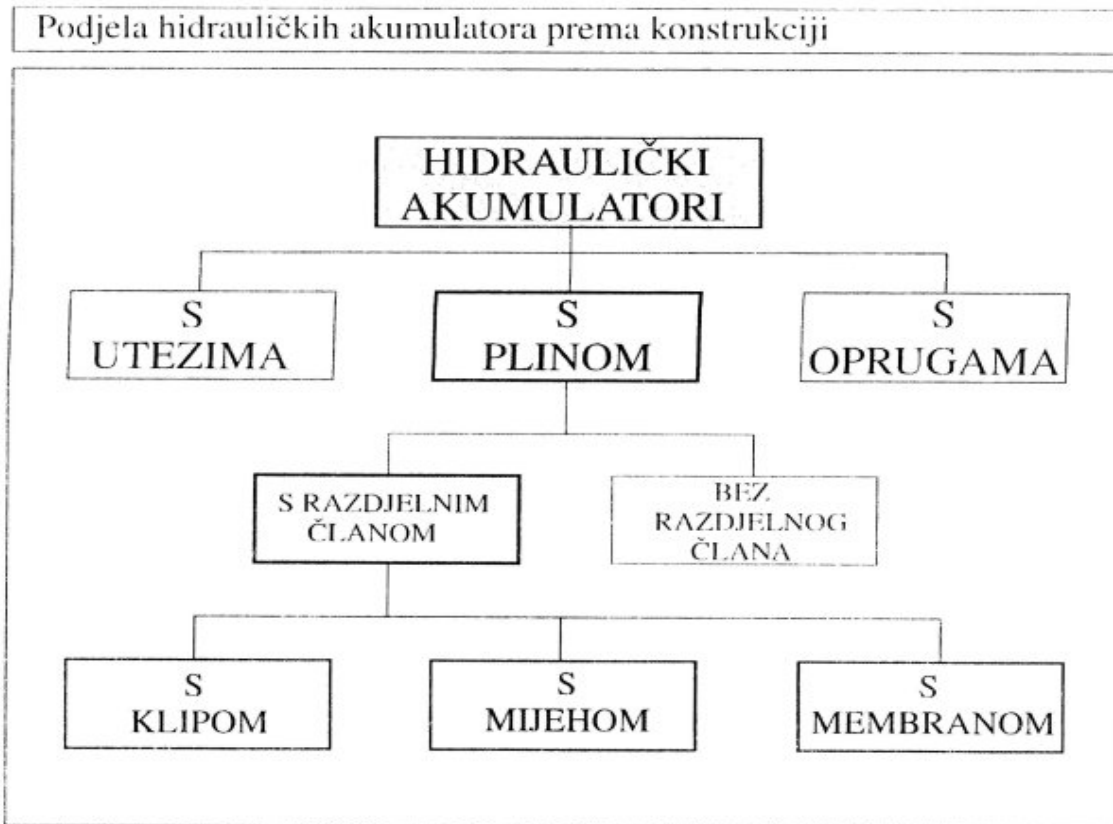




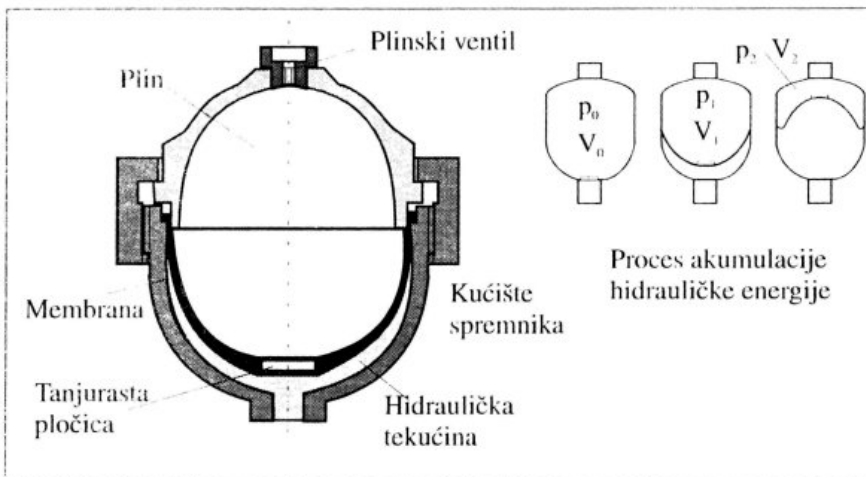
# HIDRAULIČKI AKUMULATORI

- Grupa uređaja različitih konstruktivnih oblika, koji imaju zadatak akumulirati hidrauličku energiju ili određeni volumen fluida (u vrijeme kada nisu potrebni izvršnim elementima) i osloboditi ih sustavu onda kada mu trebaju

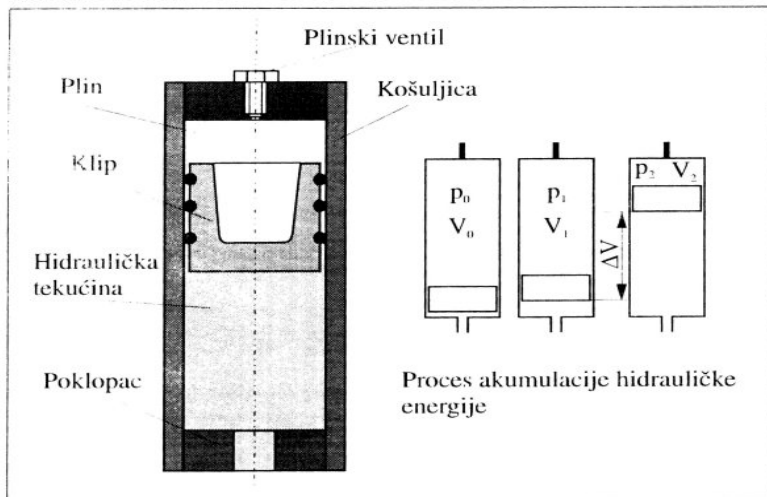
# Podjela hidrauličkih akumulatora



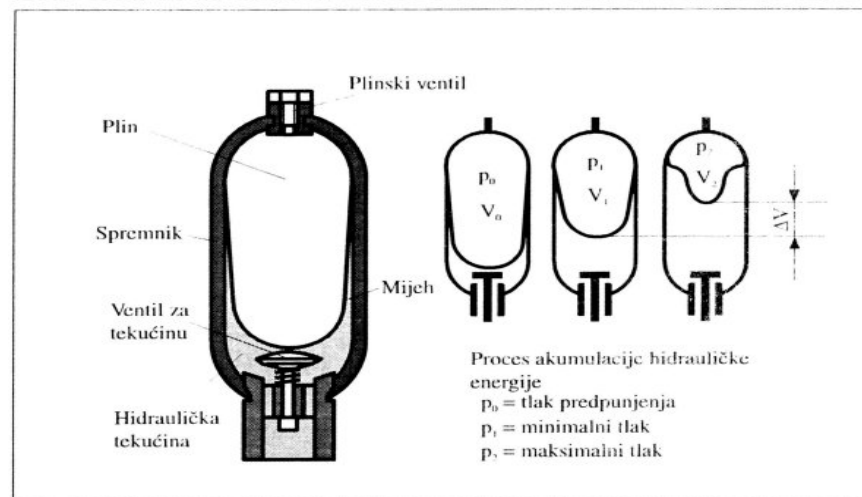
### Hidroakumulator s membranom



### Klipni hidroakumulator



### Hidroakumulator s mijehom

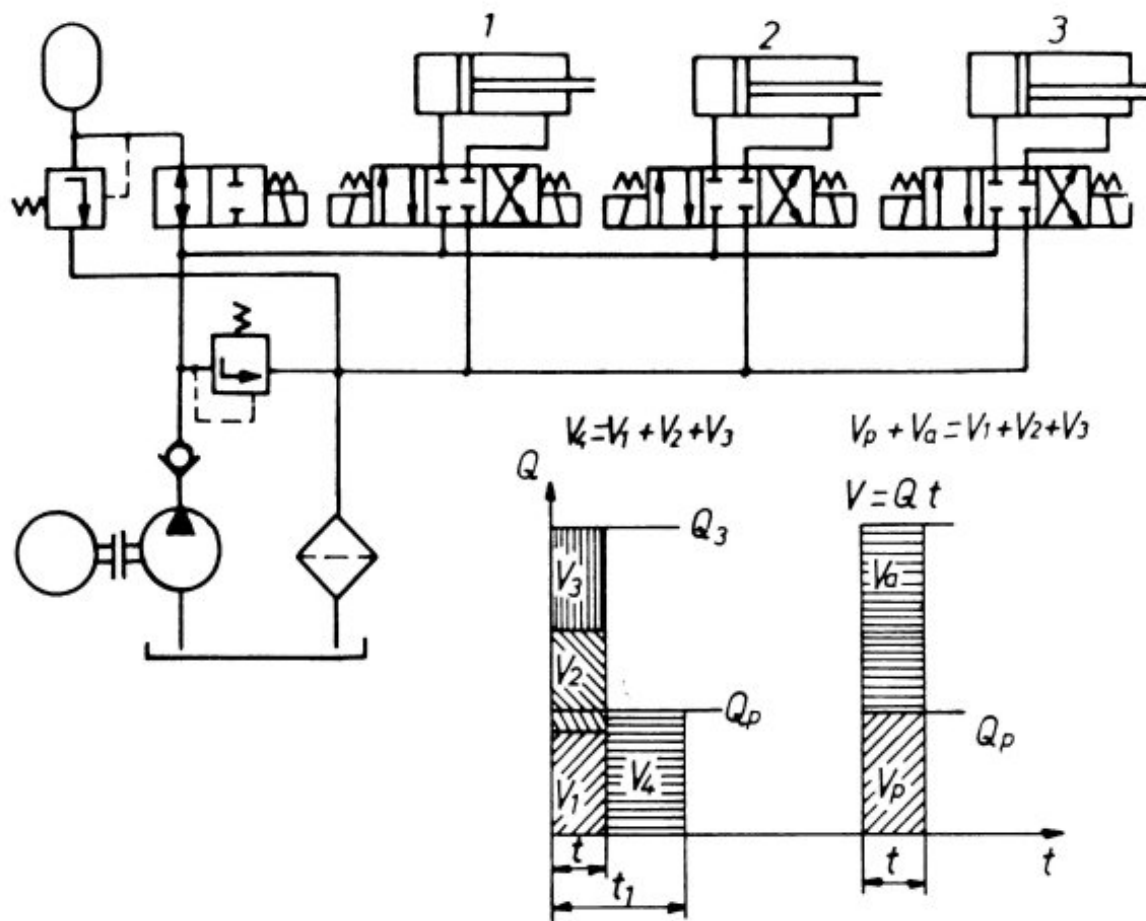




# Zadatak akumulatora u hidrauličkom sustavu

- Ušteda energije
- Smanjenje kapaciteta pumpe
- Prigušivanje hidrauličkih udara
- Smanjenje oscilacije tlaka
- Kompenzacija volumena i dr.

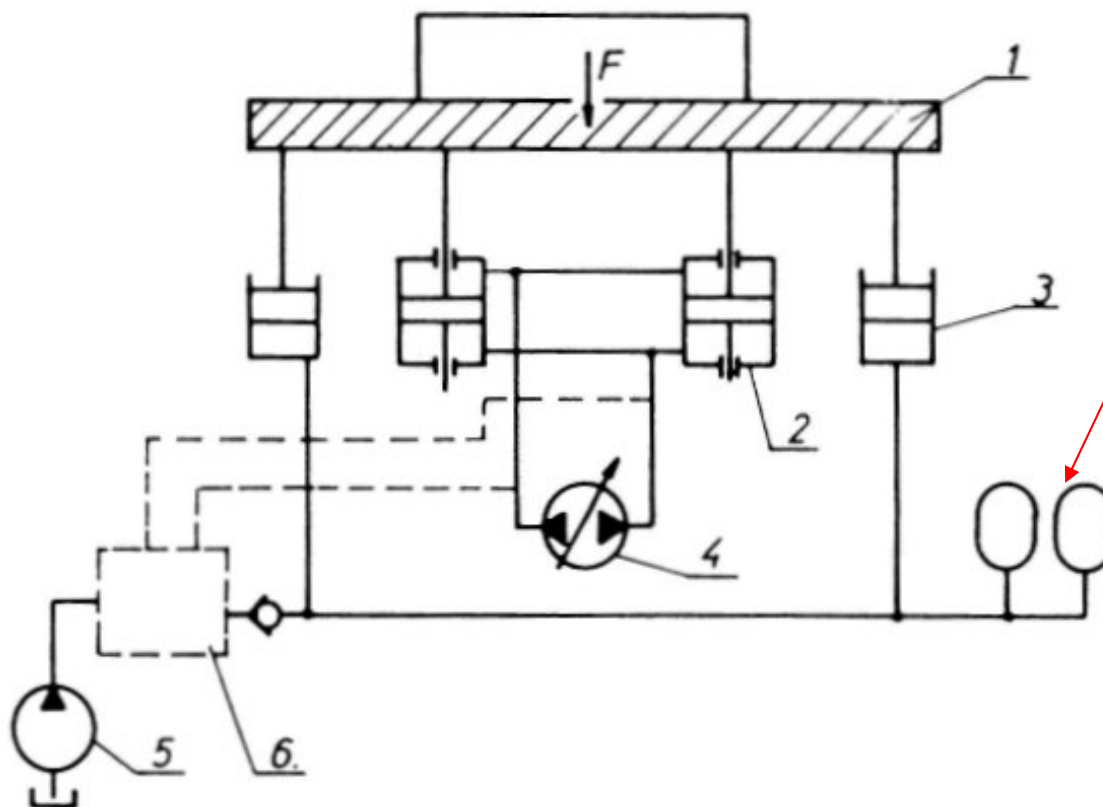
# Ugradnja hidrauličkog akumulatora zbog smanjenja kapaciteta pumpe



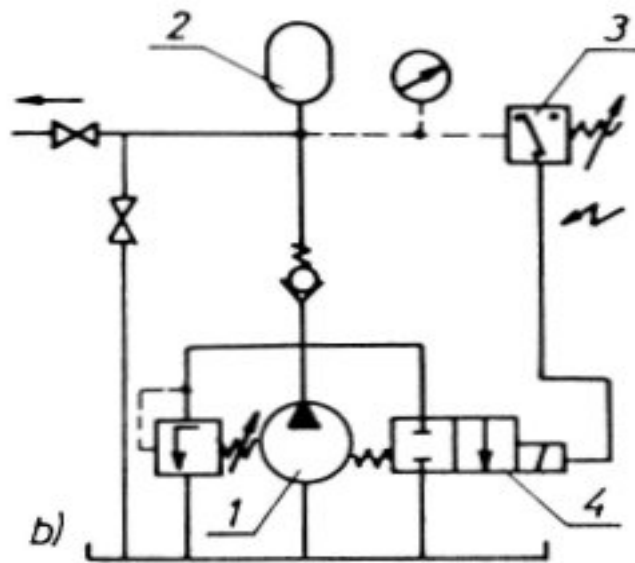
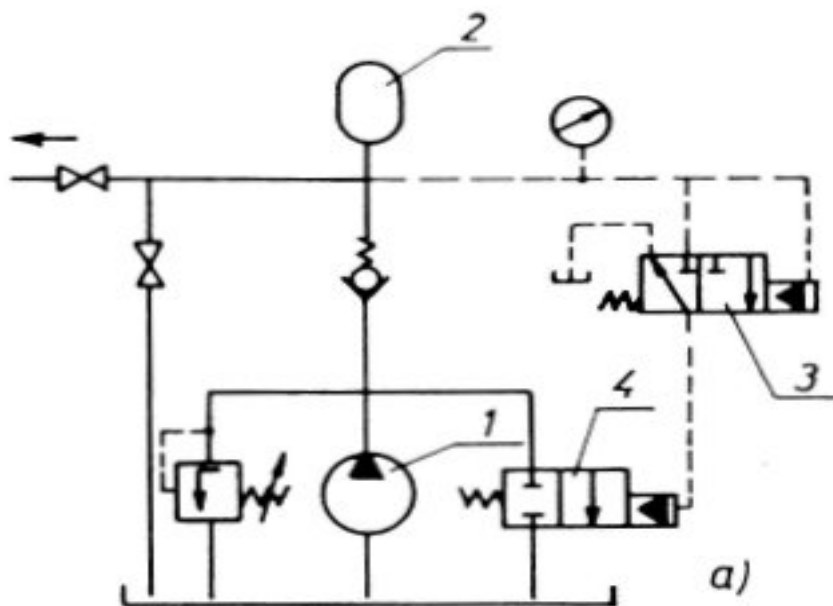
Pumpa ima kapacitet potreban za osiguranje volumena  $V_4$ . Kada je potrebno predati volumen  $V_1 + V_2 + V_3$  tada se ostatak nadomješta iz akumulatora

# Shema gradnje u cilju štednje energije

Akumulatori se pune kod spuštanja

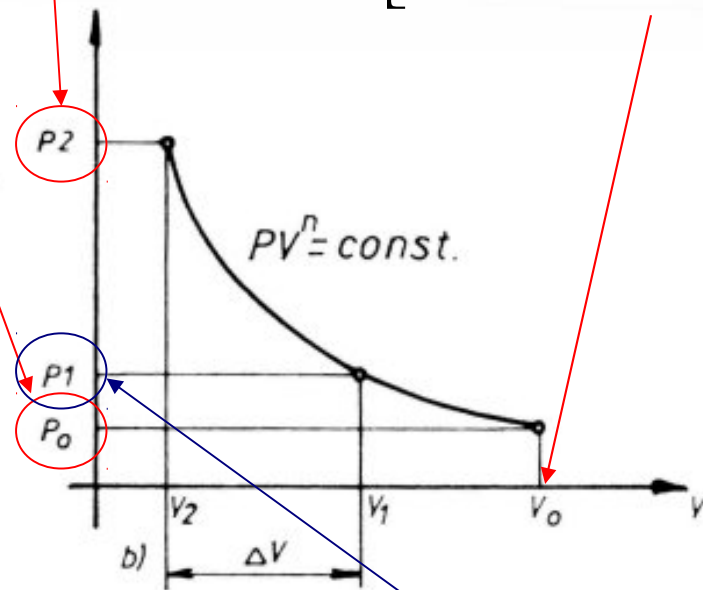
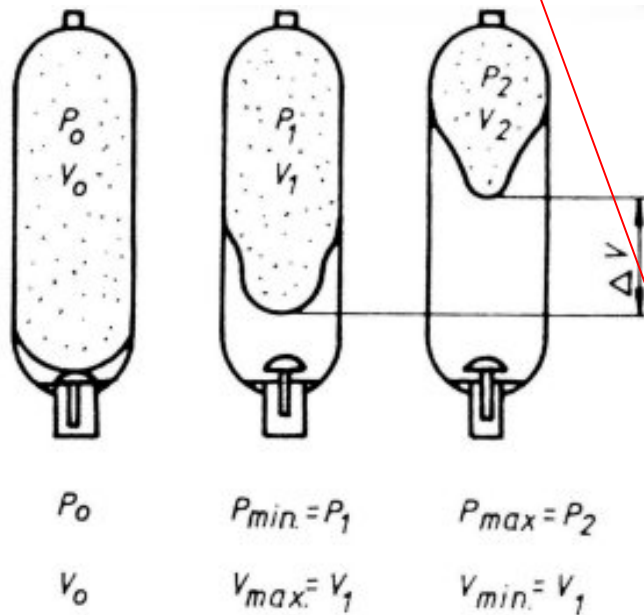


# Shema upravljanja punjenja akumulatora hidrauličko vs. električno upravljanje



# Proračun

Maksimalni tlak  
Tlak punjena (najčešće  $0.9 p_1$ )



$$V_0 = \frac{\Delta V}{\left[ \left( \frac{p_0}{p_1} \right)^{\frac{1}{n}} - \left( \frac{p_0}{p_2} \right)^{\frac{1}{n}} \right]}$$

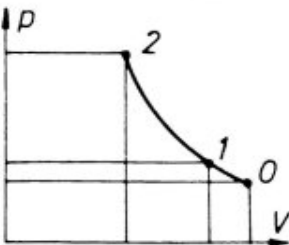
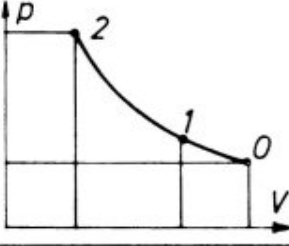
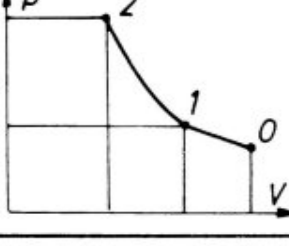
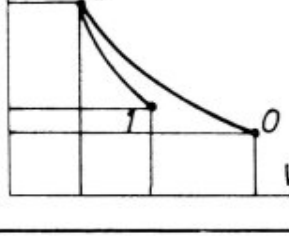
Radni tlak

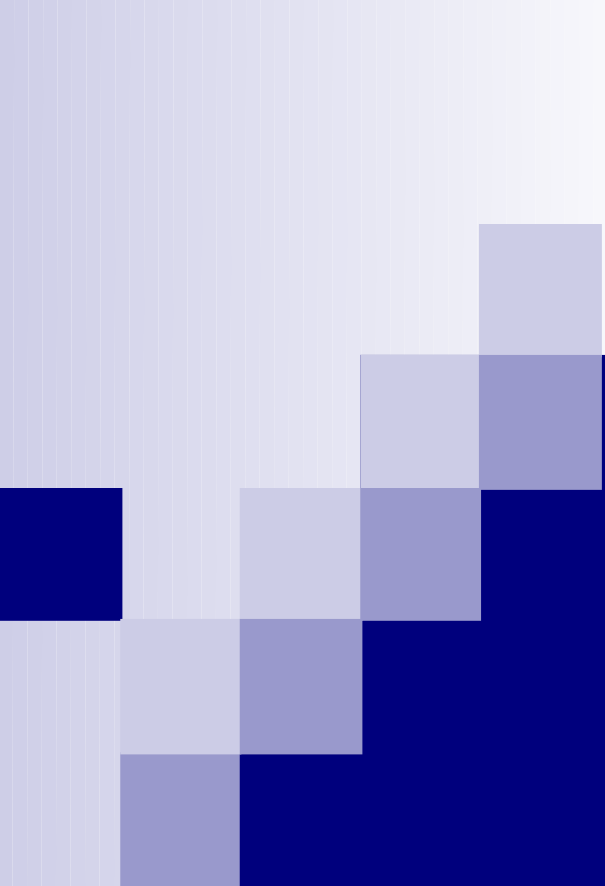
Izoterma ( $n=1$ ) –  $t > 3s$  (spora ekspanzija)

Adijabata ( $n=\kappa$ ) –  $t < 1s$  (brza ekspanzija)

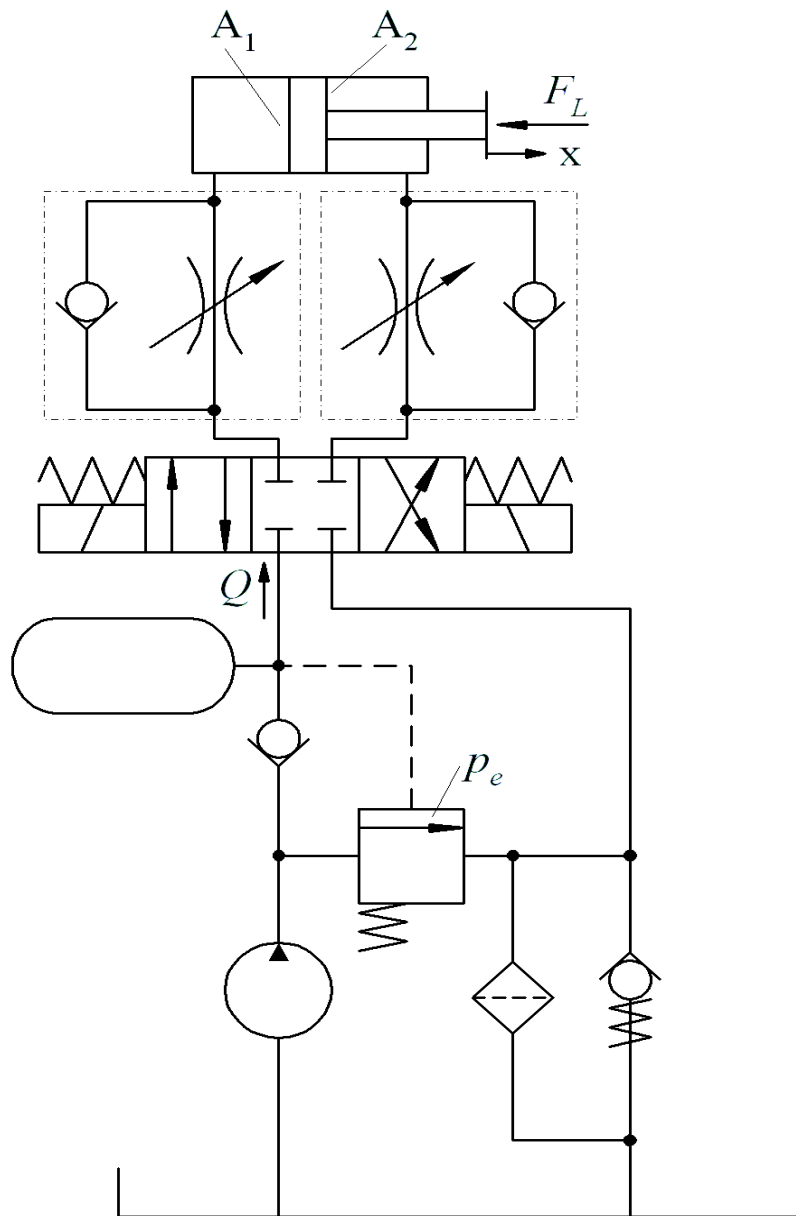
Politropa ( $n$ ) –  $1s < t < 3s$



|                                                                                     | Proces                                                                                                             | Kriterij upotrebe                                                                                                                              |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
|    | <p><math>0 \rightarrow 1</math> adiabatsko punjenje</p> <p><math>1 \leftrightarrow 2</math> adiabatski proces</p>  | <p>Kod akumuliranja energije</p> <p><math>p_0 = 0,9 p_1</math></p> <p><math>p_2 = 2 p_1</math></p> <p><math>\Delta V = 0,362 V_0</math></p>    |
|    | <p><math>0 \rightarrow 1 \leftrightarrow 2</math></p> <p>izotermički proces</p>                                    | <p>Kompenzacija izgubljenog ulja</p> <p><math>p_0 = 0,9 p_1</math></p> <p><math>p_2 = 2 p_1</math></p> <p><math>\Delta V = 0,45 V_0</math></p> |
|    | <p><math>0 \rightarrow 1</math> izotermički punjenje</p> <p><math>1 \leftrightarrow 2</math> adiabatski proces</p> | <p>Opružni sistem kod vozila</p> <p><math>p_0 = 0,9 p_1</math></p> <p><math>p_2 = 2 p_1</math></p> <p><math>\Delta V = 0,351 V_0</math></p>    |
|  | <p><math>0 \rightarrow 1</math> izotermički proces</p> <p><math>2 \rightarrow 1</math> adiabatski proces</p>       | <p>Sigurnosna funkcija</p> <p><math>p_0 = 0,9 p_1</math></p> <p><math>p_2 = 2 p_1</math></p> <p><math>\Delta V = 0,288 V_0</math></p>          |



# Zadatak



Prikazan je uređaj za automatsku izmjenu alata alatnog stroja. Cilindar ciklički ponavlja radni takt prikazan u dijagramu. Pumpa je stalno u pogonu. Stupnjeve djelovanja i gubitke tlaka zanemariti.

Zadano:

Pogon:

$$F_{L,\max} = 10 \text{ kN kod gibanja}$$

$$p_e = 160 \text{ bar}$$

$$A_1 = 10 \text{ cm}^2, \quad \phi = A_1 / A_2 = 2$$

$$x_{\max} = 50 \text{ cm} \quad n_{\text{mot}} = 1500 \text{ min}^{-1}$$

Radni takt:

$$t = 8 \text{ s (vrijeme jednog takta)}$$

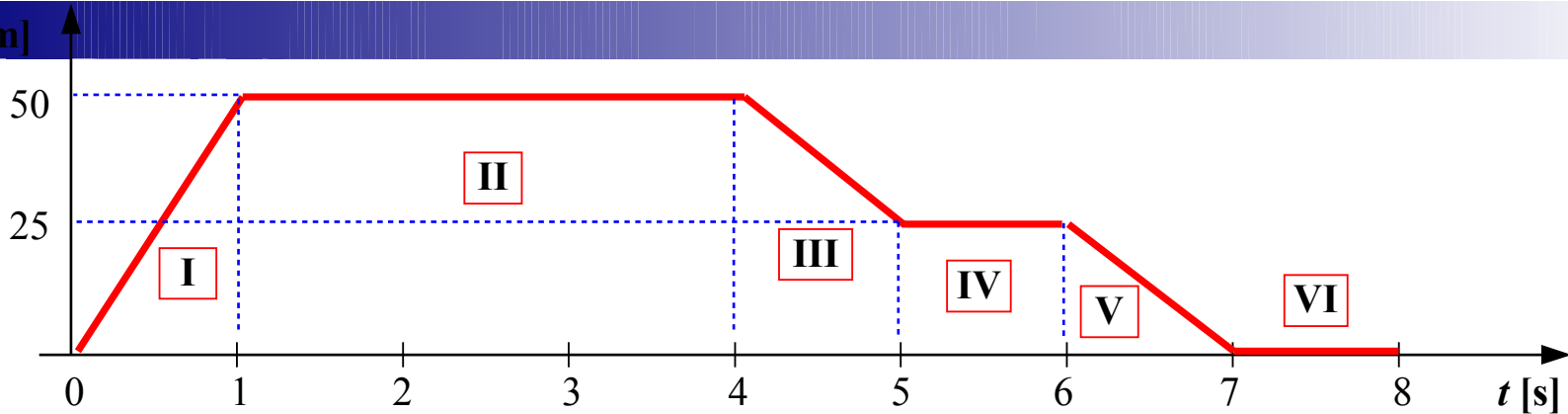
Dani dijagram prikazuje položaje cilindra tijekom jednog radnog ciklusa

Spremnik energije (akumulator):

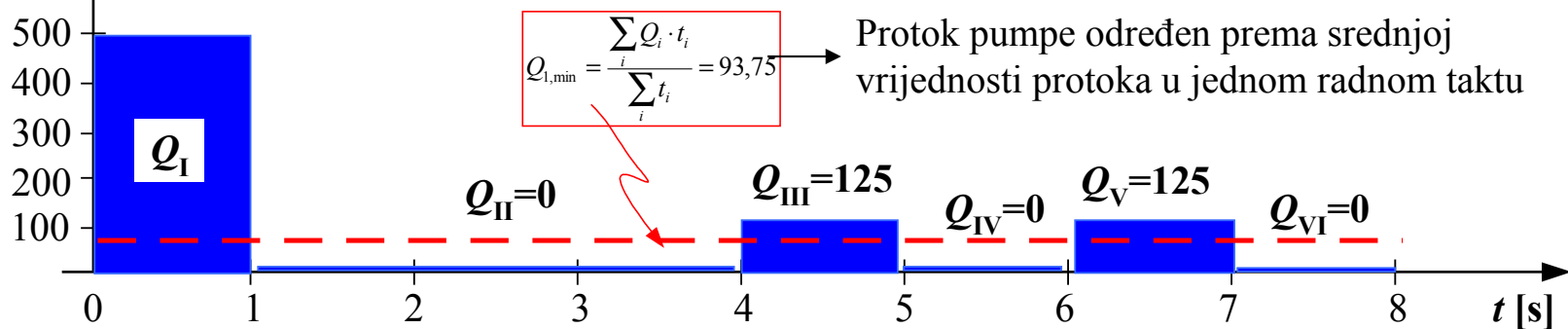
Izentropska promjena stanja (punjenje/praznjenje)

$$(p_0 = 0.9 p_1, \quad n = 1.4)$$

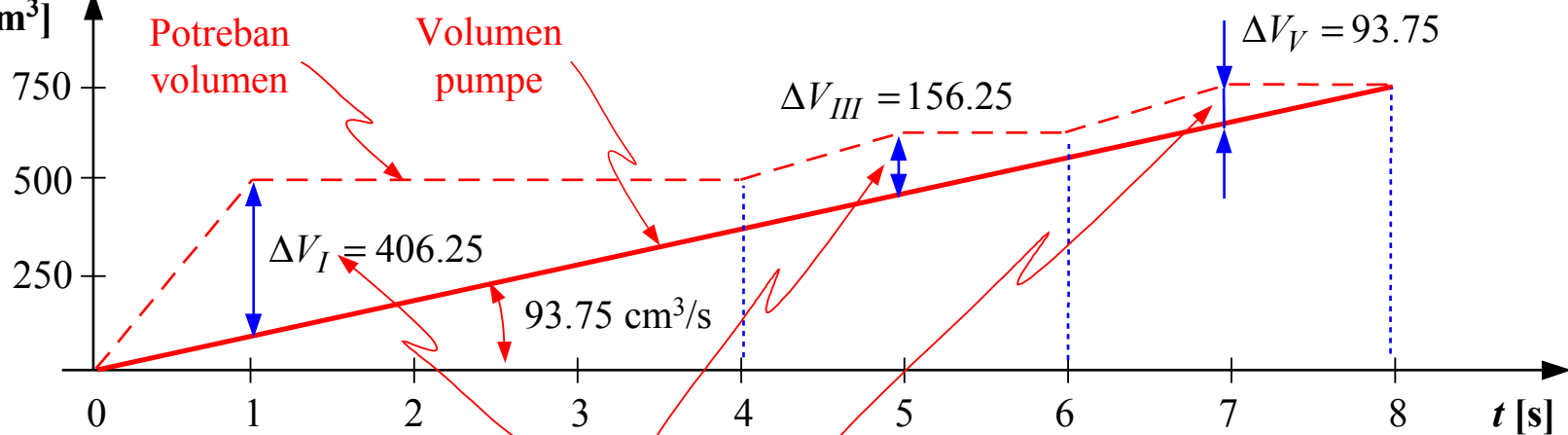
$x$  [cm]



$Q$  [cm<sup>3</sup>/s]



$V$  [cm<sup>3</sup>]



Potreban nadoknaditi iz akumulatora

$$\Delta V = \max(\Delta V_i) = \Delta V_I$$

$$V_0 = ?$$

- Za dimenzioniranje akumulatora uzima se maksimalni  $\Delta V_i$

$$\Delta V = \max(\Delta V_i) = \Delta V_4 = 406,25 \text{ cm}^3$$

- Uz poznatu promjenu volumena koju akumulator mora kompenzirati u hidrauličkom sustavu, te poznatu promjenu stanja (izoterma –  $t > 3\text{s}$  (spora ekspanzija), adijabata –  $t < 1\text{s}$  (brza ekspanzija) ili politropa –  $1\text{s} < t < 3\text{s}$ ), akumulator se dimenzionira prema sljedećem izrazu:

$$V_0 = \frac{\Delta V}{\left[ \left( \frac{p_0}{p_1} \right)^{\frac{1}{n}} - \left( \frac{p_0}{p_2} \right)^{\frac{1}{n}} \right]}$$

- Gdje su radni tlak  $p_1$  i tlak punjenja  $p_0$  jednaki:

$$p_1 = \frac{F_{L,\max}}{A_1} = \frac{10000}{10/100^2} = 100 \cdot 10^5 \text{ Pa} = 100 \text{ bar}$$

$$p_0 = 0.9 p_1 = 0.9 \cdot 100 = 90 \text{ bar}$$

- Potrebni volumen hidrauličkog akumulatora je prema tome:

$$V_0 = \frac{406,25}{\left[ \left( \frac{90}{100} \right)^{\frac{1}{1,4}} - \left( \frac{90}{160} \right)^{\frac{1}{1,4}} \right]} = 1539,9 \text{ cm}^3$$