Fakultet kemijskog inženjerstva i tehnologije
Zavod za termodinamiku, strojarstvo i energetiku

ENERGETIKA

Studij: Kemijsko inženjerstvo (V semestar)

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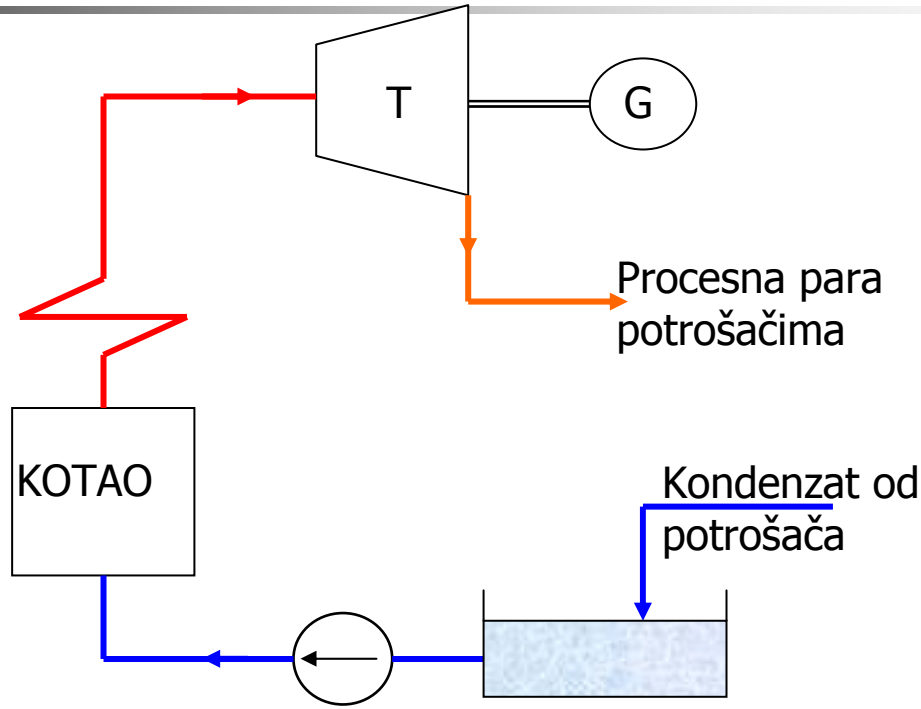
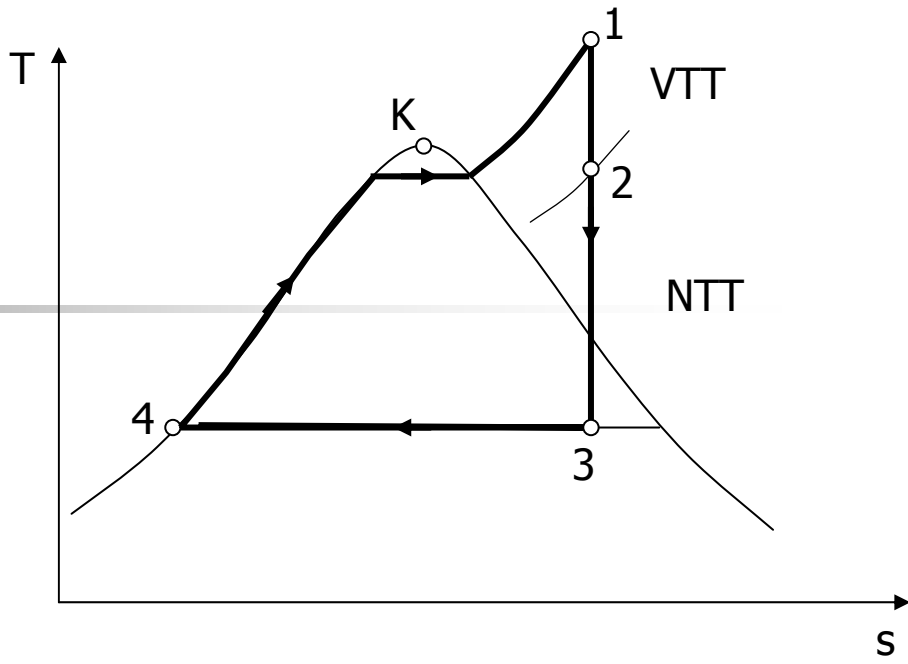
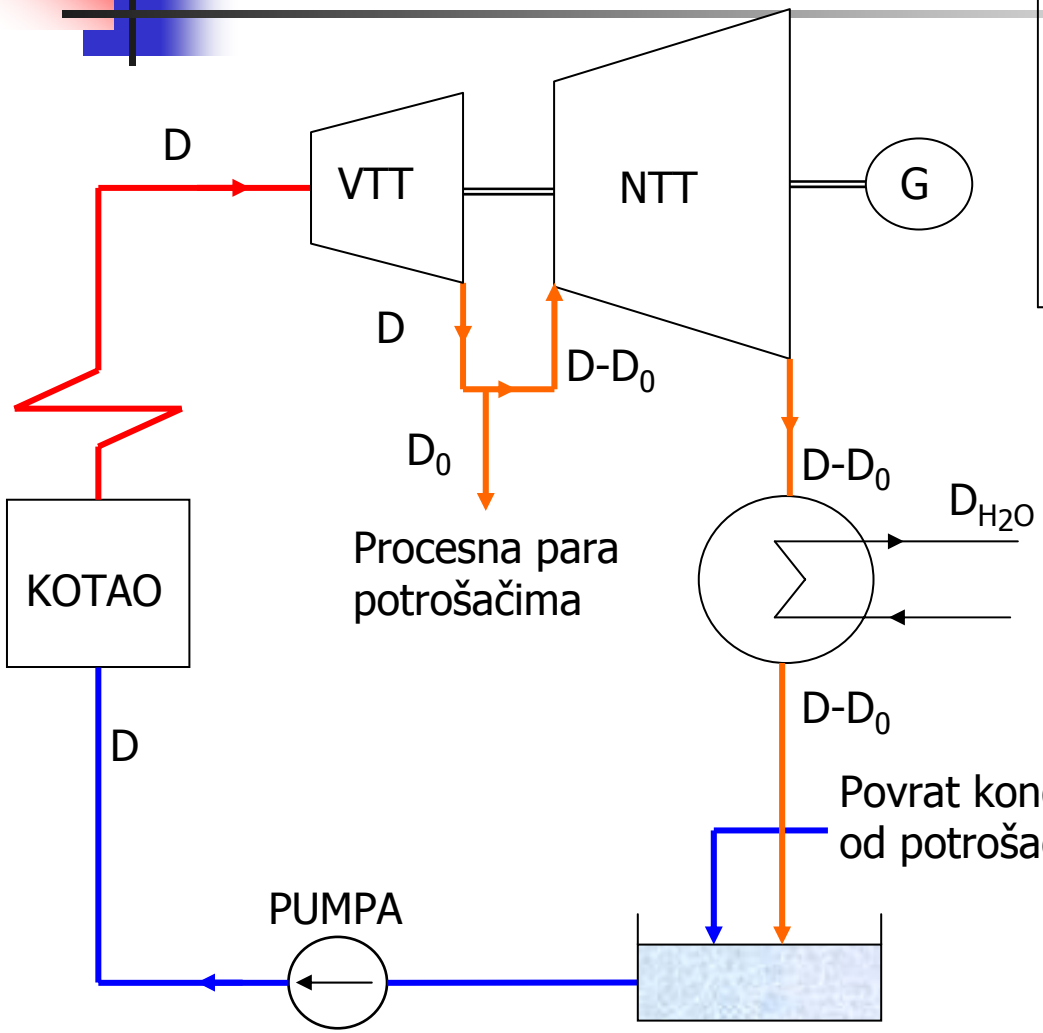
Protutlačna turbina



Turbina s reguliranim oduzimanjem





Zadano: p_1=90bar; t_1=540°C,
D=210t/h; D_0=0,6D.

Očitano: h_1=3485kJ/kg,
h_2=2790kJ/kg, h_3=2035kJ/kg,
h_4=120kJ/kg, p_4=0,04bar

Za zadanu situaciju i parametre pare izračunajte dobivenu električnu snagu, potrošnju ugljena donje toplinske vrijednost 7118kJ/kg ili prirodnog plina donje toplinske vrijednosti 33000kJ/m^3, ako je stupanj iskorištenja kotla 86%, potrošnju rashladne vode uz povišenje temperature za 21°C, termodinamički stupanj djelovanja (%) i stupanj iskorištenja (%).

Ukupna snaga postrojenja - električna:

$$N_e = N_{VTT} + N_{NTT} = \frac{D \cdot (h_1 - h_2) + (D - D_0) \cdot (h_2 - h_3)}{3600}$$

$$N_e = \frac{210 \cdot 10^3 \cdot (3485 - 2790) + 0{,}4 \cdot 210 \cdot 10^3 \cdot (2790 - 2035)}{3600} = 58{,}2 \cdot 10^3 \, kW_e = 58{,}2 MW_e$$

Bilanca kotla: $$Q_K = D \cdot (h_1 - h_4) = D_g \cdot H_d \cdot \eta_K$$

Potrošnja ugljena:

$$D_g = \frac{D \cdot (h_1 - h_4)}{H_d \cdot \eta} = \frac{210 \cdot 10^3 \cdot (3485 - 120)}{7118 \cdot 0{,}86} = 115{,}4 \cdot 10^3 \, kg/h = 115{,}4 \frac{t}{h}$$

$$Q_K = 504{,}7 \cdot 10^3 \frac{kJ}{h}$$

Potrošnja prirodnog plina:

$$V_g = \frac{210 \cdot 10^3 \cdot (3485 - 1209)}{33000 \cdot 0{,}86} = 16841{,}4 \frac{m^3}{h}$$

Toplina odvedena u kondenzatoru:

$$Q_C = (D - D_0) \cdot (h_3 - h_4) = D_{H_2O} \cdot c_{pH_2O} \cdot \Delta T_{H_2O}$$

$$D_{H_2O} = \frac{(D - D_0) \cdot (h_3 - h_4)}{c_{pH_2O} \cdot \Delta T_{H_2O}} = \frac{210 \cdot 10^3 \cdot (2035 - 120)}{4{,}187 \cdot 21} = 1{,}83 \cdot 10^6 \frac{kg}{h}$$

Termodinamički stupanj djelovanja:

$$\eta_t = \frac{N_e \cdot 3600}{Q_K} = \frac{58{,}2 \cdot 10^3 \cdot 3600}{210 \cdot 10^3 \cdot (3485 - 120)} 0{,}357 = 35{,}7\%$$

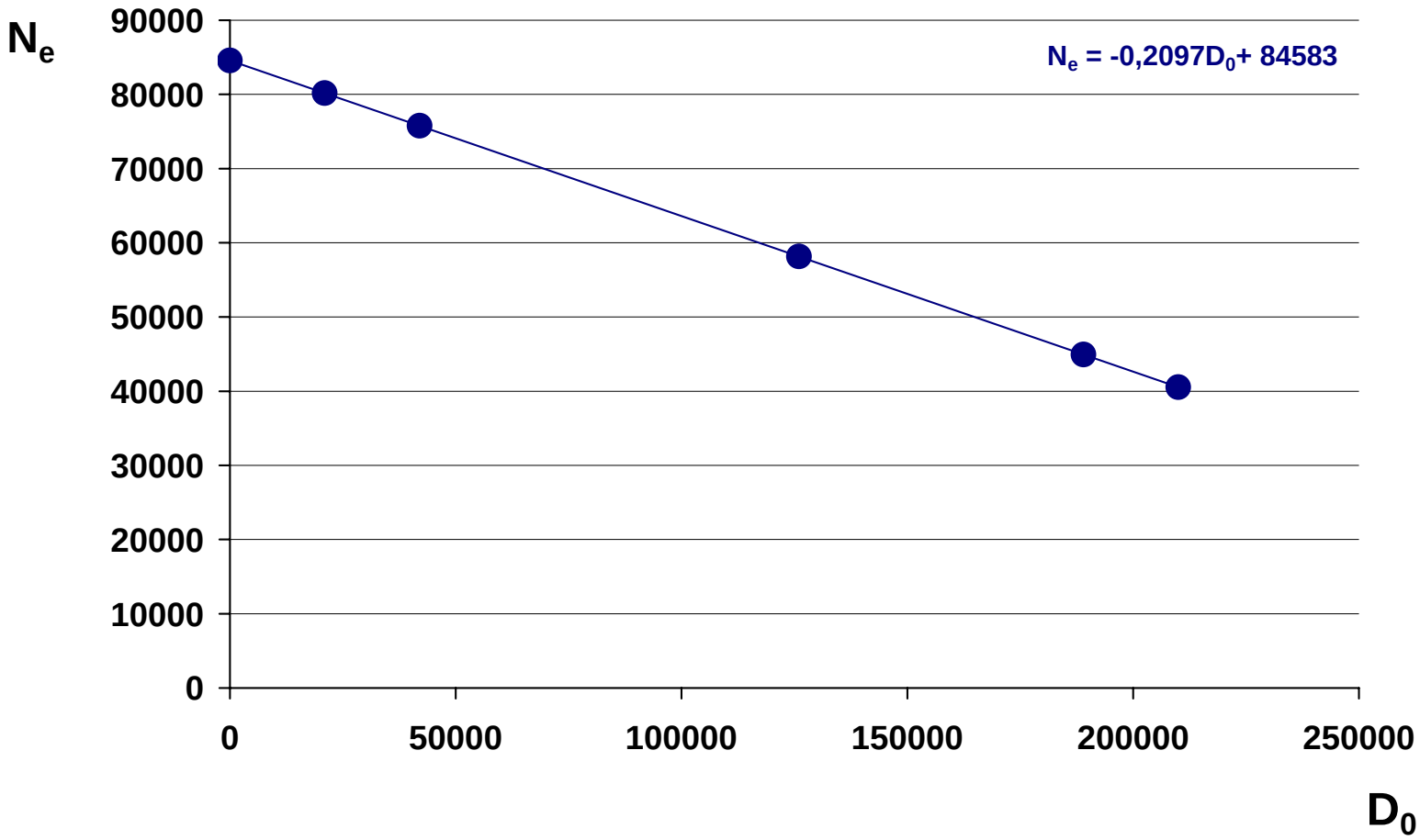
Ekonomičnost postrojenja – toplinski faktor iskorištenja:

$$f = \frac{N_e \cdot 3600 + Q_0}{Q_K} = \frac{N_e \cdot 3600 + Q_0}{D_G \cdot H_d \cdot \eta_K} = \eta_t + \frac{Q_0}{Q_K} = 0{,}730 = 73\%$$

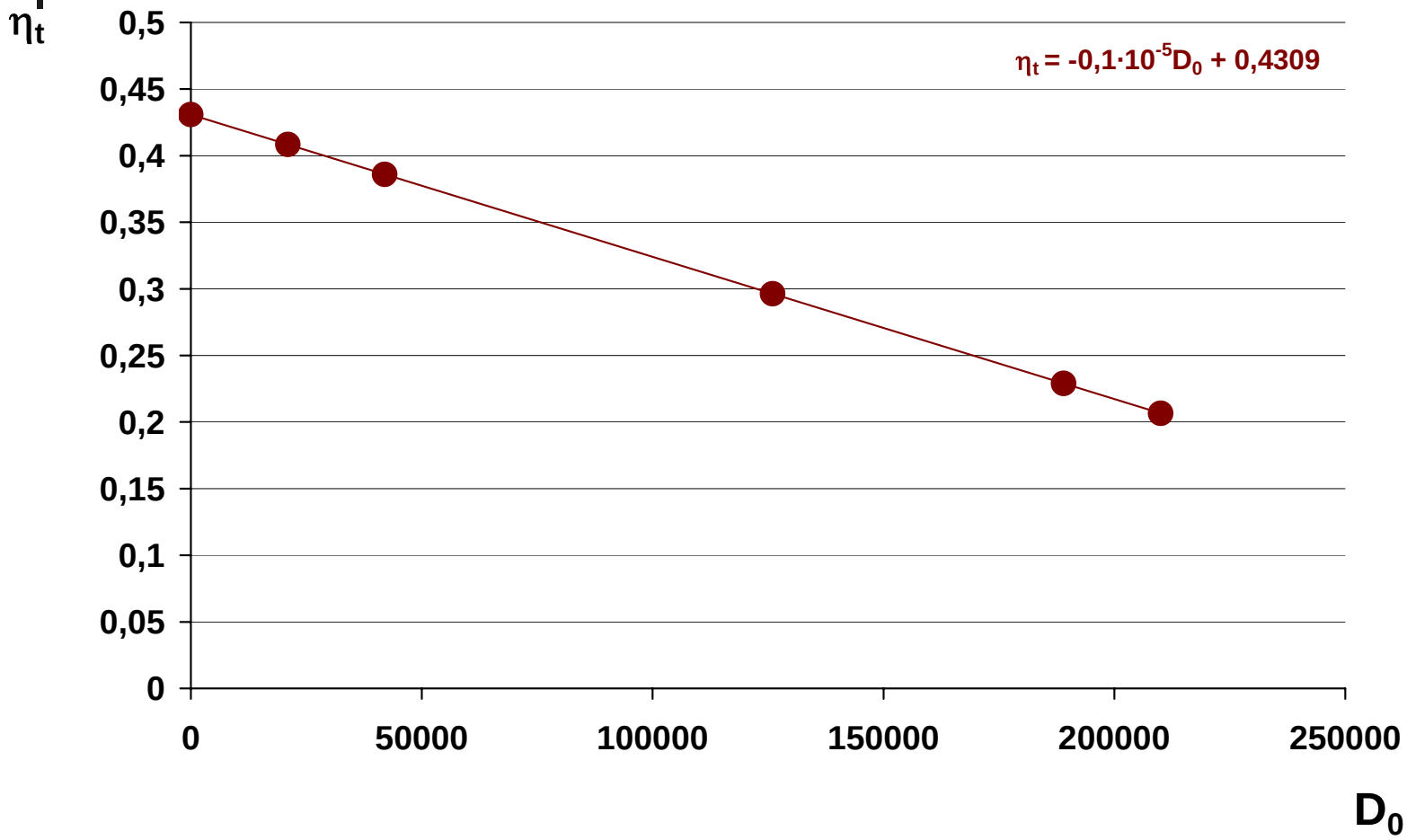
Toplina odvedena potrošaču:

$$Q_0 = D_0 \cdot h_2 = 74300 \cdot 2540 = 188{,}7 \cdot 10^6 \ \frac{kJ}{h}$$

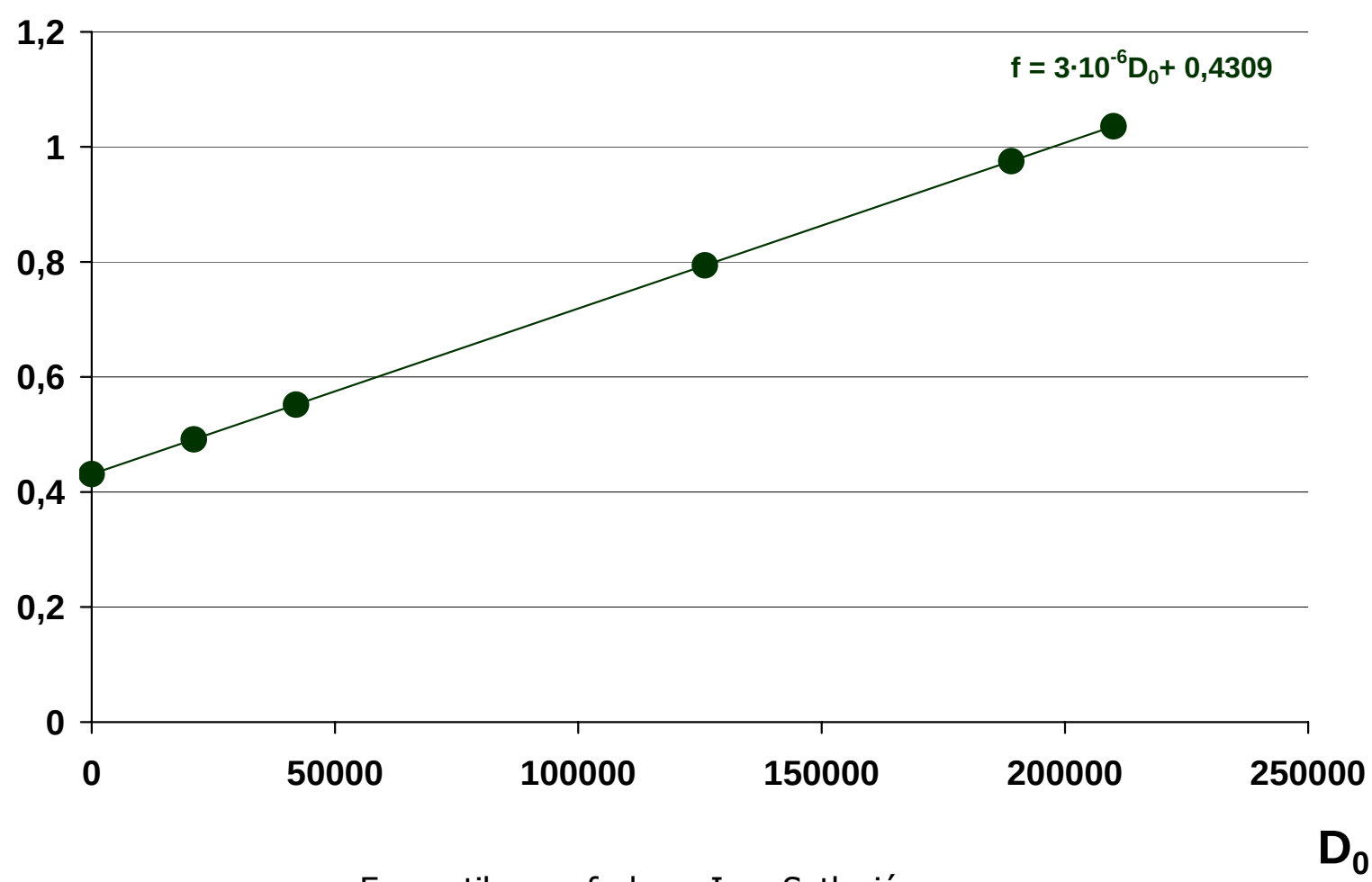
Ovisnost N_e o količini oduzete pare D_0 uz D=konst



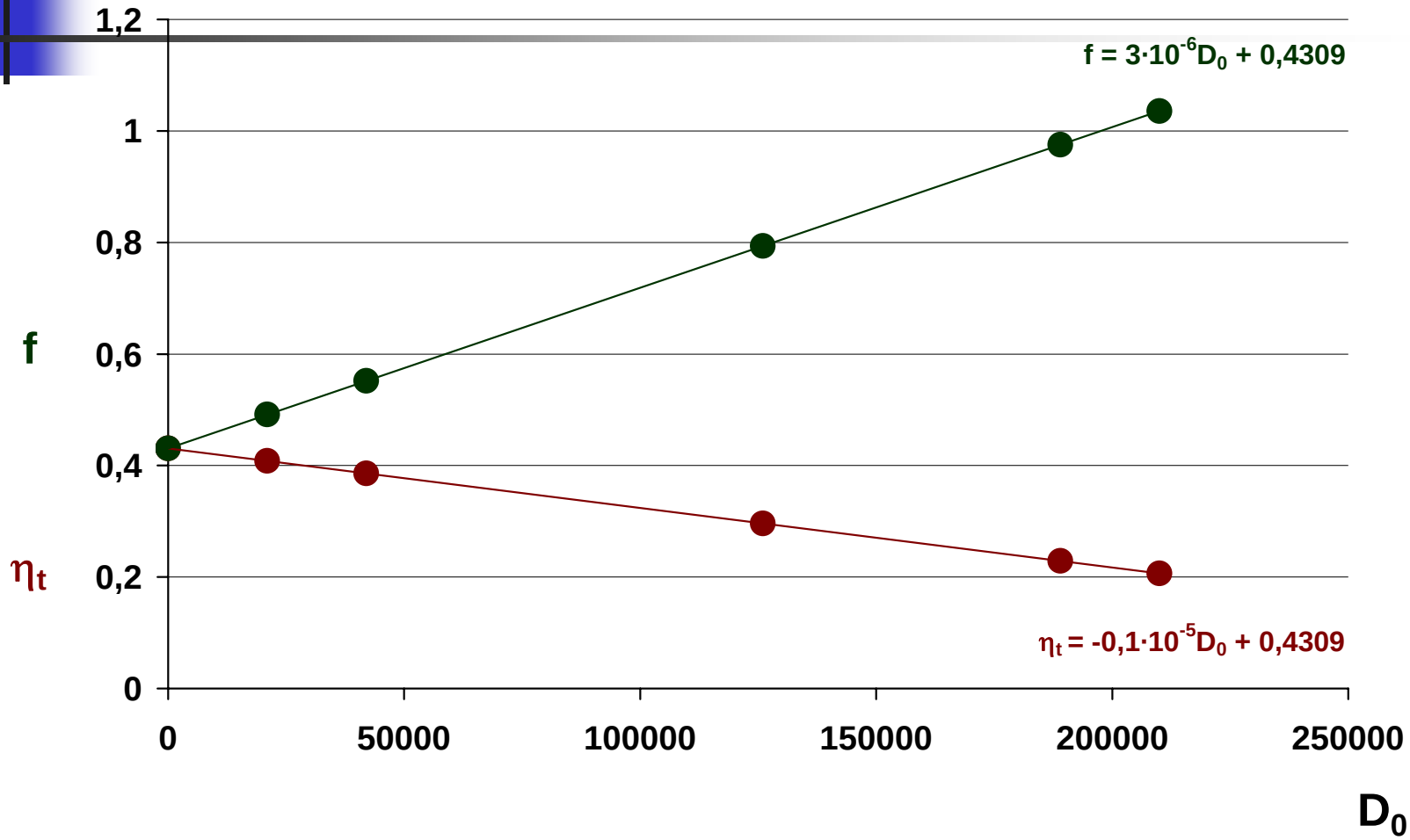
Ovisnost η_t o količini oduzete pare D_0 uz D=konst



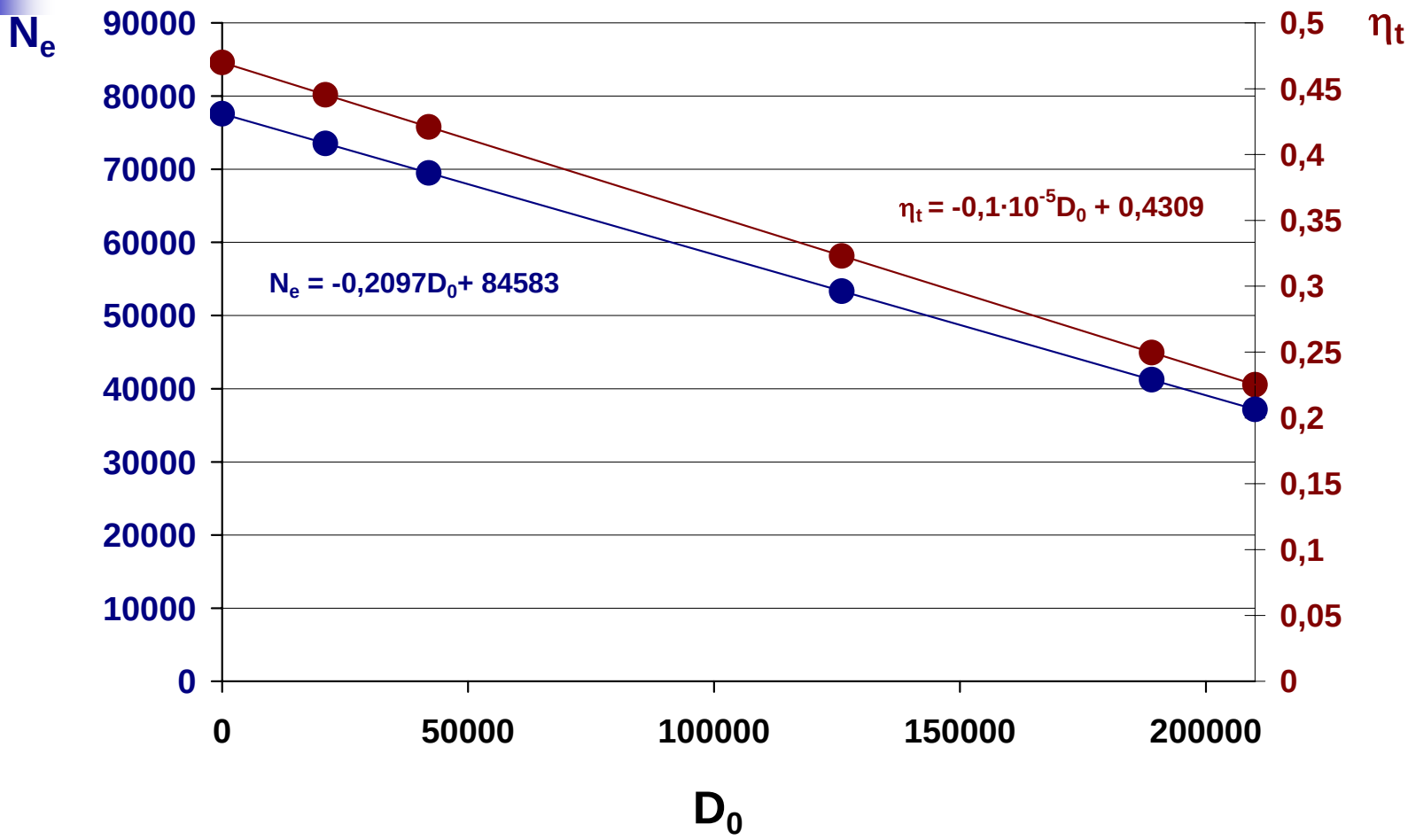
Ovisnost f o količini oduzete pare D_0 uz D=konst



Trendovi f i η_t



Trendovi N_e i η_t



Izračunajte na godišnjoj razini proizvedenu količinu električne energije i toplinske energije isporučene potrošačima. Rezultat izrazite u MWh, tEu i tEn.

1 godina ima 365x24=8760 sati.

$$E_e = N_e \cdot 8760 = 58{,}2\,MW_e \cdot 8760h = 509832\,MWh_e = 509832 \cdot 10^3\,kWh_e$$

$$E_e = \frac{N_e(kWh)}{8141kWh} = \frac{509832 \cdot 10^3\,kWh_e}{8141kWh} = 62625{,}2tEu$$

$$E_e = \frac{N_e(kWh)}{11630kWh} = \frac{509832 \cdot 10^3\,kWh_e}{11630kWh} = 43837{,}7tEn$$

$$E_e = 509832 \cdot 10^3\,kWh \cdot 3600 = 1{,}835 \cdot 10^{12}\,kJ = 1{,}835PJ$$