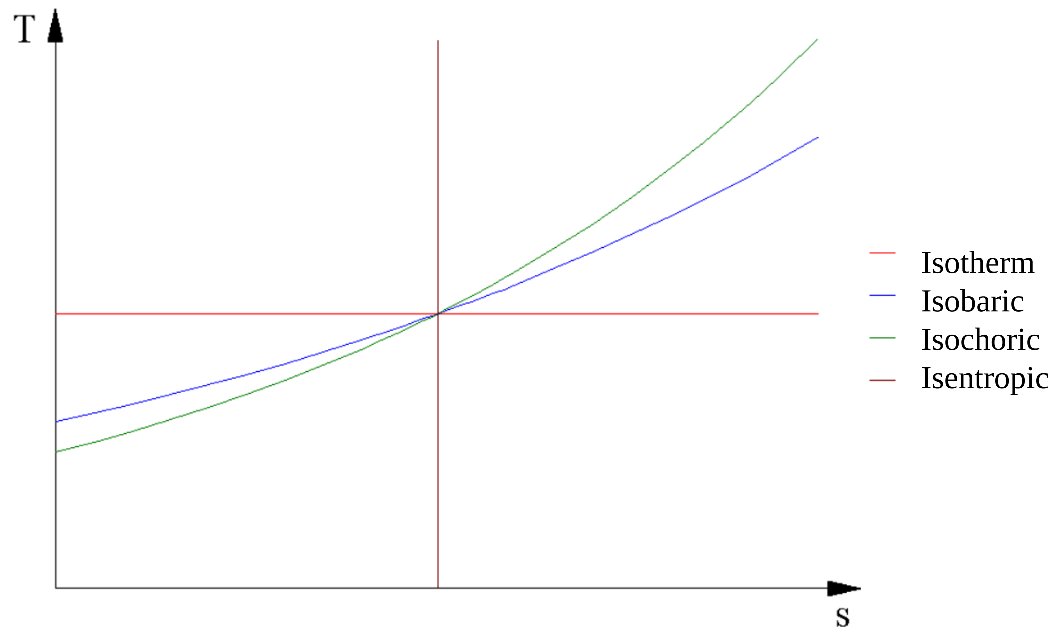
Energetic processes and equipment (BMEGEENBGEB)

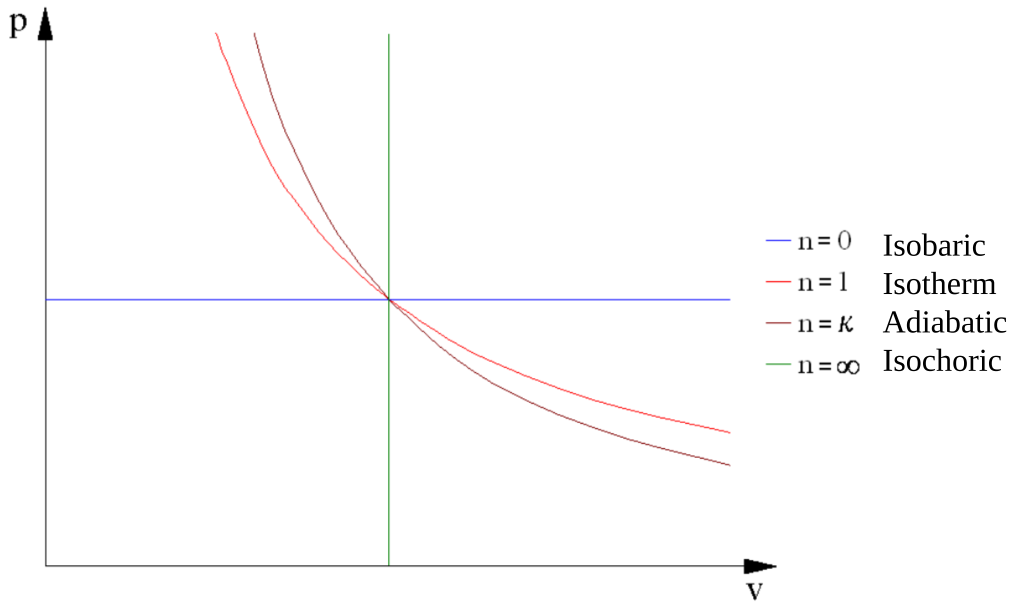
Basics

2020

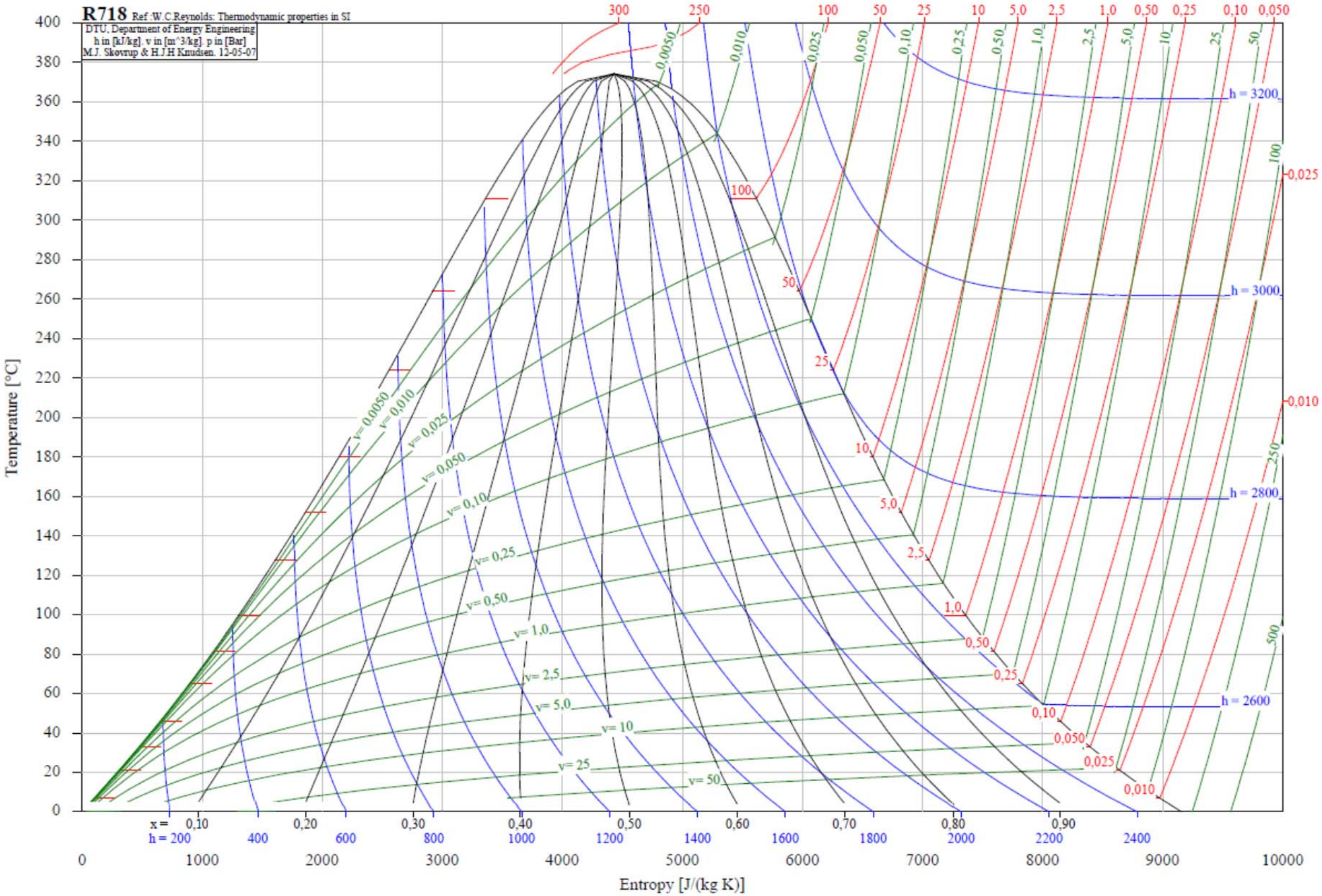
Friday:8:45-11:00(Lectures);					
Educ. week	Date	Topics	Pres.	Tests	Lectures
1	2020.09.11	Repeat, main cycles	Bereczky		T
2	2020.09.18	Solar Cells	Mayer M.		T
3	2020.09.25	Cooling	Maiyaleh		T
4	2020.10.02	Cooling	Maiyaleh		T
5	2020.10.09	Combustion	Lezsovits	TEST	J
6	2020.10.16	Combustion	Lezsovits		J
7	2020.10.23	Turbines	Sztankó		J
8	2020.10.30	Turbines	Sztankó		J
9	2020.11.06	ICE	Bereczky		J
10	2020.11.13	ICE	Bereczky	TEST	J
11	2020.11.20	Gas engines	Bereczky		J
12	2020.11.27				N.E.
13	2020.12.04	Fuel cells	Kovács Viki		T
14	2020.12.11	supp.TEST	Bereczky	TEST + supp. 1.+ 2.	J

Friday:11:15-13:00(DCs);									
Educ. week	Date	Solarcell	Cooling system	Stacioner bolier test	FBC	Gas Engine Heat Balance	Gas Turbine	Supp. Labs.	Room
1	2020.09.11								-
2	2020.09.18								-
3	2020.09.25								DCs
4	2020.10.02	1	2						DCs
5	2020.10.09	2	1						DCs
6	2020.10.16			1	2				DCs
7	2020.10.23			2	1				DCs
8	2020.10.30								
9	2020.11.06					1	2		DCs
10	2020.11.13	Livable Future Park in Fót, start from BME at 11:00 ** (?)							
11	2020.11.20					2	1		DCs
12	2020.11.27								-
13	2020.12.04								-
14	2020.12.11							1+2	DCs
	Loc.	**D6***	**F3**	**F6**	**F5**	**F6**	**F1**	**-**	
	Lecturer and lab supervisor	Szilágyi	T. Maiyaleh	V.Kovács	T. Szűcs	K. Lukács	V. Józsa		



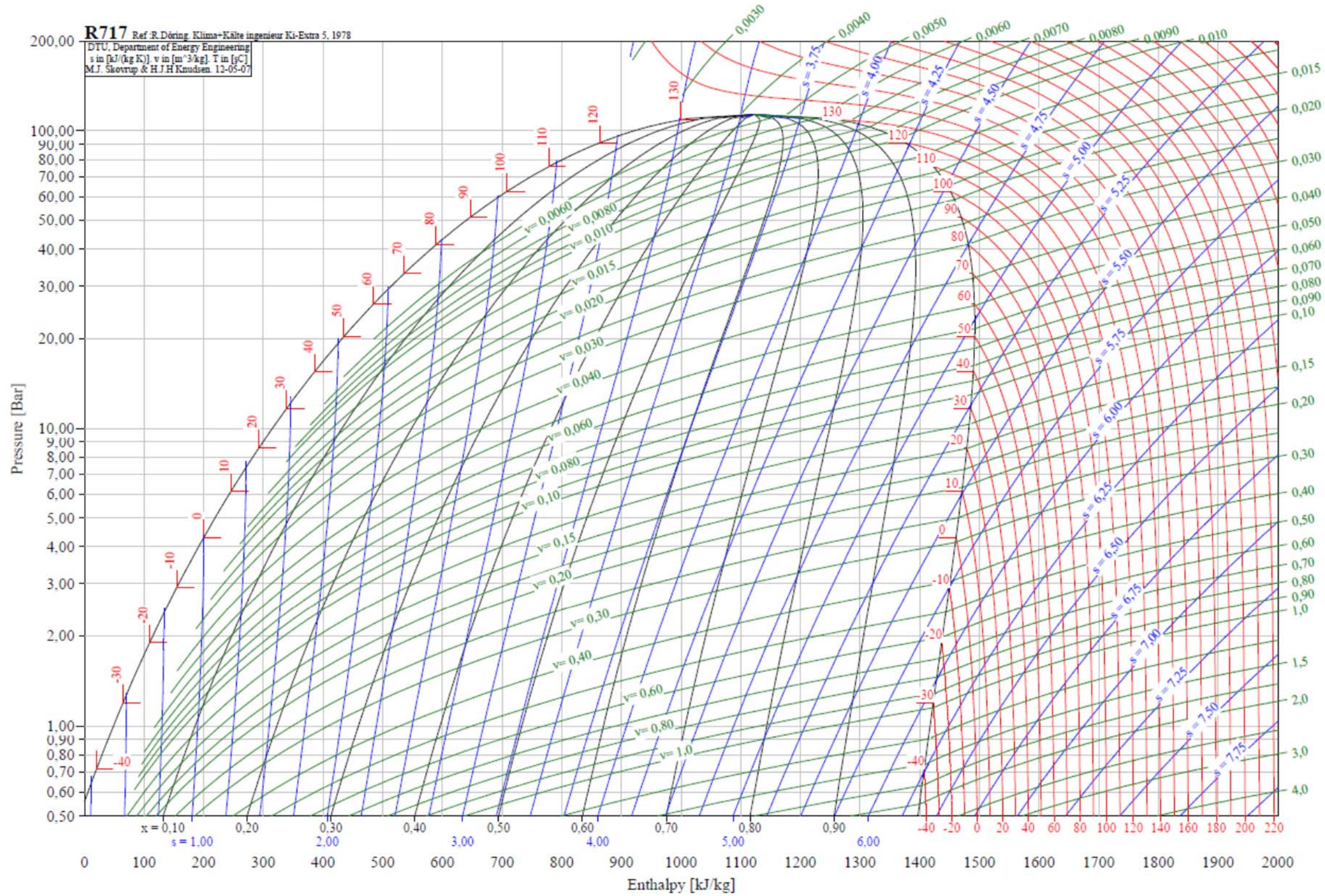


Source: Guide to seminars of Heat Engines (A. Kun-Balog)



T-S diagram of H_2O

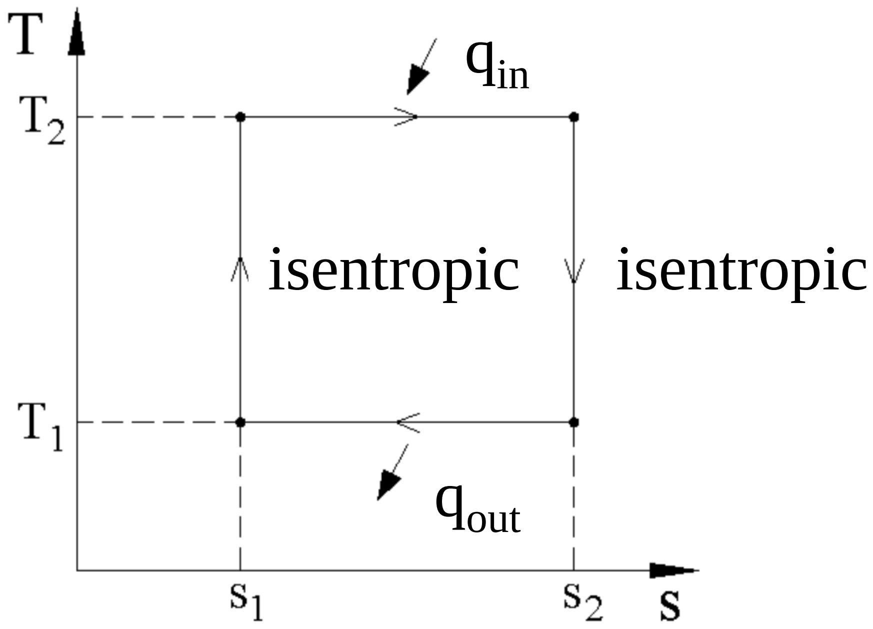
Source: Guide to seminars of Heat Engines (A. Kun-Balog)



logp-h diagram of Ammonia

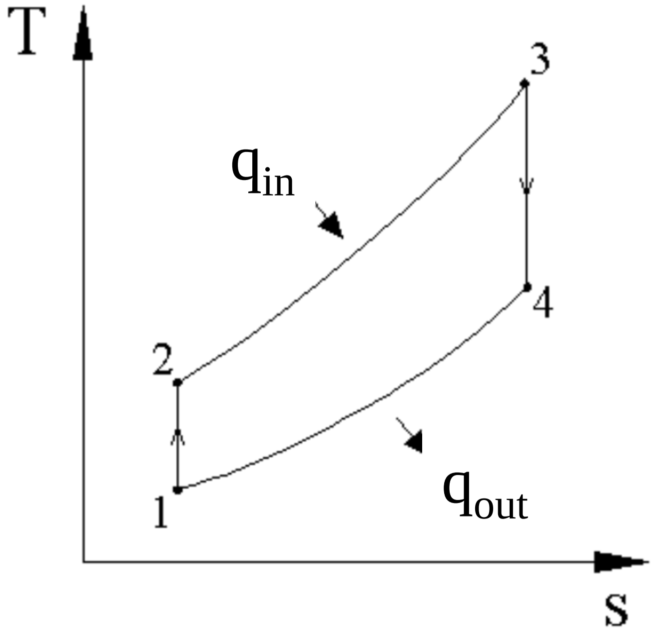
Source: Guide to seminars of Heat Engines (A. Kun-Balog)

$$\eta_t = 1 - \frac{q_{out}}{q_{in}} = 1 - \frac{T_1 \cdot (s_2 - s_1)}{T_2 \cdot (s_2 - s_1)} = 1 - \frac{T_1}{T_2}$$



Carno cycle

Source: Penninger- Maiyaleh: Heat Engines (in Hungarian)

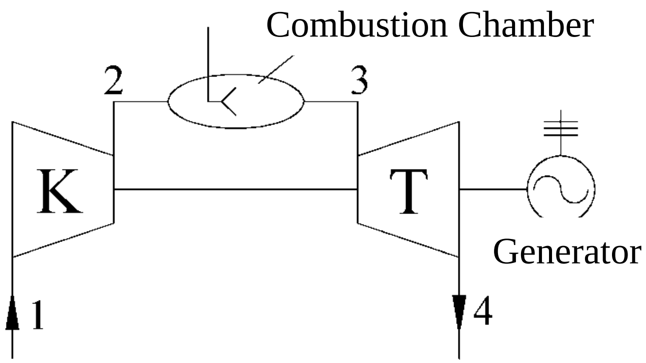


$$\eta_t = 1 - \frac{1}{\pi^{\frac{\kappa-1}{\kappa}}}$$

Brayton-Joule cycle

Source: Penninger- Maiyaleh: Heat Engines (in Hungarian)

Theoretical Gas Turbine



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

$$\frac{p_2}{p_1} = \pi$$

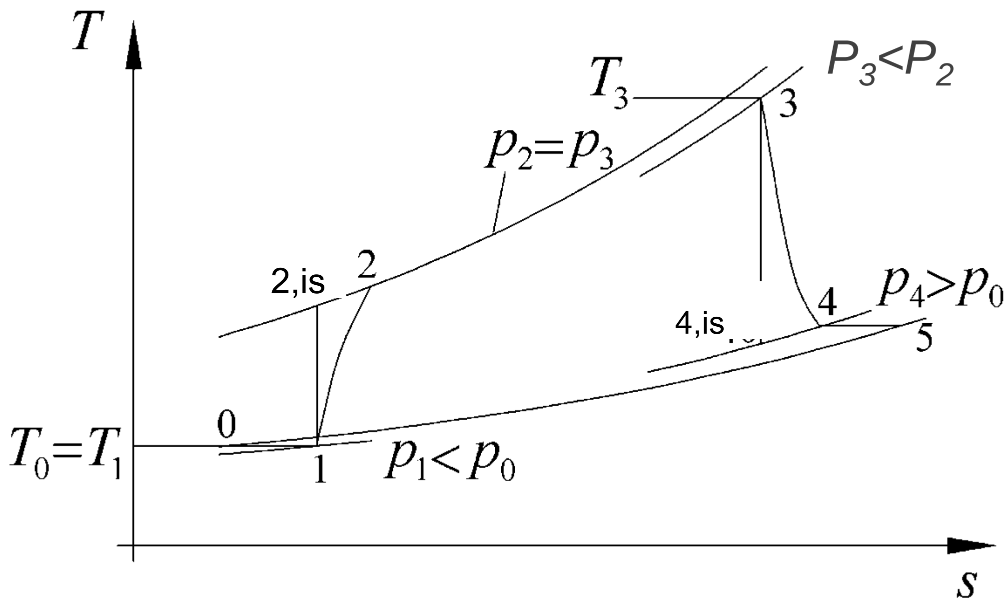
$$P_C = \dot{m} \cdot \Delta h_{1-2} = \dot{m} \cdot c_{p,air} \cdot \left(T_2 - T_1\right) = \dot{m} \cdot c_{p,air} \cdot T_1 \cdot \left(\frac{T_2}{T_1} - 1\right) = \dot{m} \cdot c_{p,air} \cdot T_1 \cdot \left(\pi^{\frac{\kappa_{air} - 1}{\kappa_{air}}} - 1\right)$$

$$\dot{Q}_{in} = \dot{m} \cdot \Delta h_{3-2} = \dot{m} \cdot c_{p,exh} \cdot \left(T_3 - T_2\right)$$

$$P_T = \dot{m} \cdot \Delta h_{3-4} = \dot{m} \cdot c_{p,exh} \cdot \left(T_3 - T_4\right) = \dot{m} \cdot c_{p,exh} \cdot T_3 \cdot \left(1 - \frac{1}{\frac{T_3}{T_4}}\right) = \dot{m} \cdot c_{p,exh} \cdot T_3 \cdot \left(1 - \frac{1}{\delta^{\frac{\kappa_{exh} - 1}{\kappa_{exh}}}}\right)$$

Source: Penninger- Maiyaleh: Heat Engines (in Hungarian)

Real Gas Turbine



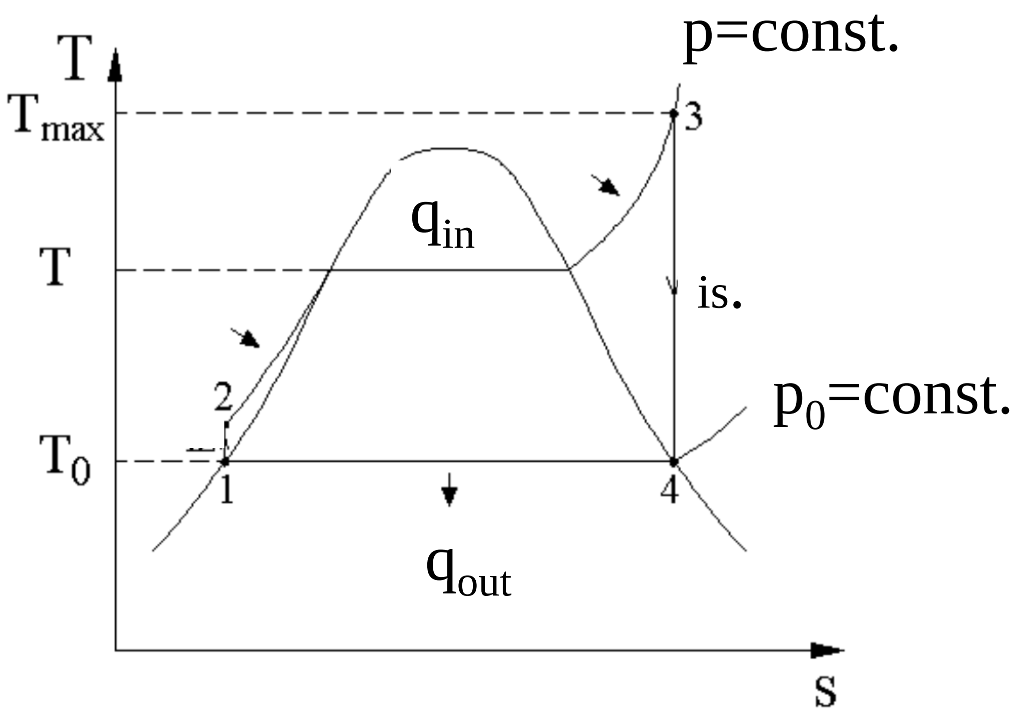
$$\delta = \frac{p_3}{p_4} = \prod \sigma_i \cdot \pi$$

$$P_C = \dot{m}_{air} \cdot \left(h_2 - h_1\right) = \dot{m}_{air} \cdot c_{p\,air} \cdot \left(T_2 - T_1\right) = \dot{m}_{air} \cdot c_{p\,air} \cdot T_1 \cdot \left(\pi^{\frac{\kappa_{air}-1}{\kappa_{air}}} - 1\right) \cdot \frac{1}{\eta_{adC}}$$

$$P_T = \dot{m}_{exh} \cdot \left(h_3 - h_4\right) = \dot{m}_{exh} \cdot c_{p\,exh} \cdot \left(T_3 - T_4\right) = \dot{m}_{exh} \cdot c_{p\,exh} \cdot T_3 \cdot \left(1 - \frac{1}{\delta^{\frac{\kappa_{exh}-1}{\kappa_{exh}}}}\right) \cdot \eta_{adT}$$

$$\eta_{ad,C} = \frac{T_{2,0} - T_1}{T_2 - T_1} \qquad \eta_{adT} = \frac{T_3 - T_4}{T_3 - T_{4,0}}$$

Source: Guide to seminars of Heat Engines (A. Kun-Balog)



$$\eta_t = 1 - \frac{q_{out}}{q_{in}} = 1 - \frac{h_4 - h_1}{h_3 - h_2}$$

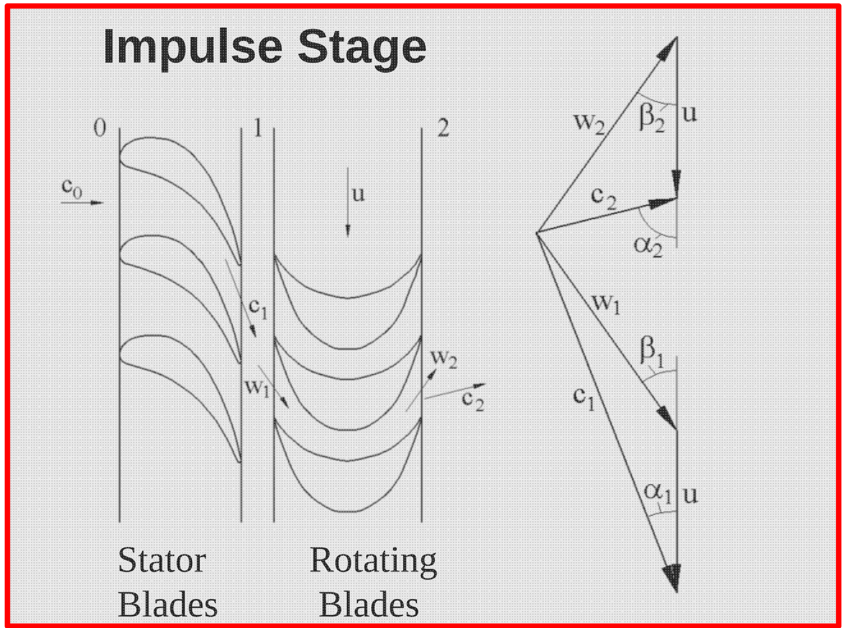
Clausius – Rankine cycle

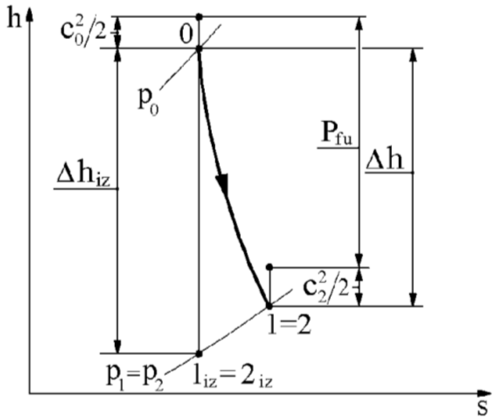
Source: Penninger- Maiyaleh: Heat Engines (in Hungarian)

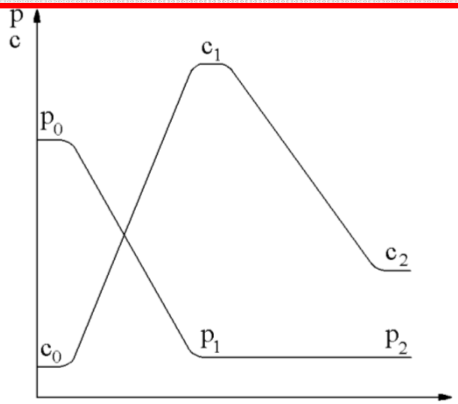
Steam Turbines

$$P_u = F_u \cdot u = \dot{m} \cdot u \cdot \left(\overrightarrow{c_{1u}} - \overrightarrow{c_{2u}}\right) = \dot{m} \cdot u \cdot \left(|w_{1u}| + |w_{2u}|\right)$$

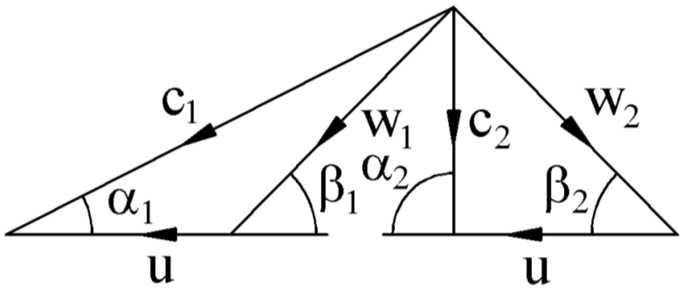
$$\eta_u = \frac{P_u}{\Delta h_{iz} + \frac{c_0^2}{2} - \frac{c_2^2}{2}}$$







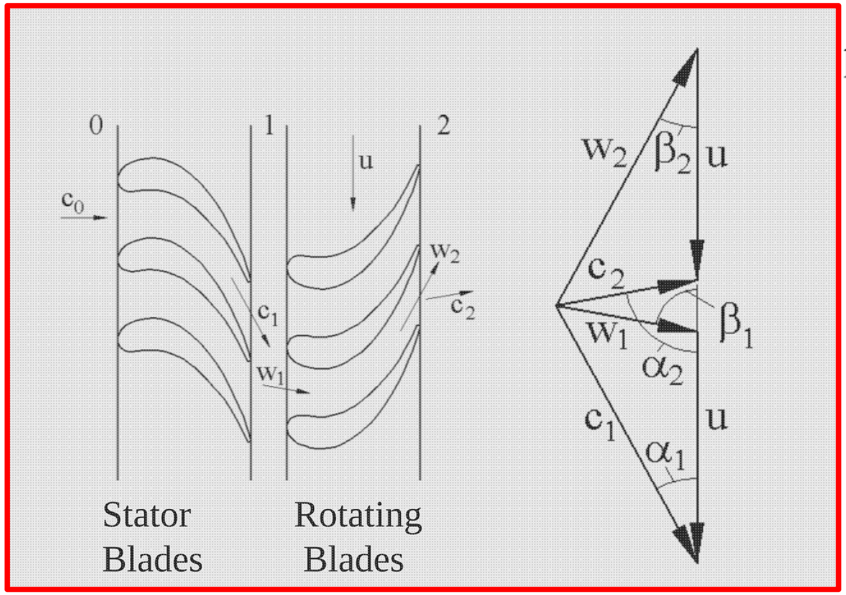
Theoretical
Optimal

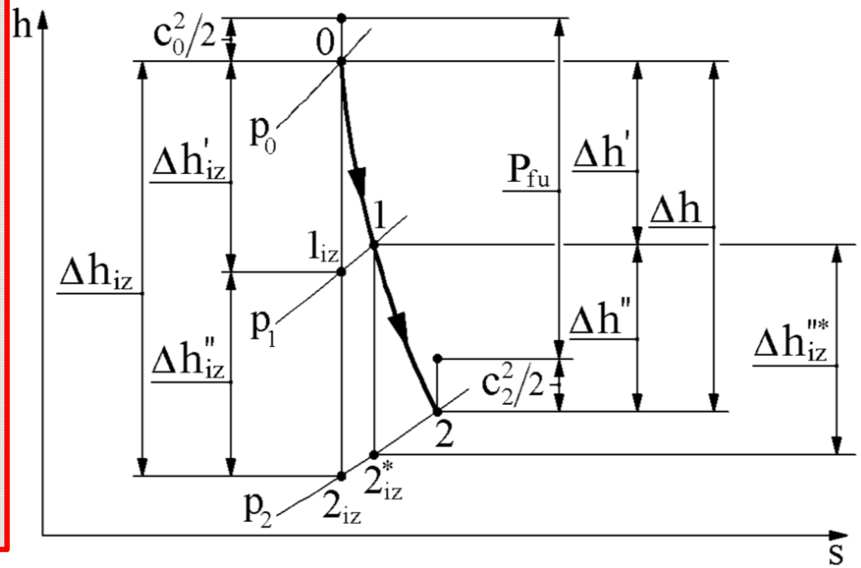


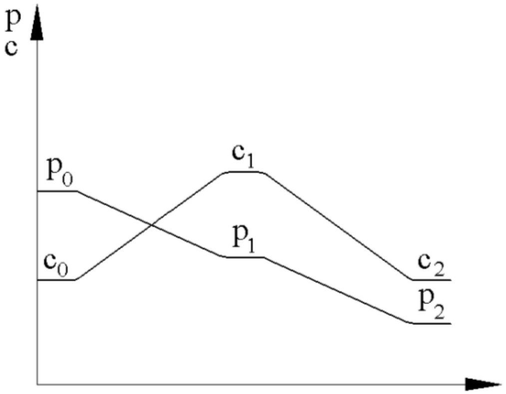
Source: Guide to seminars of Heat Engines (A. Kun-Balog)

Reaction Stage

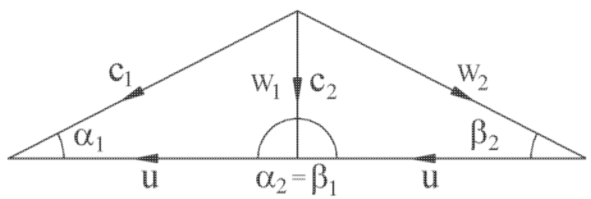
$$r = \frac{\Delta h''}{\Delta h' + \Delta h''}$$





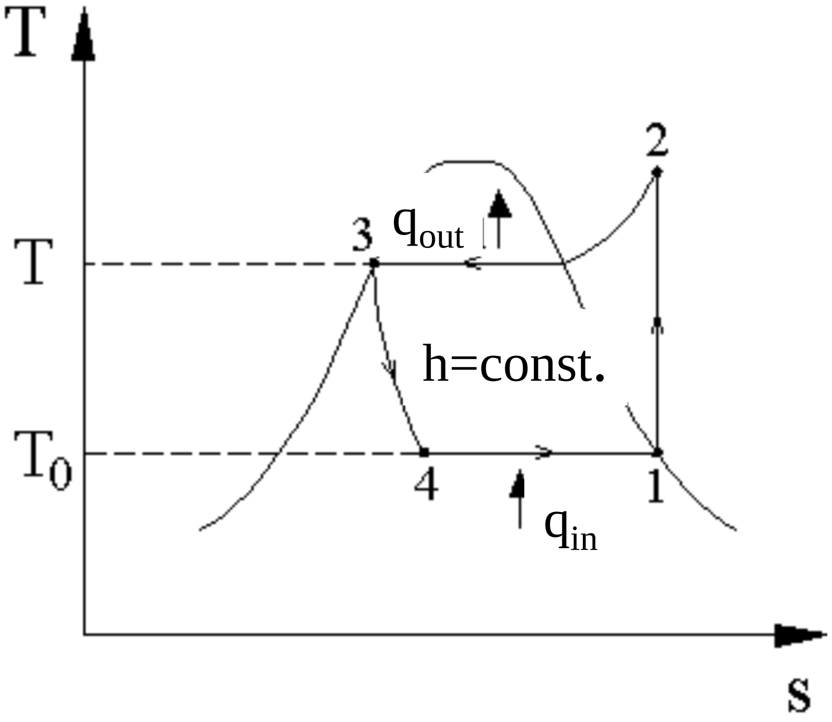


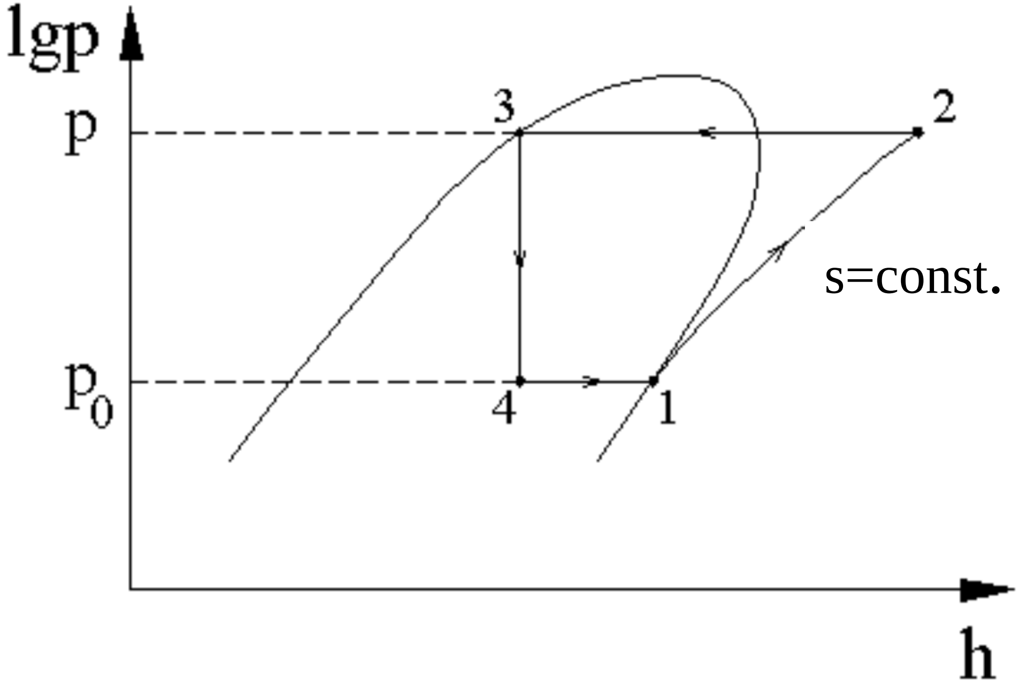
Theoretical
Optimal



Source: Guide to seminars of Heat Engines (A. Kun-Balog)

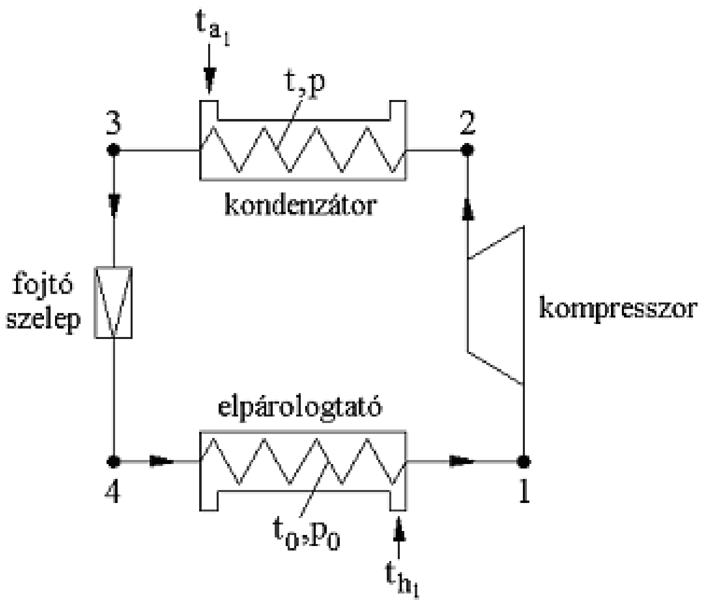
Theoretical Cooling cycle

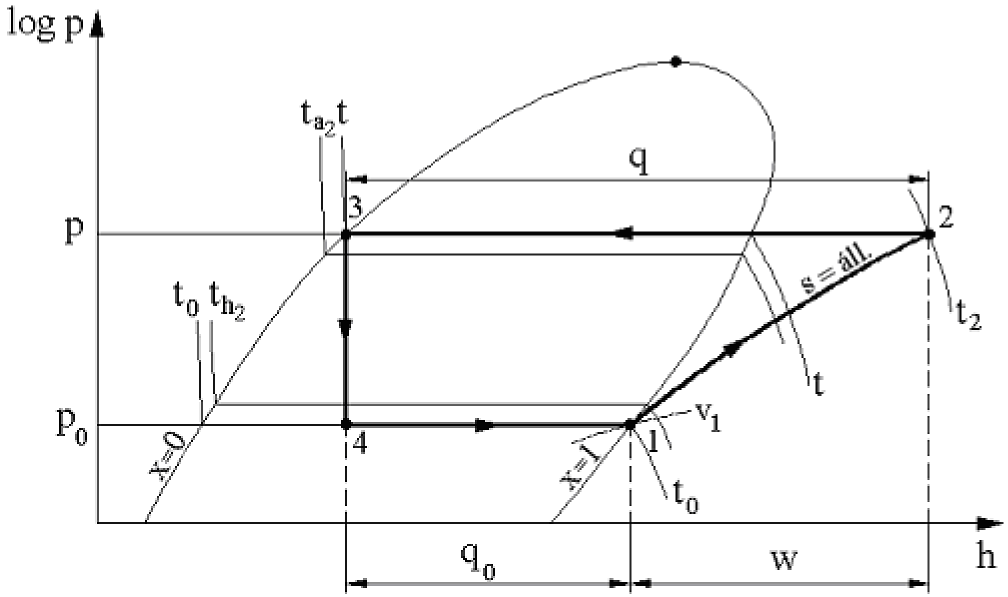


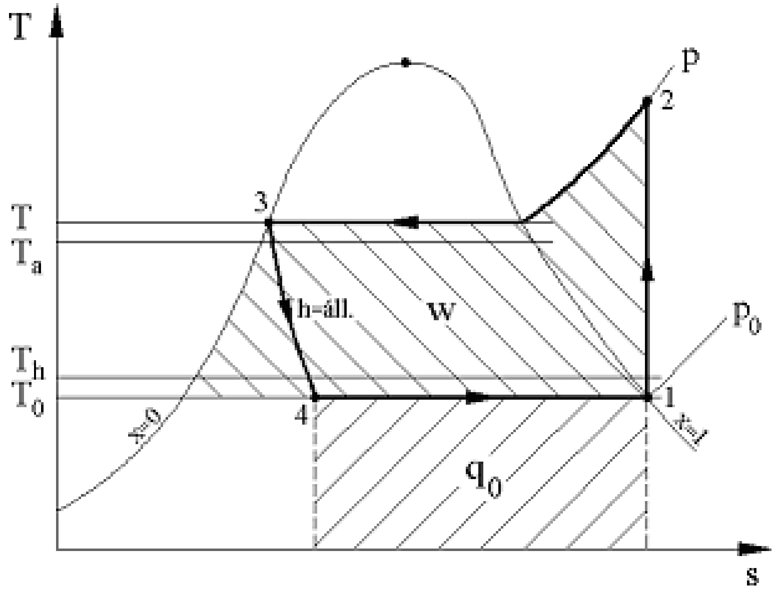


$$COP = \varepsilon = \frac{q_0}{w} = \frac{h_1 - h_4}{h_2 - h_1}$$

Source: Penninger- Maiyaleh: Heat Engines (in Hungarian)







$$q_0 = h_1 - h_4 \quad \left[\frac{kJ}{kg}\right]$$

$$w = h_2 - h_1 \quad \left[\frac{kJ}{kg}\right]$$

$$q = h_2 - h_3 \quad \left[\frac{kJ}{kg}\right]$$

$$C.O.P. = \frac{q_0}{w}$$

A hűtőfolyamat teljesítménytényezője:

Excess air factor

$$C_8H_{18} + 12{,}5\ O_2 = 8\ CO_2 + 9\ H_2O$$

$$C_8H_{18} + 12{,}5\ (O_2 + 79/21N_2) = 8\ CO_2 + 9\ H_2O + 12{,}5\ 79/21N_2$$

$$114\ kg\ C_8H_{18} + 400\ kg\ O_2 + 1316{,}67\ kg\ N_2 = 352kgCO_2 + 162kgH_2O + 1316{,}67kgN_2$$

$$\mathbf{1\ kg\ C_8H_{18} + 15{,}06\ kg\ air} = 3{,}09\ kg\ CO_2 + 1{,}42\ kg\ H_2O + 11{,}55\ kg\ N_2$$

$$\lambda = m_{real}/m_{theoretical} = \mathbf{m_{real}/B^*\mu_{lo}}$$

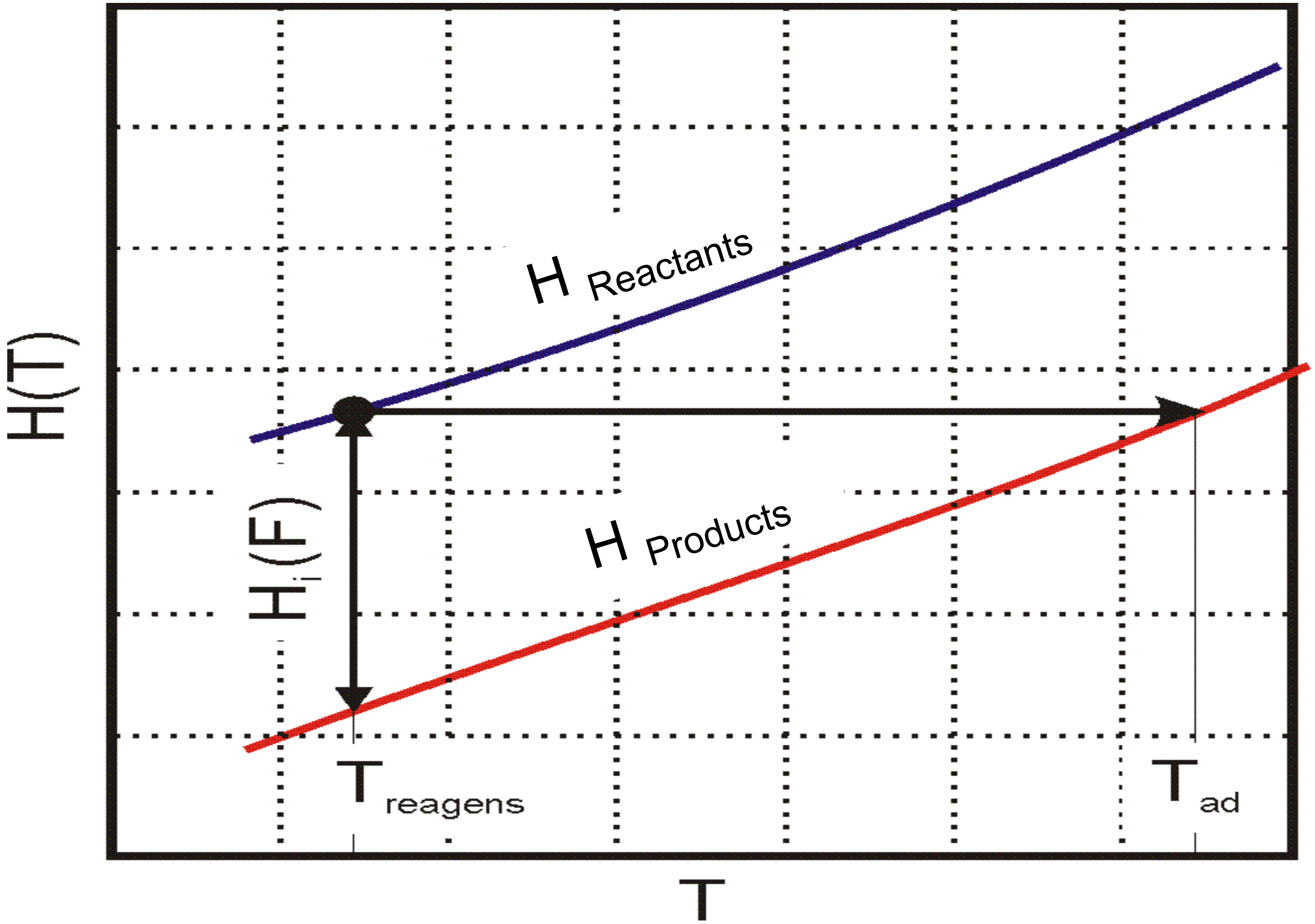
Stoichiometric air-fuel ratio

$$\lambda = 1 + \left[\frac{\mathrm{CO}_{2\max}}{\mathrm{CO}_{2,\mathrm{meas.}}} - 1 \right] \cdot \frac{\mathrm{V}_0}{\mathrm{L}_0} \approx \frac{\mathrm{CO}_{2\max}}{\mathrm{CO}_{2,\mathrm{meas.}}}$$

$$\lambda = 1 + \left[\frac{O_{2,meas.}}{21 - O_{2,meas.}} \right] \cdot \frac{V_0}{L_0} \approx \frac{21}{21 - O_{2,meas.}}$$

Source: Penninger- Maiyaleh: Heat Engines (in Hungarian)

Theoretical Flame Temperature



$$\sum_j b_j \int_{298}^{T_{ad,}} c_{p,b_j}(T)dT = \sum_i a_i \int_{298}^{T_{begining}} c_{p,a_i}(T)dT$$

(Adiabatic) Flame Temperature :

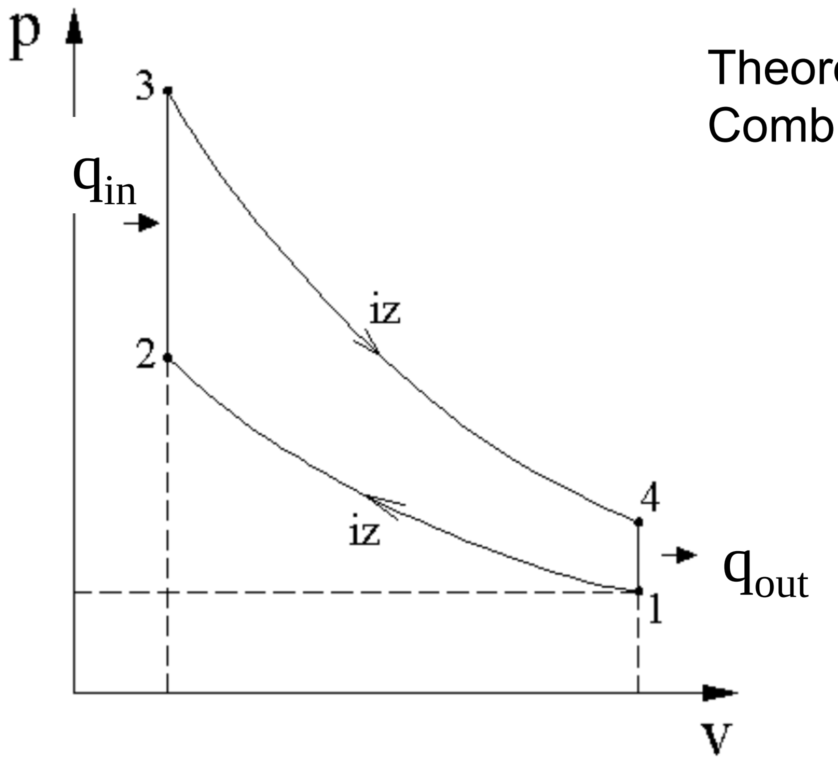
- Theoretical Flame Temperature:
  – Reactants: fuel, O2, N2
  – Combustion products : CO2, CO, H2O, N2

- Real Combustion (Dissociation)
  – Combustion products : CO2, CO, H2O, N2, H, O, N, OH, CH, C2, etc..

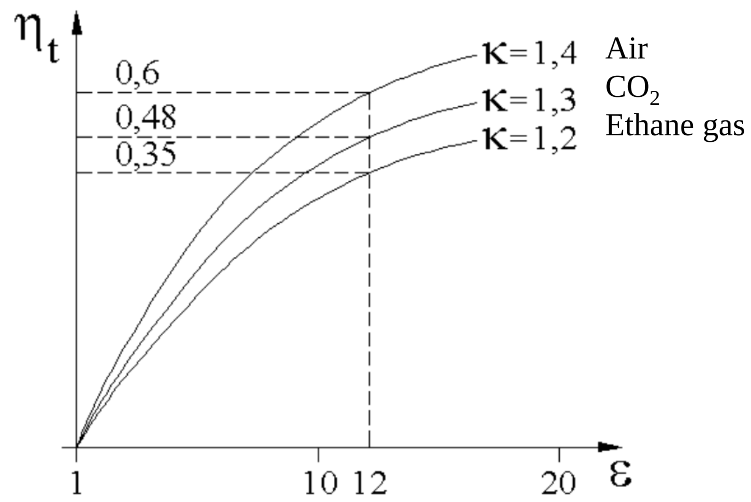
$$\tfrac{1}{2}O_2 \Leftrightarrow O \qquad \tfrac{1}{2}\mathrm{H}_2 \Leftrightarrow \mathrm{H} \qquad \tfrac{1}{2}N_2 \Leftrightarrow N \qquad \tfrac{1}{2}H_2 + \tfrac{1}{2}O_2 \Leftrightarrow OH$$

$$H_2 + \tfrac{1}{2}O_2 \Leftrightarrow H_2O \qquad CO + \tfrac{1}{2}O_2 \Leftrightarrow CO_2$$

Theoretical -Spark Ignition- Internal Combustion Engine cycle

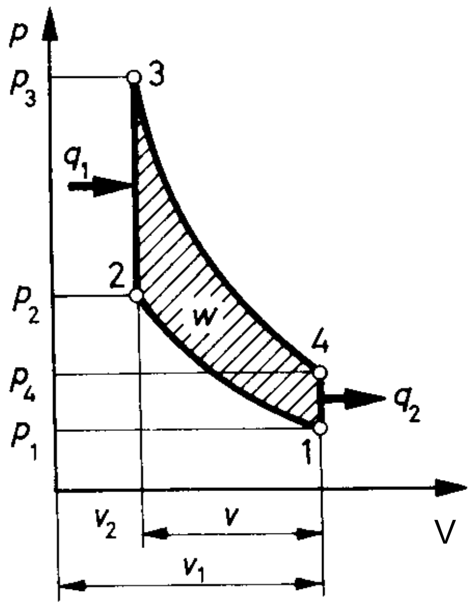


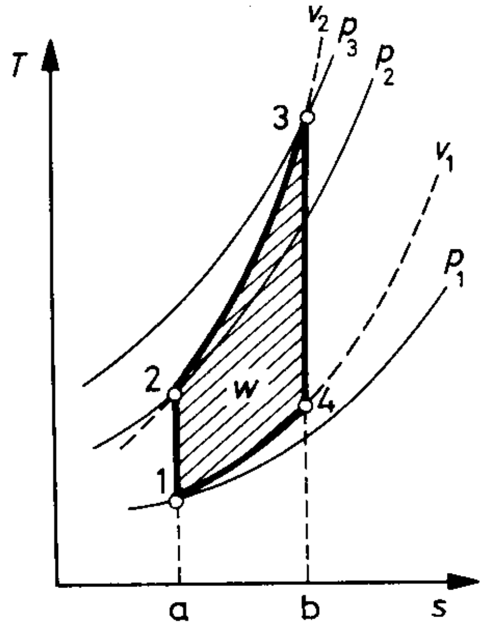
$$\eta_t = 1 - \frac{1}{\varepsilon^{\kappa - 1}}$$



Source: Penninger- Maiyaleh: Heat Engines (in Hungarian)

The ideal air standard Otto cycle:





$$\varepsilon = \frac{V_1}{V_2}$$

$$\eta = \frac{-\sum W}{Q_1} = \frac{\sum Q}{Q_1} = \frac{c_v(T_3 - T_2) - c_v(T_4 - T_1)}{c_v(T_3 - T_2)} = 1 - \frac{T_4 - T_1}{T_3 - T_2} = 1 - \frac{1}{\varepsilon^{\kappa - 1}}$$

2020 End

Check questions

1. What equipment does use the Brayton-Joule cycle?
2. What are the elements of the open Brayton-Joule cycle?
3. What are the losses of the real Gas Turbine cycle?
4. What equipment does use the Clausius - Rankine cycle?
5. What are the elements of the Clausius - Rankine cycle?
6. What is the degree of reaction?
7. What is the degree of reaction in the impulse stage?
8. What does the COP mean?
9. How to determine the COP for a chiller?
10. How to determine H-T diagram using the Tad?
11. How to determine H-T diagram using the HHV, LHV?
12. Which is the higher in the case of CO firing HHV or LHV?

Real Adiabatic Flame Temperature