Internal Combustion Engines

Asst. Prof. Dr. Levent YÜKSEK

Exercise-Otto cycle

Below listed data are provided for a four stroke internal combustion engine which operates according to air-standard **OTTO** cycle. Please calculate the **pressure** and **temperature** of the characteristic cycle points and the indicated mean effective pressure (***P_{mi}***)of the cycle**.**

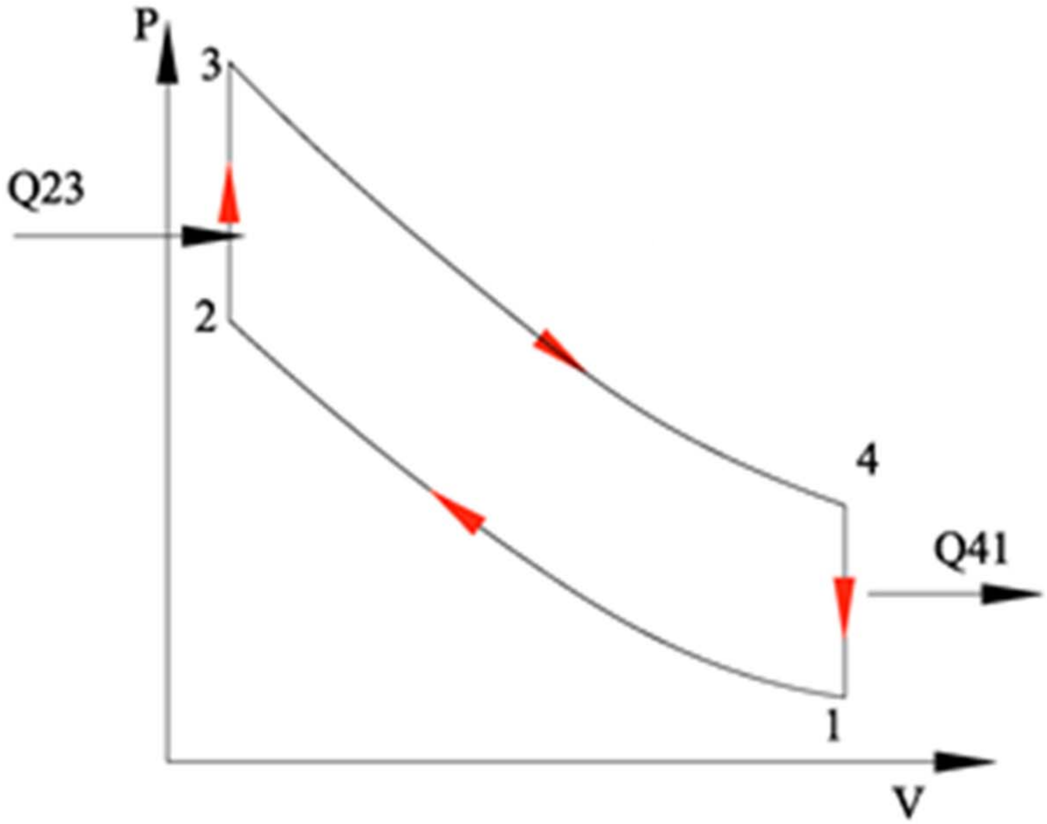
Given parameters,

- Temperature at the beginning of compression stroke= 20^{o}C
- Pressure at the beginning of compression stroke= 1 Bar
- Compression Ratio is 10.5
- Pressure increase ratio is 2
- Ratio of specific heats is 1.41

*(The SEILIEGER Cycle **Pmi** and **ηt equations are given below. You can use these equations for calculating OTTO Cycle Pmi** and **ηt)***

$$Pmi = \eta_T \cdot \frac{P_1.\varepsilon^k}{(k-1).(\varepsilon-1)}\left[\rho - 1 + k\rho\left(\varepsilon_g - 1\right)\right] \quad \eta_T = 1 - \frac{1}{\varepsilon^{(k-1)}} \cdot \frac{\rho.\varepsilon_g^k - 1}{\rho - 1 + k.\rho.\left(\varepsilon_g - 1\right)}$$

Exercise-Otto cycle



Exercise-Otto cycle

$P_1 = 1 \text{ Bar}$

$P_2 = P_1 . \varepsilon^k$

$P_2 = 1.10,5^{1,41} = 27,53 \text{ Bar}$

$\frac{P_3}{P_2} = \rho \ , \quad \frac{P_3}{27,53} = 2$

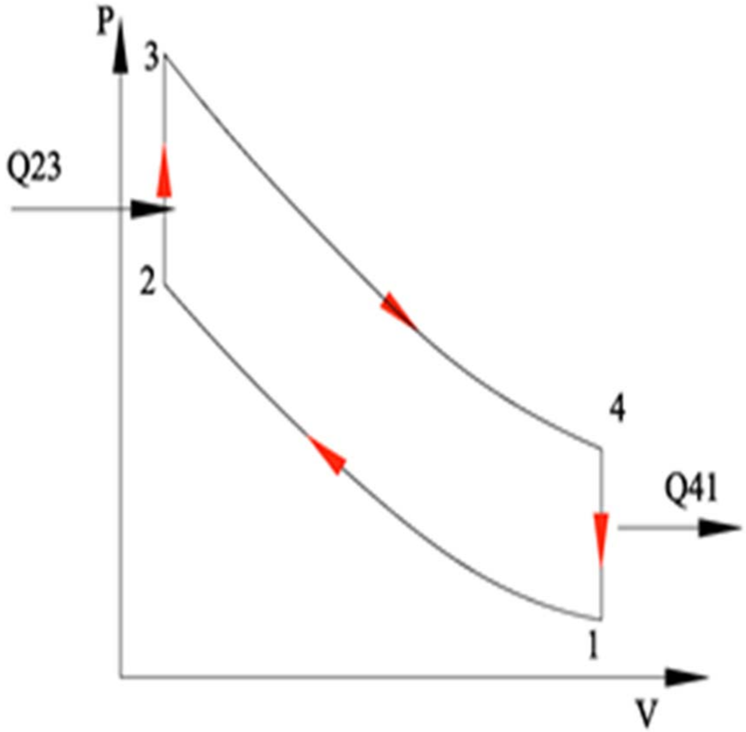
$P_3 = 55,06 \text{ Bar}$

$P_4 = \frac{P_3}{\varepsilon^k} \ , \ P_4 = \frac{55,06}{10,5^{1,41}}$

$P_4 = 2 \text{ Bar}$

$T_1 = 293 \text{ K}$

$T_2 = T_1 . \varepsilon^{k-1}$



$T_2 = 293.10,5^{1,41-1} \ , \ T_2 = 768,34 \text{ K}$

Exercise-Otto cycle

$T_2 = 293.10{,}5^{1{,}41-1}\ ,\ T_2 = 768{,}34\,\mathrm{K}$

$\dfrac{T_3}{T_2} = \rho\ ,\ \dfrac{T_3}{768{,}34} = 2$

$T_3 = 1536{,}68\,\mathrm{K}$

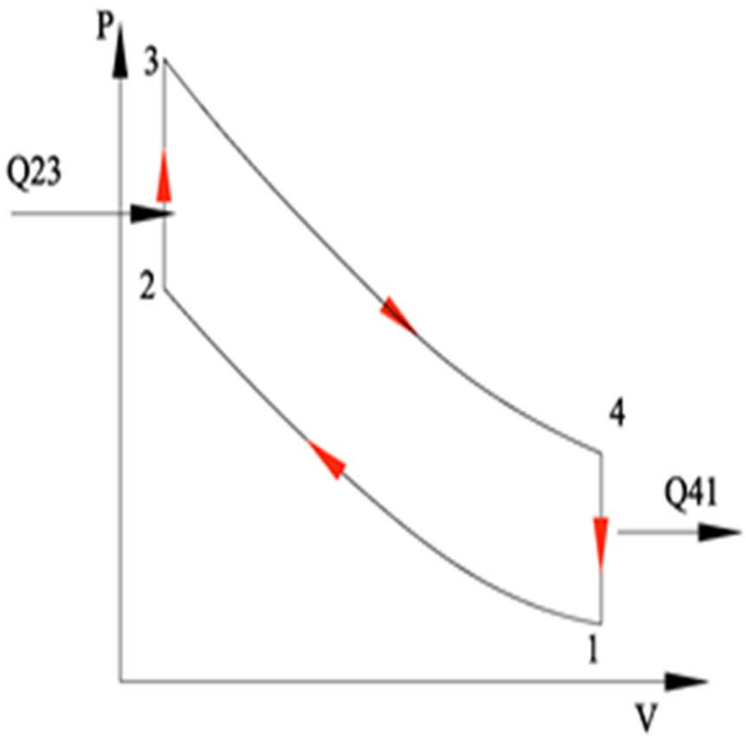
$T_4 = \dfrac{T_3}{\varepsilon^{k-1}}\ ,\ T_4 = \dfrac{1536{,}68}{10{,}5^{1{,}41-1}}$

$T_4 = 585{,}99\ \mathrm{K}$

$\eta_T = 1 - \dfrac{1}{\varepsilon^{k-1}}\ ,\ 1 - \dfrac{1}{10{,}5^{1{,}41-1}}\ ,\ \eta_T = 0{,}6186$

$Pmi = \eta_T . \dfrac{P_1}{k-1} . \dfrac{\varepsilon^k}{\varepsilon - 1} . (\rho - 1)$

$Pmi = 0{,}6186 . \dfrac{1}{1{,}41-1} . \dfrac{10{,}5^{1{,}41}}{10{,}5-1} . (2-1) = 4{,}372\ \mathrm{Bar}$



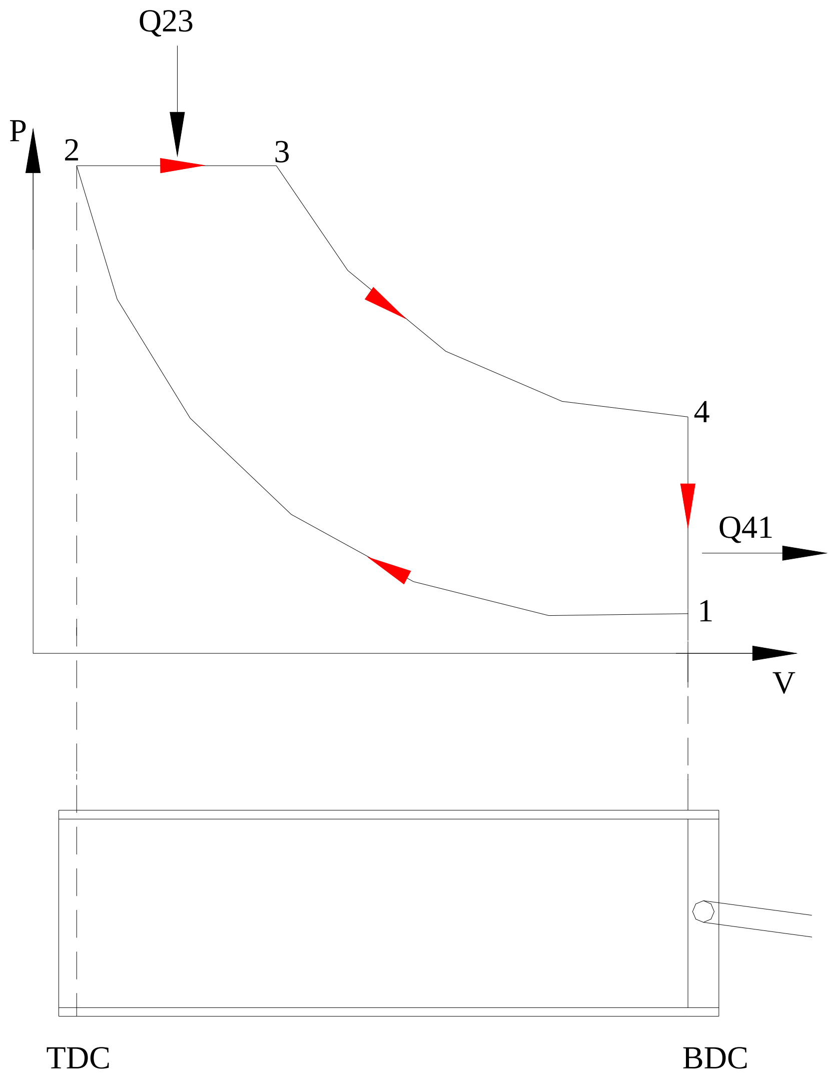
Exercise-Diesel cycle

Below listed data are provided for a four stroke internal combustion engine which operates according to air-standard **DIESEL** cycle. Please calculate the **pressure** and **temperature** of the characteristic cycle points and the indicated mean effective pressure (***P_{mi}***)of the cycle**.**

Given parameters,
Pressure at the beginning of compression stroke is 1 Bar.
Temperature at the beginning of compression stroke is 27°C.
Cut-off Ratio is 1.4
Ratio of specific heats 1.37
Pressure at the beginning of the heat input process is 57.3 Bars.
(The SEILIEGER Cycle ***Pmi*** *and* ***ηt equations are given below. You can use these equations for finding OTTO Cycle Pmi*** *and* ***ηt)***

$$Pmi = \eta_T \cdot \frac{P_1.\varepsilon^k}{(k-1).(\varepsilon-1)}\left[\rho - 1 + k\rho\left(\varepsilon_g - 1\right)\right] \qquad \eta_T = 1 - \frac{1}{\varepsilon^{(k-1)}} \cdot \frac{\rho.\varepsilon_g^k - 1}{\rho - 1 + k.\rho.\left(\varepsilon_g - 1\right)}$$

Exercise-Diesel cycle



Exercise-Diesel cycle

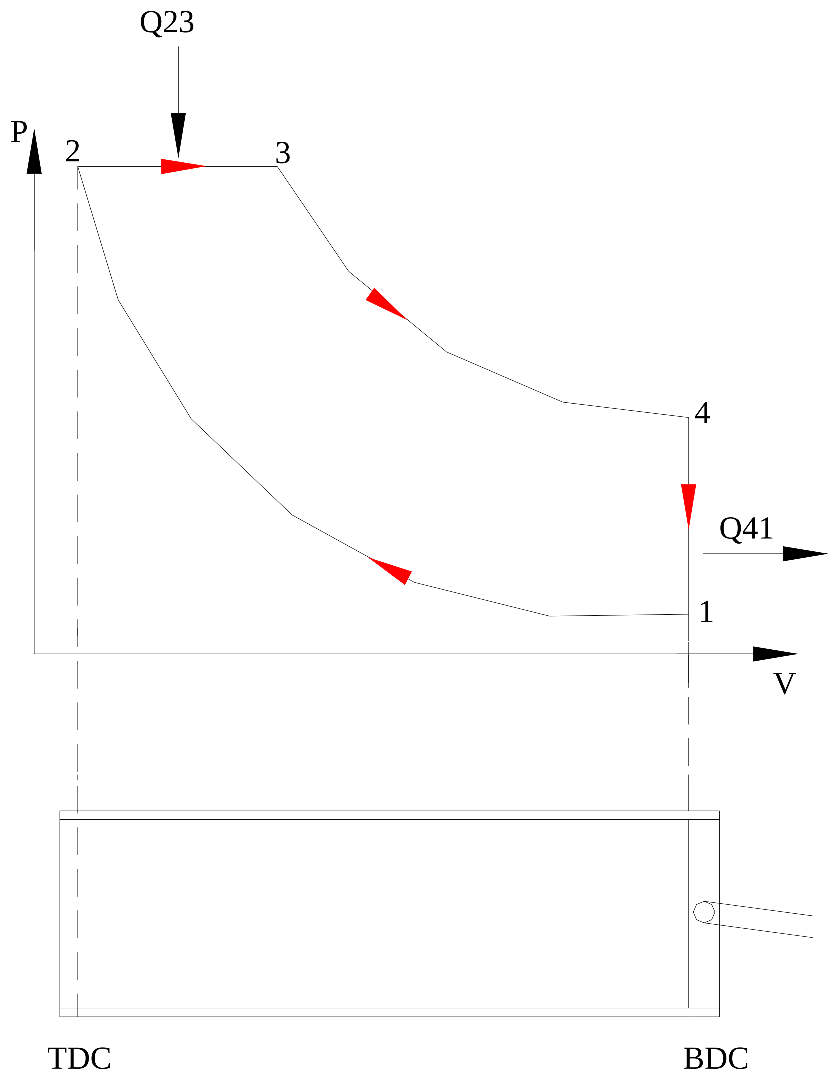
$$T_1 = 300K$$

$$P_1 = 1\,Bar$$

$$P_2 = 57.3\,Bars$$

$$\varepsilon_g = 1.4$$

$$k = 1.37$$



Exercise-Diesel cycle

$$P_2 = P_1.\varepsilon^k$$

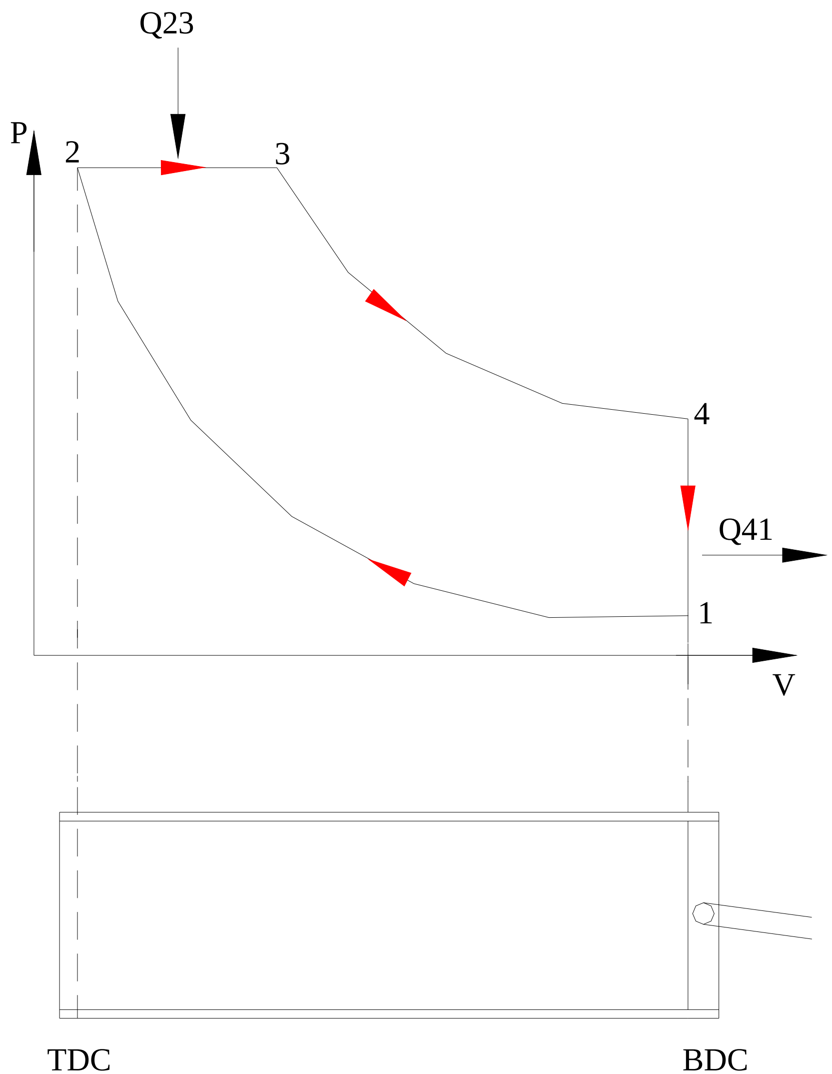
$$57.3 = 1.\varepsilon^{1.37}$$

$$\varepsilon = 19.2$$

$$P_2 = P_3$$

$$P_3 = 57.3\,Bars$$

$$P_4 = \frac{P_3}{\left(\dfrac{\varepsilon}{\varepsilon_g}\right)^k} = \frac{57.3}{\left(\dfrac{19.2}{1.4}\right)^{1,37}} = 1.57\,Bars$$



Exercise-Diesel cycle

$$T_2 = T_1 . \varepsilon^{k-1}$$

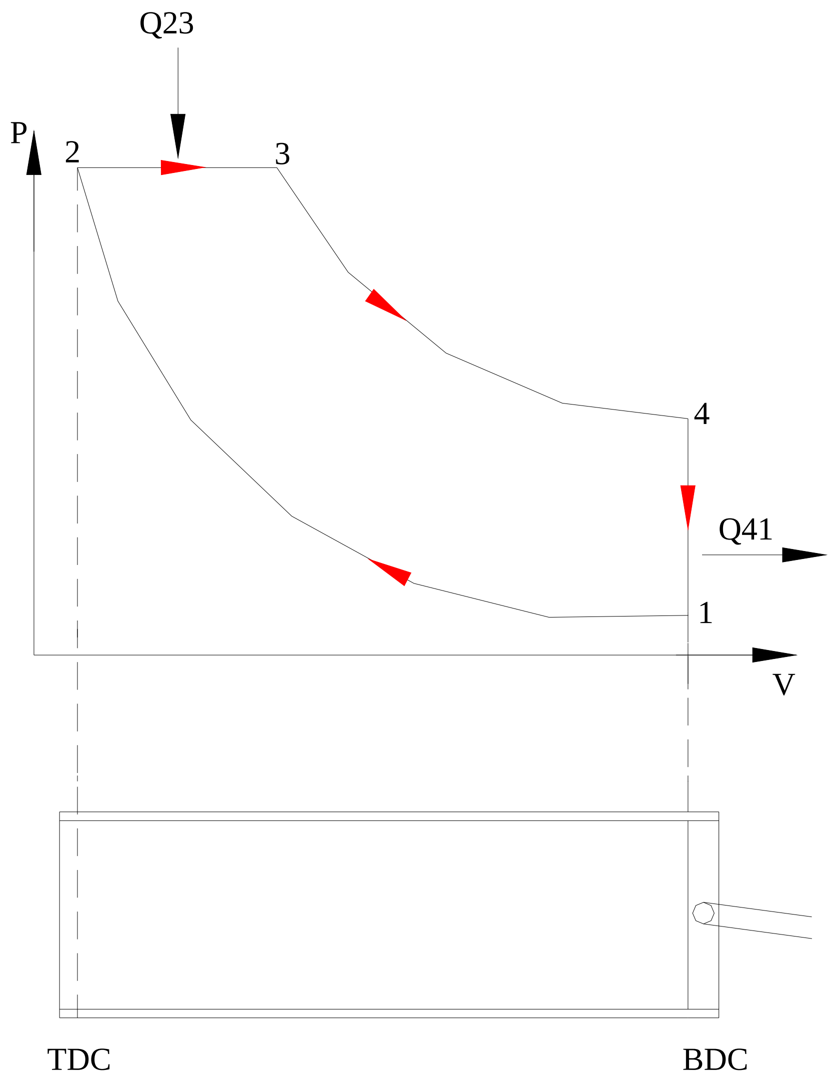
$$T_2 = 300.19.2^{1.37-1}$$

$$T_2 = 895.24K$$

$$T_3 = T_2 . \varepsilon_g$$

$$T_3 = 895.24x1.4$$

$$T_3 = 1253.3K$$

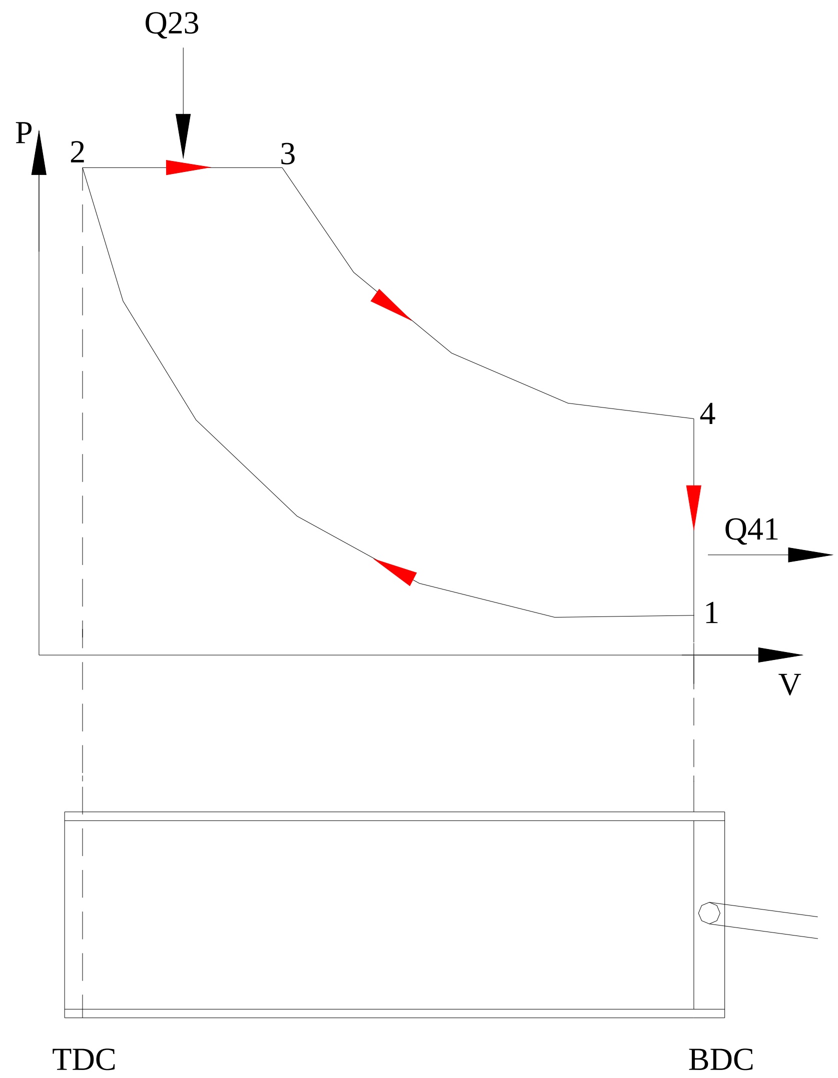


Exercise-Diesel cycle

$$T_4 = \frac{T_3}{\left(\frac{\varepsilon}{\varepsilon_g}\right)^{k-1}}$$

$$T_4 = \frac{1253.3}{\left(\frac{19.2}{1.4}\right)^{1.37-1}}$$

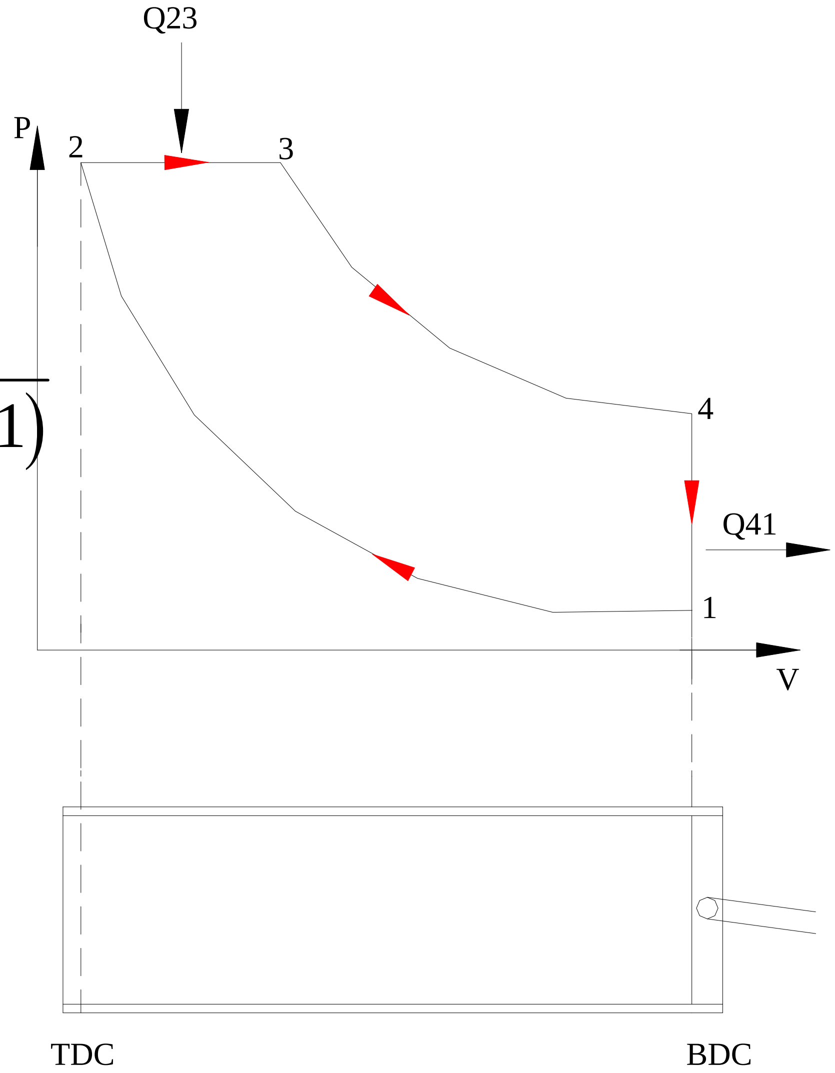
$$T_4 = 475.81K$$



Exercise-Diesel cycle

$$\eta_T = 1 - \frac{1}{\varepsilon^{(k-1)}} \cdot \frac{\rho.\varepsilon_g^k - 1}{\rho - 1 + k.\rho.\left(\varepsilon_g - 1\right)}$$

$$\eta_T = 1 - \frac{1}{19.2^{(1.37-1)}} x \frac{1x(1.4^{1.37}) - 1}{1 - 1 + (1.37)\,\mathrm{x}\,1x\left(1.4 - 1\right)}$$



Exercise-Dual (Seiliger)cycle

Below listed data are provided for a four stroke internal combustion engine which operates according to air-standard **DUAL** cycle. Please calculate the **pressure** and **temperature** of the characteristic cycle points and the indicated mean effective pressure (***P_{mi}***)of the cycle**.**

Given parameters,
Pressure at the beginning of compression stroke is 1 Bar.
Pressure and temperature at the end of heat input process are 43.05x10^5 Pa and 2410K respectively.
Temperature at the end of expansion stroke is 1150K.
Compression ratio is 11.
Ratio of specific heats 1.41
*(The SEILIEGER Cycle **Pmi** and **ηt** **equations are given below. You can use these equations for finding OTTO Cycle Pmi** and **ηt**)*

$$Pmi = \eta_T \cdot \frac{P_1.\varepsilon^k}{(k-1).(\varepsilon-1)}\left[\rho - 1 + k\rho(\varepsilon_g - 1)\right] \qquad \eta_T = 1 - \frac{1}{\varepsilon^{(k-1)}} \cdot \frac{\rho.\varepsilon_g^k - 1}{\rho - 1 + k.\rho.(\varepsilon_g - 1)}$$

Exercise-Dual (Seiliger)cycle

$P_1 = 1.01.10^5\ Bars$

$P_2 = P_1.\varepsilon^k$

$P_2 = 1.01.10^5\ x11^{1.41} = 29.6\ Bars$

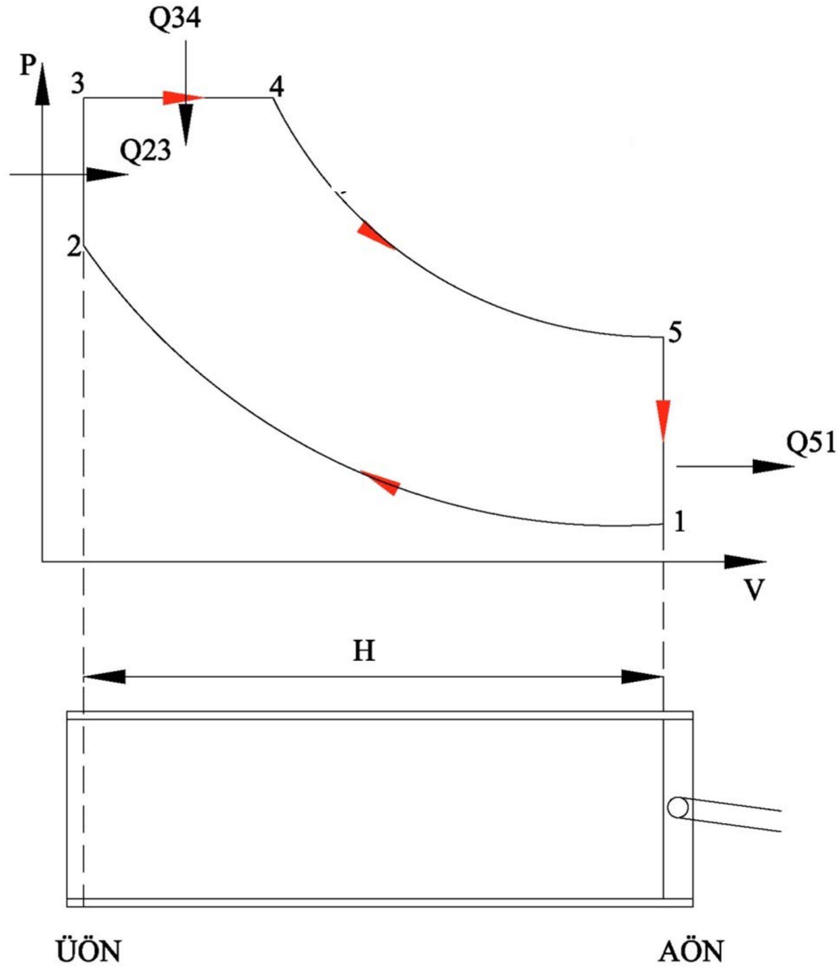
$P_3 = P_4 = 43.05\ Bars$

$T_4 = 2410\ K$

$T_5 = 1150\ K$

$$T_5 = \frac{T_4}{\left(\frac{\varepsilon}{\varepsilon_g}\right)^{k-1}} \quad 1150 = \frac{2410}{\left(\frac{11}{\varepsilon_g}\right)^{1,41-1}}$$

$\varepsilon_g = 1,81$



Exercise-Dual (Seiliger)cycle

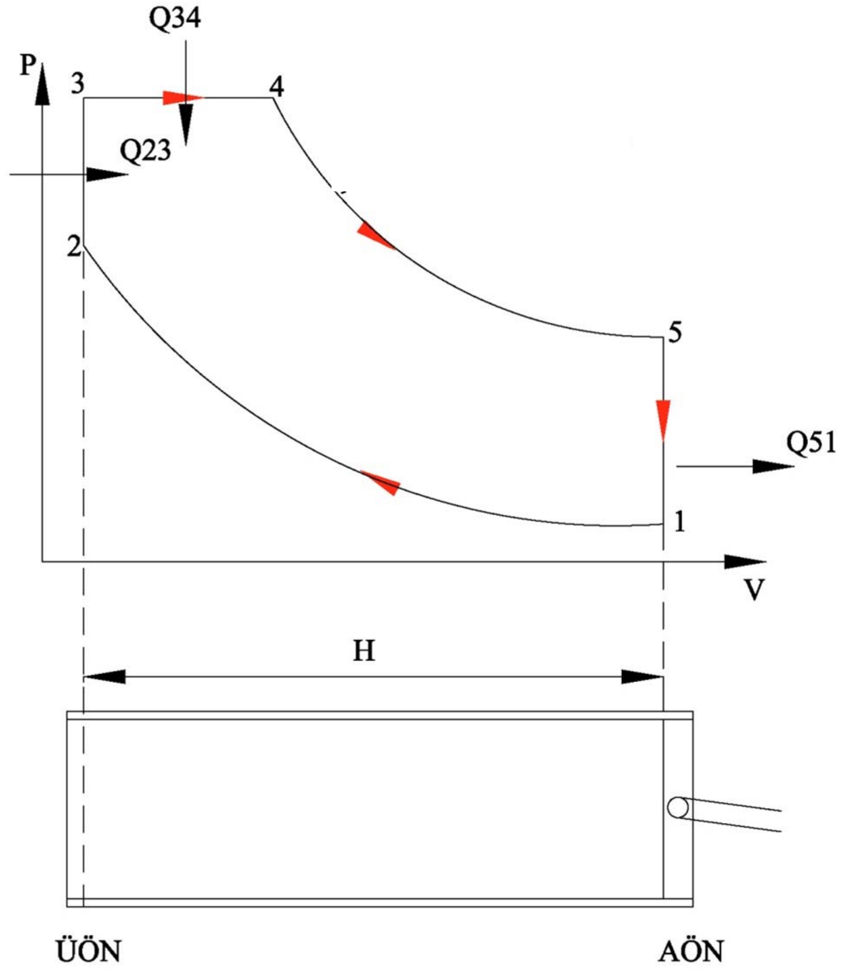
$$T_4 = T_3 . \varepsilon_g$$

$$2410 = T_3 x 1.81$$

$$T_3 = 1331.4K$$

$$\frac{P_3}{P_2} = \rho \qquad \frac{43,5}{29,6} = \rho$$

$$\rho = 1,469$$



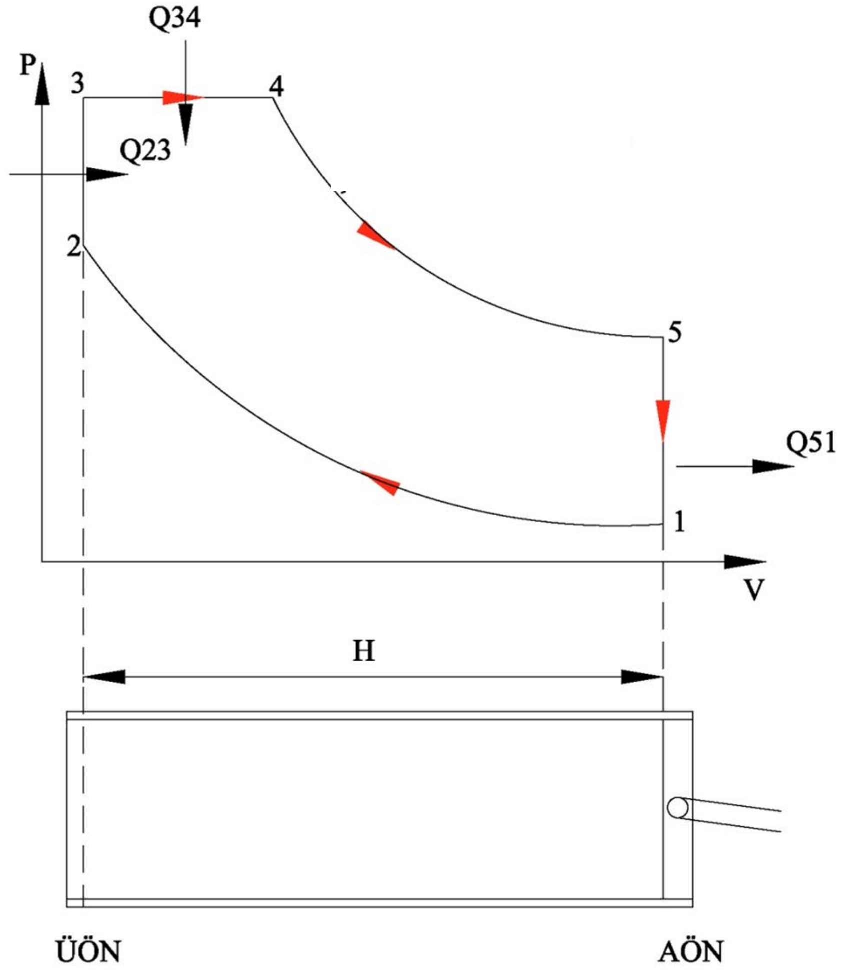
Exercise-Dual (Seiliger)cycle

$$\frac{T_3}{T_2} = \rho \qquad \frac{1331.4}{T_2} = 1.469$$

$$T_2 = 906.39K$$

$$T_2 = T_1.\varepsilon^{k-1} \quad 906,39 = T_1.11^{0,41}$$

$$T_1 = 339,11K$$

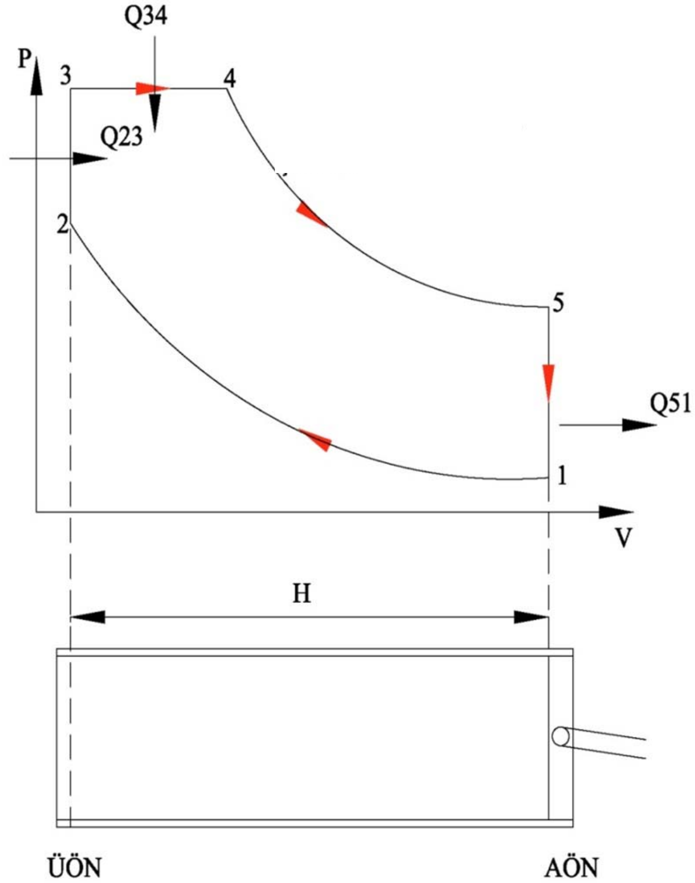


Exercise-Dual (Seiliger)cycle

$$\eta_T = 1 - \frac{1}{\varepsilon^{k-1}} \cdot \frac{\rho.\varepsilon_g^{k} - 1}{\rho - 1 + k.\rho.\left(\varepsilon_g - 1\right)}$$

$$\eta_T = 1 - \frac{1}{11^{0,41}} \cdot \frac{1,469.1,81^{1,41} - 1}{1,469 - 1 + 1,41.1,469.\left(1,81 - 1\right)}$$

$$\eta_T = 0.5832$$



Exercise-Dual (Seiliger)cycle

$$Pmi = \eta_T \cdot \frac{P_1 . \varepsilon^k}{(k-1).(\varepsilon-1)}\left[\rho - 1 + k\rho(\varepsilon_g - 1)\right]$$

$$Pmi = 0,5832.\frac{1,01.11^{1,41}}{(1,41-1).(11-1)}\left[1,469 - 1 + 1,41.1,469(1,81-1)\right]$$

$$Pmi = 9.06\,Bars$$