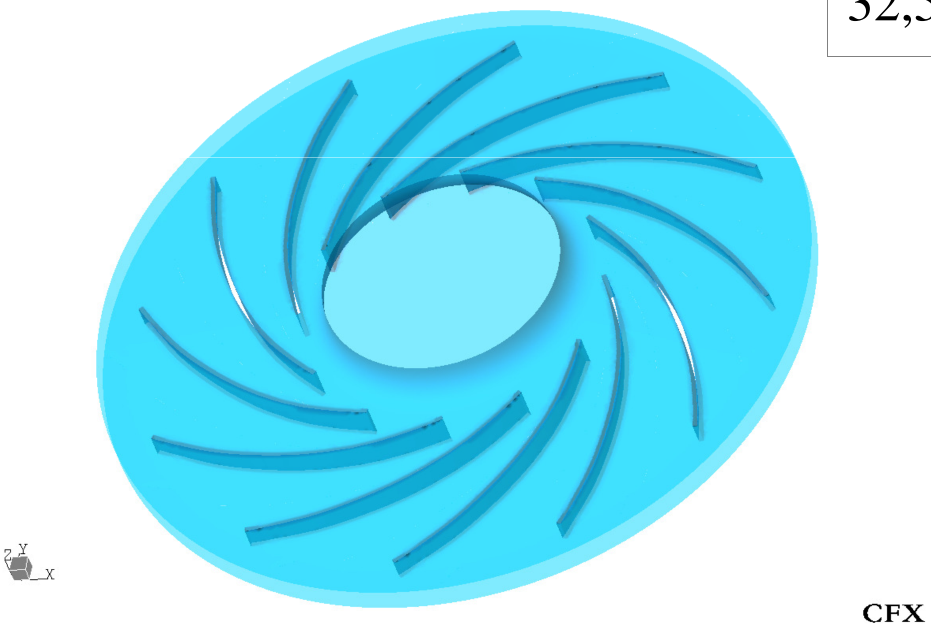
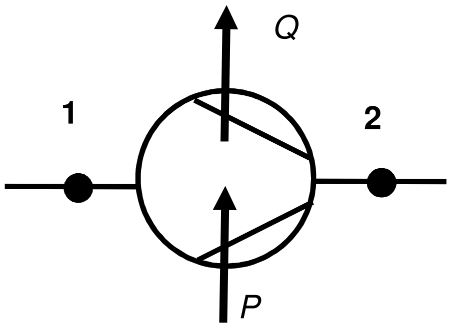
5. TURBOBLOWERS AND TURBOCOMPRESSORS

5.1. Blowers

Q [l/s]	*n [1/min]*	Δp_t *[Pa]*	ψ_t
32,5	32500	24386	1,16



5.1.2. Work process



$$\frac{P}{q_m} - \frac{Q}{q_m} = \left[\frac{v^2}{2} + gh + U + \frac{p}{\rho}\right]_1^2 = i_{t2} - i_{t1}$$

$$P = q_m\left[\frac{v^2}{2} + U + \frac{p}{\rho}\right]_1^2 \qquad U = c_V T \qquad \frac{p}{\rho} = RT = \left(c_p - c_V\right)T$$

$$P = q_m c_p\left[\frac{v^2}{2c_p} + T\right]_1^2 \qquad \frac{v^2}{2c_p} + T = T_{din} + T = T_t$$

$$\boxed{P = q_m c_p\left(T_{t2} - T_{t1}\right)} \qquad \boxed{P = q_m c_p\left(T_2 - T_1\right)}$$

5.1.3. Energetic aspects

$$\eta_e = \frac{c_p dT - dq}{c_p dT} \qquad dq = c_V dT + pd\left(\frac{1}{\rho}\right)$$

$$RT = p/\rho \qquad R\,dT = p\,d\left(\frac{1}{\rho}\right) + dp\left(\frac{1}{\rho}\right)$$

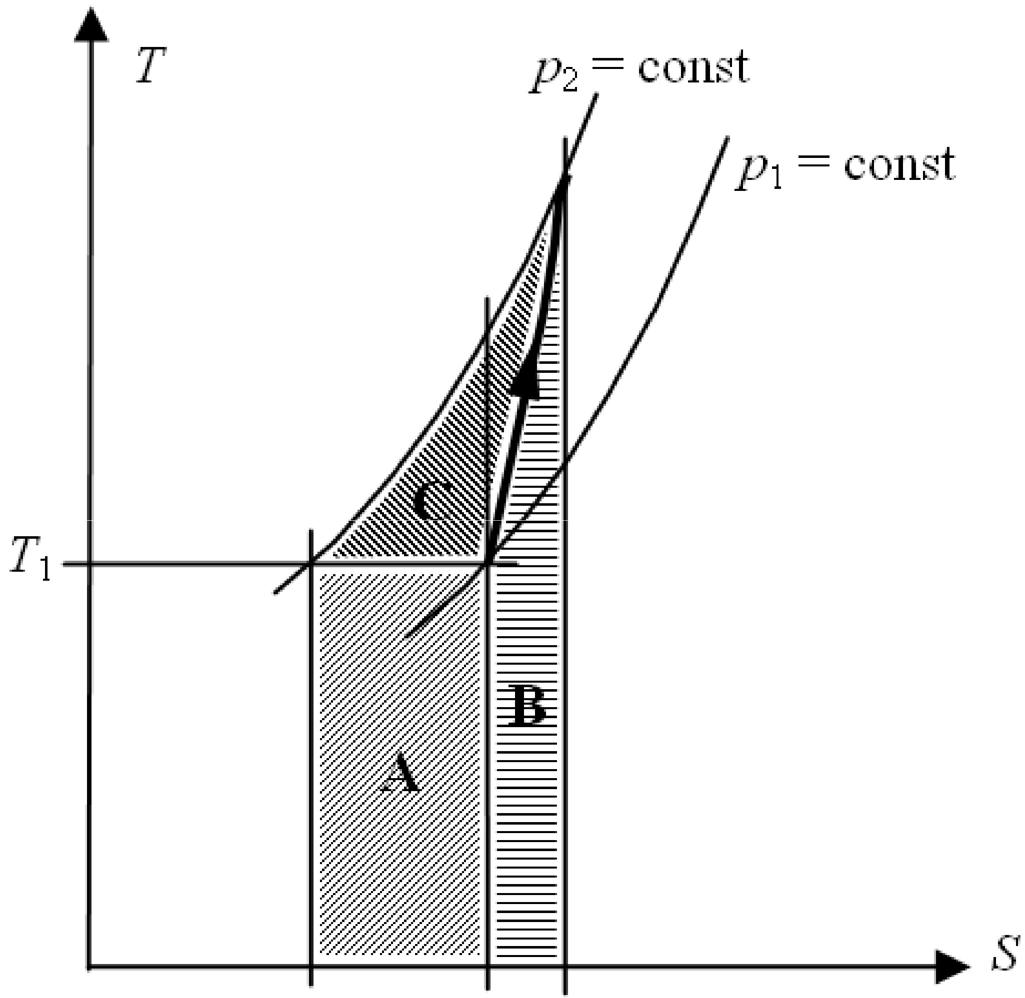
$$dq = c_V dT + R\,dT - dp\left(\frac{1}{\rho}\right) = c_P dT - dp\left(\frac{1}{\rho}\right)$$

$$\eta_e = \frac{dp\,\frac{1}{\rho}}{c_p dT} \qquad \frac{1}{\rho} = \frac{RT}{p} \qquad \eta_e = \frac{dp\,R\,T}{c_p dT\;p}$$

$$\frac{dT}{T} = \frac{R}{c_p \eta_e}\frac{dp}{p}$$

$$\boxed{\eta_p = \frac{\kappa - 1}{\kappa}\frac{\ln\frac{p_2}{p_1}}{\ln\frac{T_2}{T_1}}}$$

$$\boxed{\frac{T_2}{T_1} = \left(\frac{p_2}{p_1}\right)^{\frac{\kappa-1}{\kappa\,\eta_p}}}$$



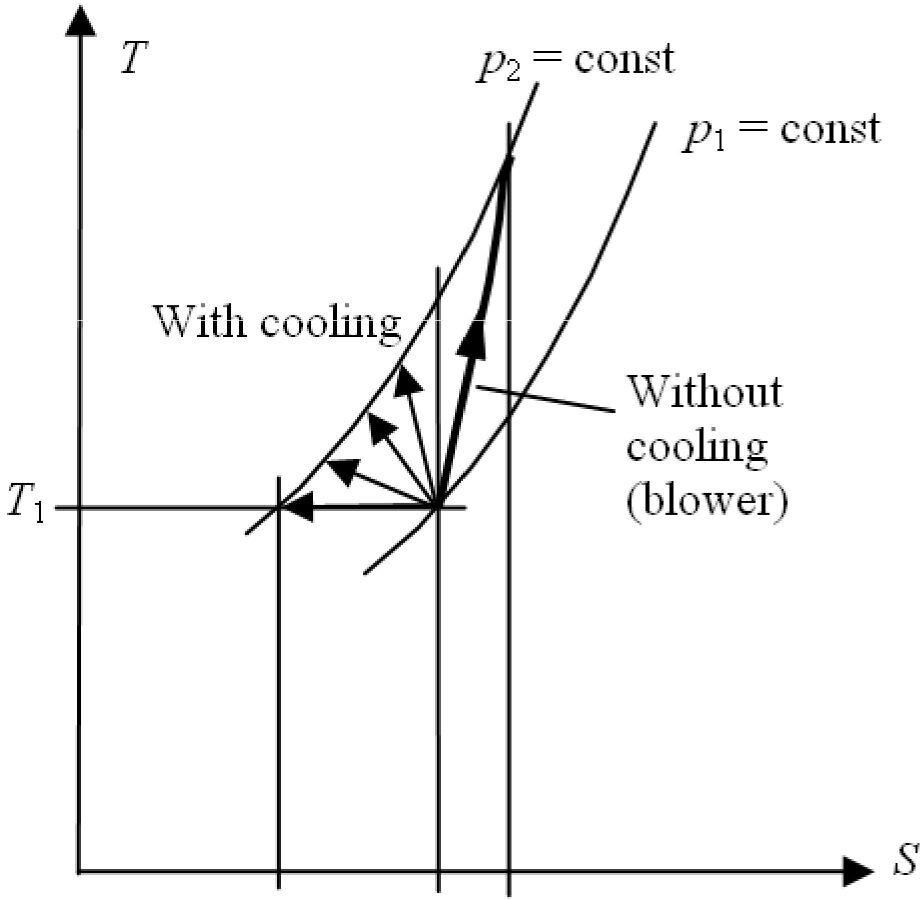
$$\eta_p = \frac{A+C}{A+B+C}$$

Isothermal power factor:

$$\lambda = \frac{H_{isoth}}{\sum P / q_m}$$

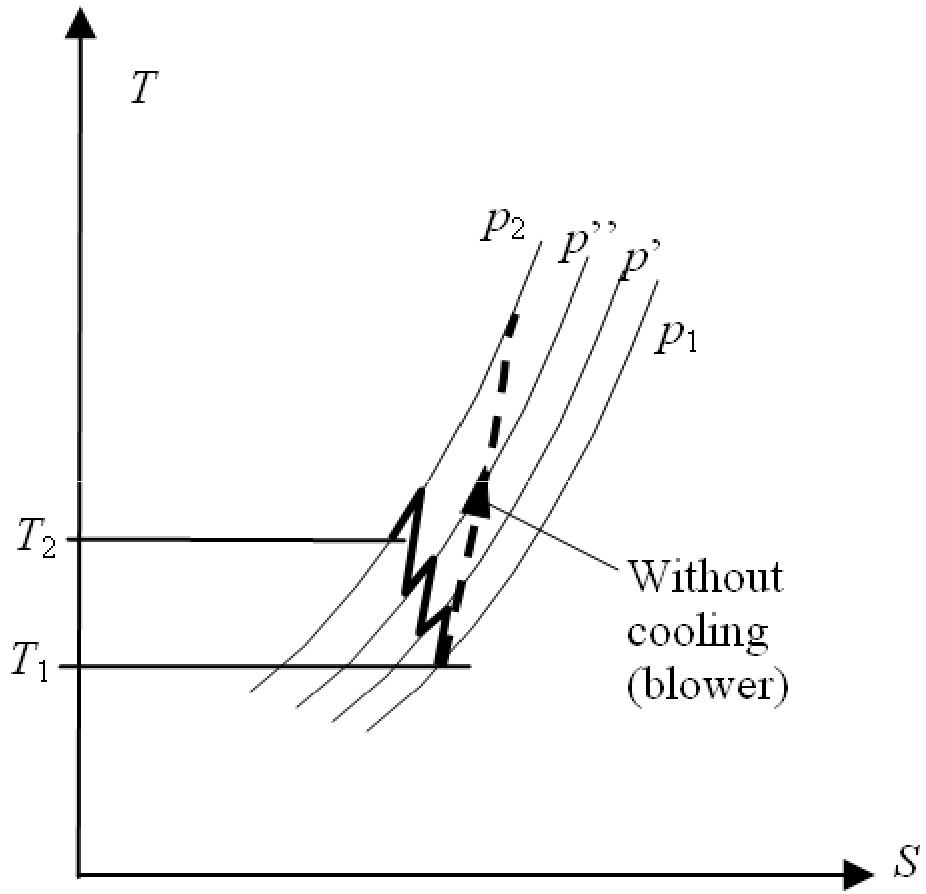
$$H_{isoth} = \int_1^2 \frac{1}{\rho} dp = RT_1 \int_1^2 \frac{1}{p} dp = RT_1 \ln \frac{p_2}{p_1}$$

5.2. Compressors



Temperature coefficient:

$$\chi = \frac{\Delta T}{u^2 / 2c_p}$$



2.

Blower: pressure ratio $p_2/p_1 = 1.6$

Inlet air: $p_1 = 10^5$ Pa, $t_1 = 20$ °C

Mass flow rate: $q_m = 1$ kg/s

Outlet temperature: $t_2 = 70$ °C

Air characteristics: $c_p = 1000$ J/(kg K), $\kappa = 1{,}40$, $R = 287$ J/(kg K)

A/ Polytropic efficiency: $\eta_p = \frac{\kappa - 1}{\kappa} \ln \frac{p_2}{p_1} \Big/ \ln \frac{T_2}{T_1}$

B/ Outlet temperature for isentropic compression: $T_{2\,IS} = T_1 \left(\frac{p_2}{p_1} \right)^{\frac{\kappa - 1}{\kappa}}$

(same pressure ratio)

C/ Shaft power input: $P = q_m c_p \left(T_2 - T_1 \right)$

D/ One stage: pressure ratio not more than $\varepsilon = 1.1$

Necessary number of stages: N = ?

$p_2/p_1 = \varepsilon^N$ $\lg(p_2/p_1) = N * \lg\varepsilon$

3.

Compressor: pressure ratio $p_2/p_1 = 4.0$

Inlet air: $p_1 = 10^5$ Pa, $t_1 = 20$ °C

Mass flow rate: $q_m = 10$ kg/s

Outlet temperature: $t_2 = 80$ ℃

Isothermal power factor: $\lambda = 0.68$

Air characteristics: $c_p = 1000$ J/(kg K), $\kappa = 1{,}40$, $R = 287$ J/(kg K)

A/ Outlet temperature for isentropic compression:

(same pressure ratio)

$$T_{2\,IS} = T_1 \left(\frac{p_2}{p_1} \right)^{\frac{\kappa - 1}{\kappa}}$$

B/ Useful isothermal specific work:

$$H_{isoth} = RT_1 \ln \frac{p_2}{p_1}$$

C/ Overall power consumption:

$$\sum P = \frac{H_{isoth}\, q_m}{\lambda}$$

D/ One stage: pressure ratio not more than $\varepsilon = 1.2$

Necessary number of stages: N = ?

$p_2/p_1 = \varepsilon^N$ $\qquad$ $\lg(p_2/p_1) = N^* \lg\varepsilon$