

ENERGETSKI STROJI IN NAPRAVE

Uvod

Pregled teoretičnih osnov

Volumetrični stroji

Turbinski stroji

Energetske naprave

ENERGETSKE NAPRAVE

Značilnosti

Prenosniki toplote

Hladilni stolpi

Kotli

Ejektorji

Značilnosti

Razdelitev

Toplotni tok, srednja temperaturna razlika in izkoristek

Prestop toplote pri spremembi agregatnega stanja

Značilnosti

Transport energije:

toplota (prenosnik toplote)

svetloba (svetilo)

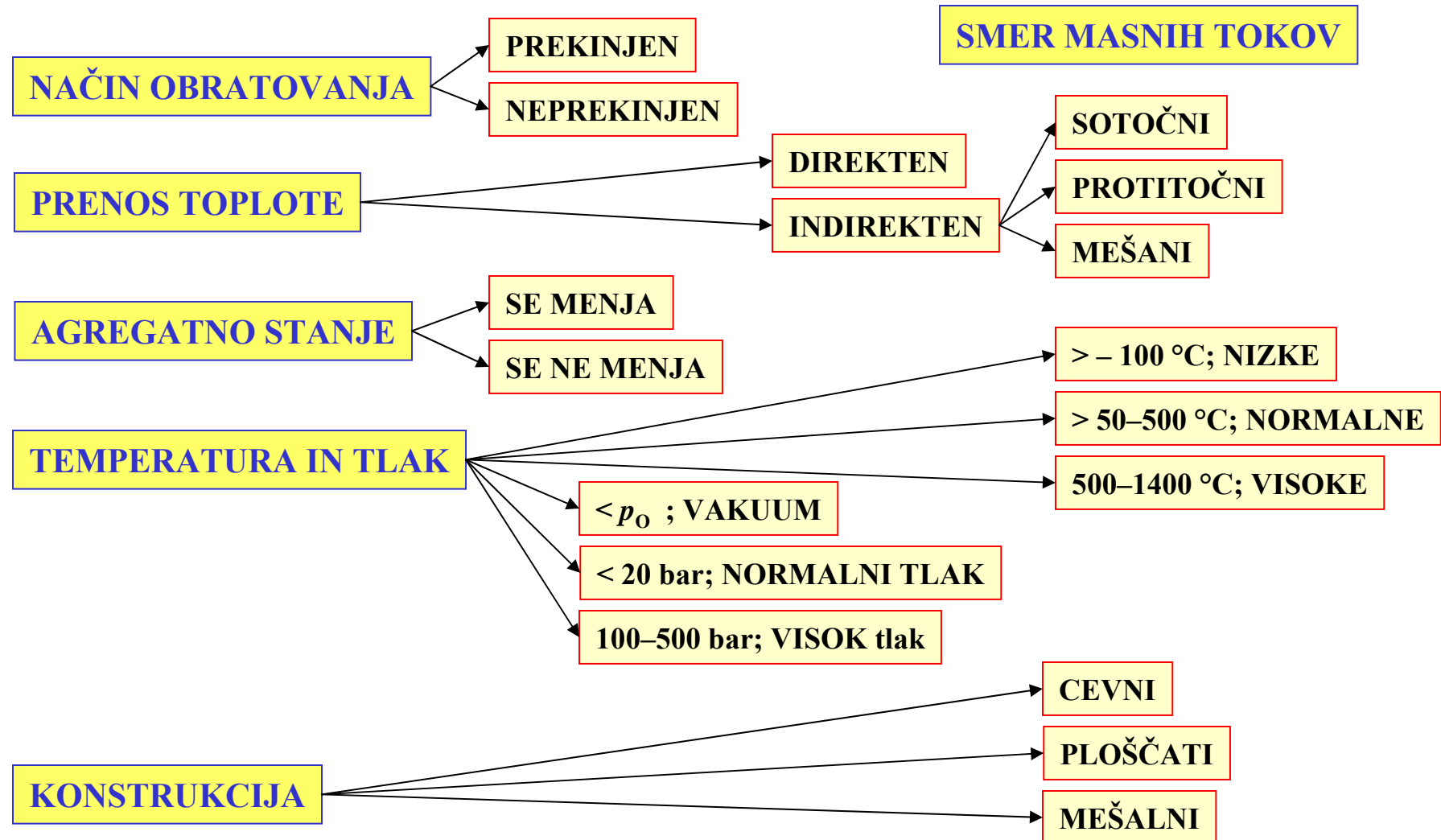
zvok (zvočnik)

električna energija (transformator, gorivne celice)

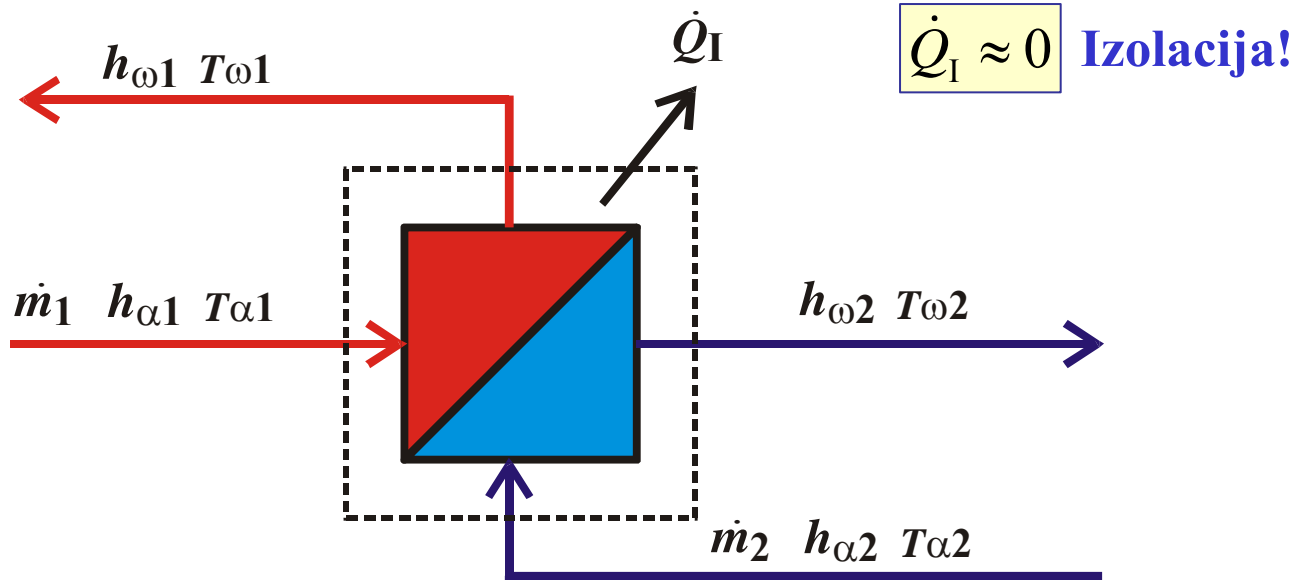
Lastnost: ni dovoda (odvoda) mehanskega dela

Kriterij: učinkovitost in gospodarnost

Prenosniki toplote, delitev



Toplota, toplotni tok



$$d\dot{Q} = k \cdot dA \cdot (T_1 - T_2)$$
 Prenos toplote v napravi ($T=T(A)$)

$$d\dot{Q} = \dot{m}_1 \cdot c_{p1} \cdot dT = \dot{m}_2 \cdot c_{p2} \cdot dT$$

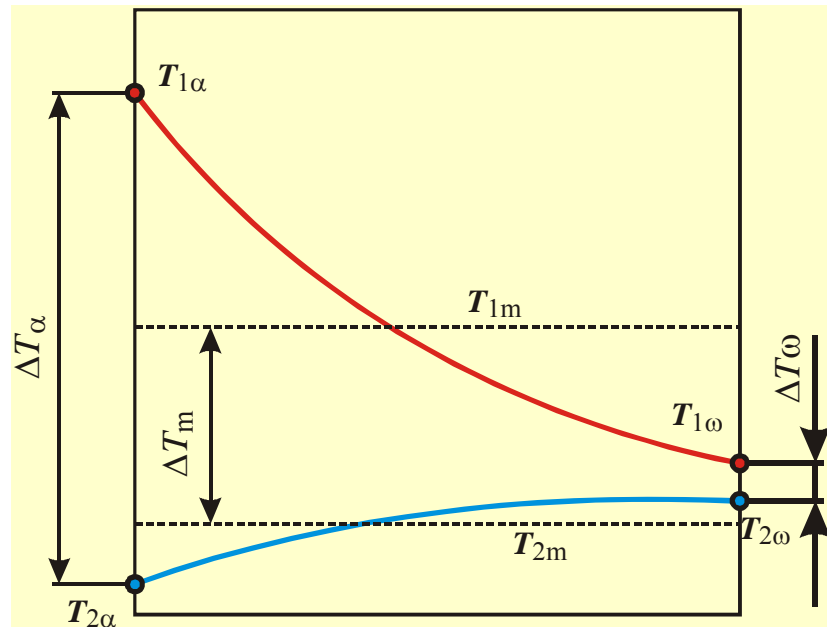
$$= \dot{m}_1 \cdot dh_1 = \dot{m}_2 \cdot dh_2$$
 Toplotna bilanca okrog naprave

Srednja logaritemska temperaturna razlika

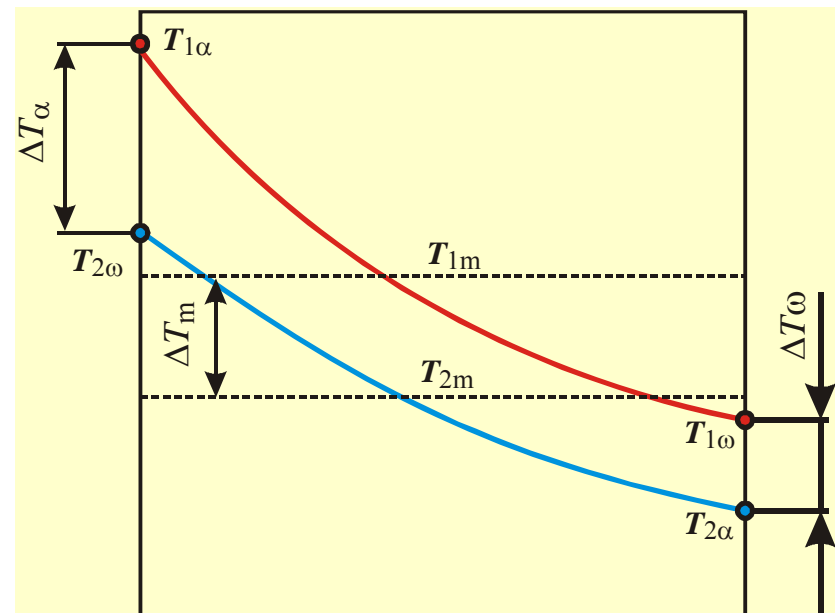
Ekvivalentna temperaturna razlika

$$\dot{Q} = k \cdot A \cdot \Delta T_m$$
$$\Delta T_m = \frac{\Delta T_\alpha - \Delta T_\beta}{\ln\left(\frac{\Delta T_\alpha}{\Delta T_\beta}\right)}$$

Sotočni prenosnik toplote



Protitočni prenosnik toplote



Izkoristek prenosnika toplote

Energijski izkoristek

$$\eta = \frac{\dot{Q} - \dot{Q}_I}{\dot{Q}} = 1 - \frac{\dot{Q}_I}{\dot{Q}} \approx 1$$

Pogoj: dobra izolacija!

$$\dot{E}_1 = \left(1 - \frac{T_O}{T_{1m}}\right) \cdot \dot{Q}$$

Izguba eksrgerijskega toka

$$\Delta \dot{E} = \dot{E}_1 - \dot{E}_2 = T_O \cdot \frac{T_{1m} - T_{2m}}{T_{1m} \cdot T_{2m}} \cdot \dot{Q}$$

Eksergijski tok, ki ga greti medij sprejme

$$\dot{E}_2 = \left(1 - \frac{T_O}{T_{2m}}\right) \cdot \dot{Q}$$

Eksergijski izkoristek

$$\zeta = \frac{\dot{E}_2}{\dot{E}_1} = 1 - \frac{\Delta \dot{E}}{\dot{E}_1}$$

Zaradi končne temperaturne razlike pri prenosu toplote eksergijske izgube niso zanemarljive!

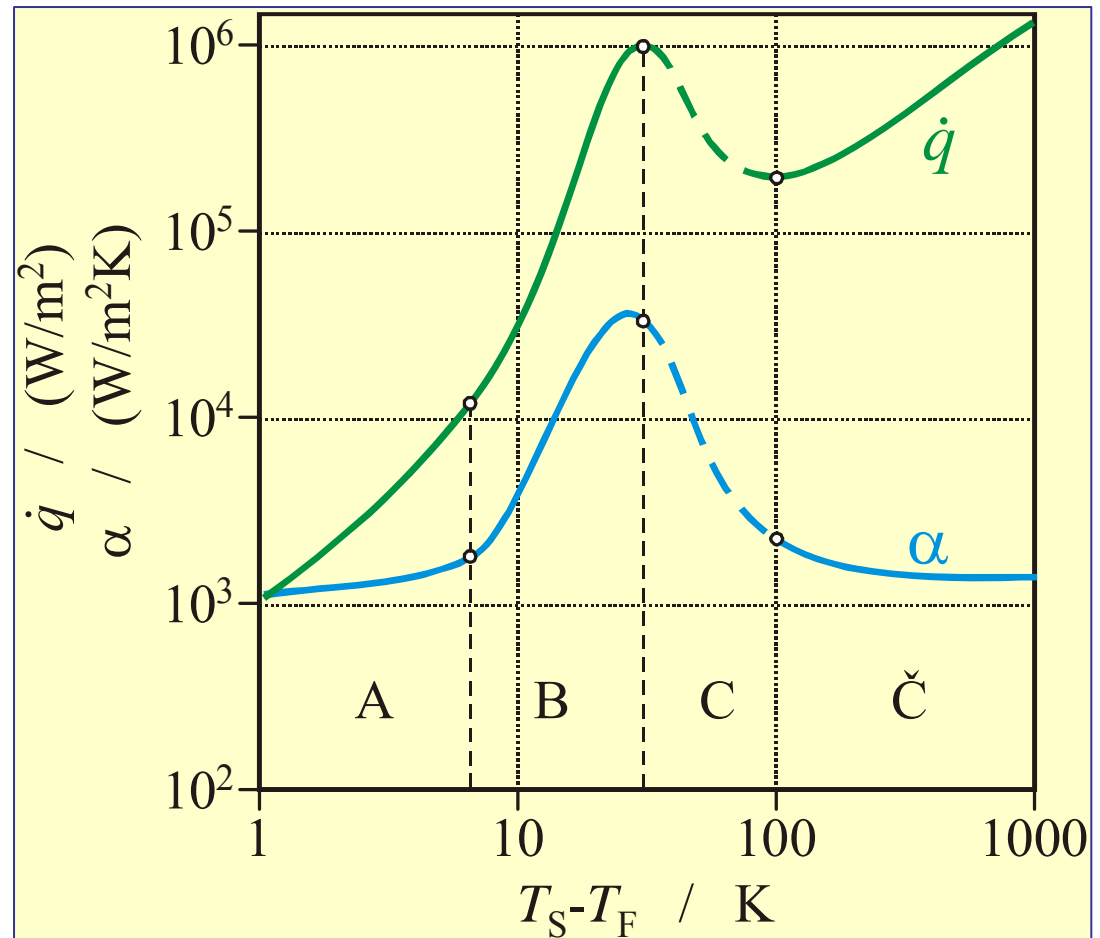
Uparjanje

A – uparjanje na prosti površini

B – mehurčkasto uparjanje

C – prehodno uparjanje

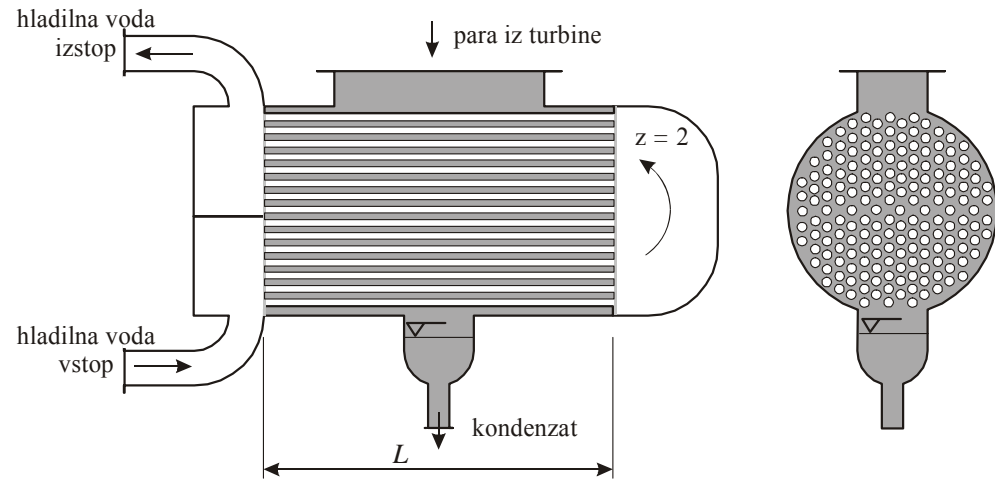
Č – filmsko uparjanje



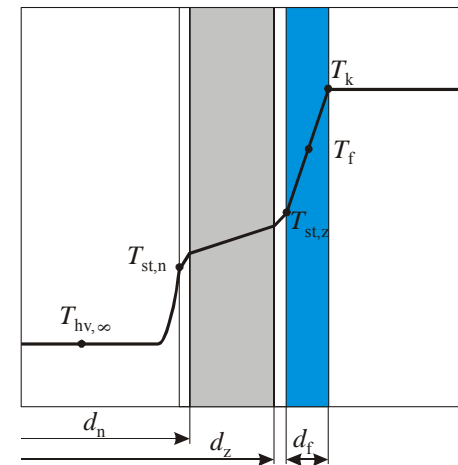
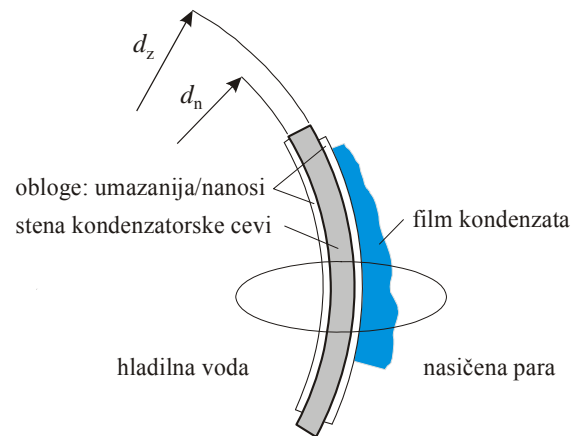
Kondenzacija

**Kapljičasta kondenzacija
(redka aplikacija)**

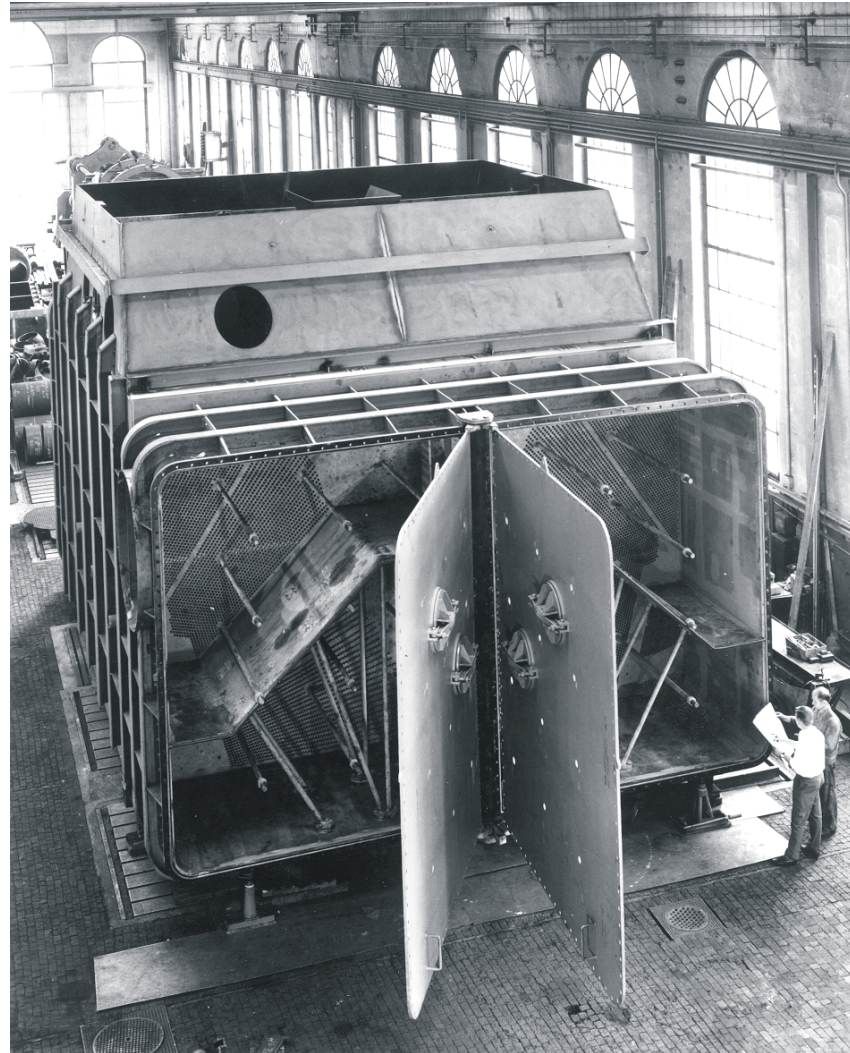
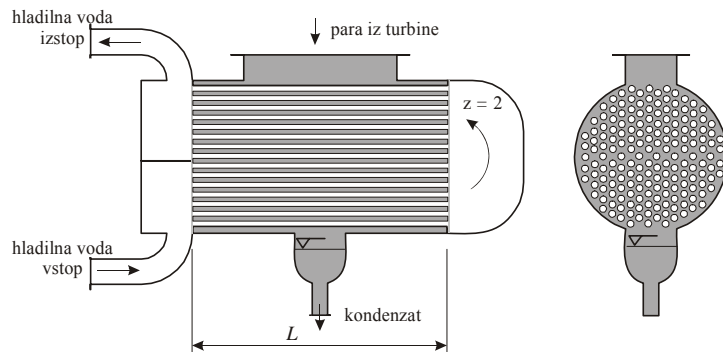
Filmska (primer kondenzatorja)



Temperaturne razmere ob steni cevi



Kondenzacija



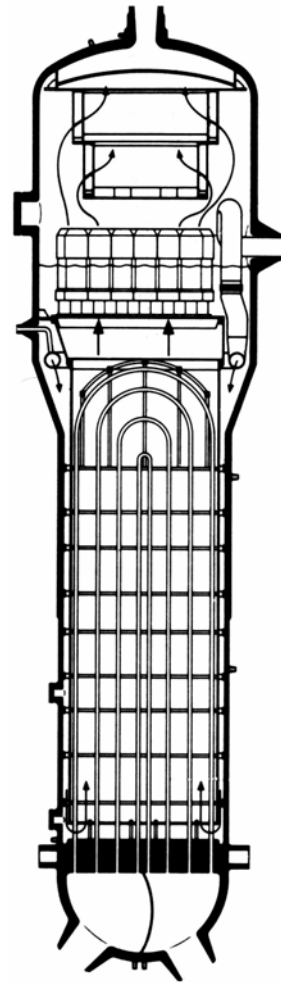
Prenosniki toplote

$$k = \frac{1}{\frac{1}{\alpha_1} + \sum \frac{\delta}{\lambda} + \frac{1}{\alpha_2}}$$

Fluid / fluid	k / (W/(m ² K))
Plin (1bar) / plin (1bar)	5-35
Plin (200-300)bar / plin (200-300)bar	150-500
Tekočina / plin (1bar)	15-17
Tekočina / tekočina	150-1200
Para okrog cevi / tekočina v ceveh	300-1200
Uparjalnik	
- naravni pretok	300-1700
- prisilni pretok	900-3000
Kondenzator	
- organske pare okrog cevi / voda v ceveh	300-1200
- para okrog cevi / voda v ceveh	1500-4000

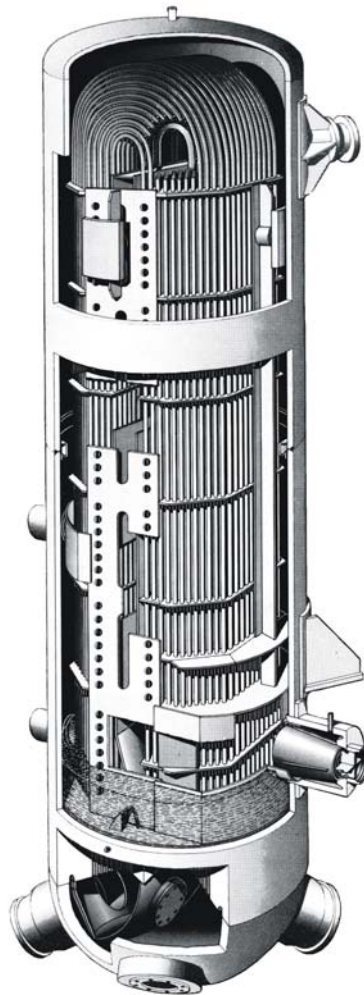
$Nu = Nu(\text{geometrije}, T, p, \dots)$

Prenosniki toplote



Uparjalnik v jedrski elektrarni

Prenosniki toplote



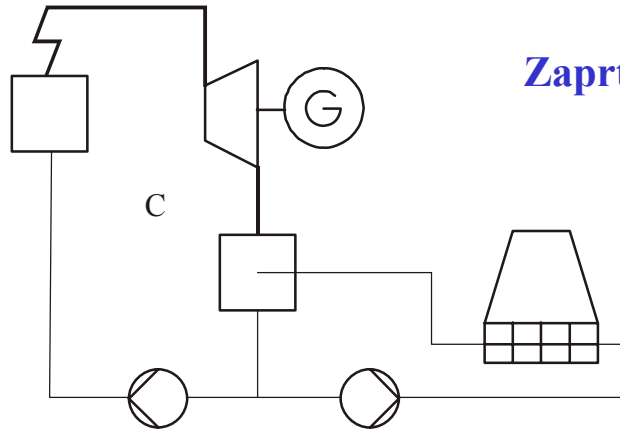
Regenerativni grelnik napajalne vode

Prenosniki toplote

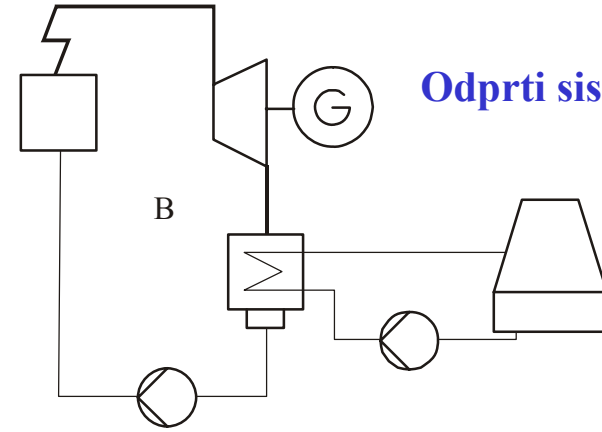
Grelnika vode



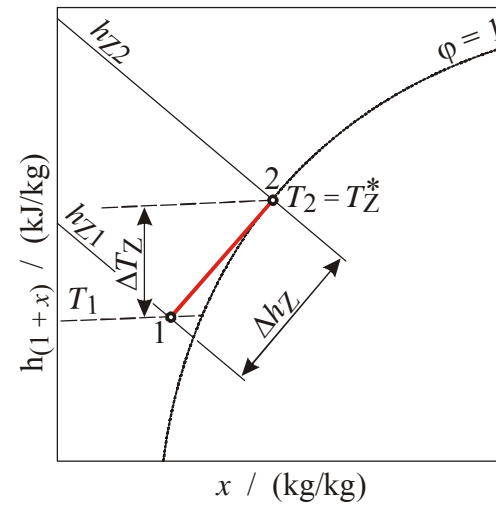
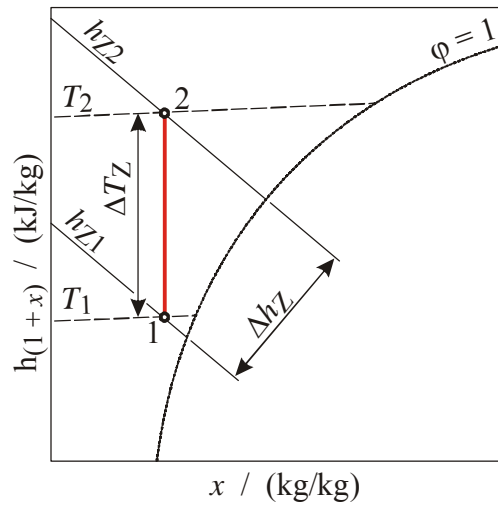
Hladilni stolpi



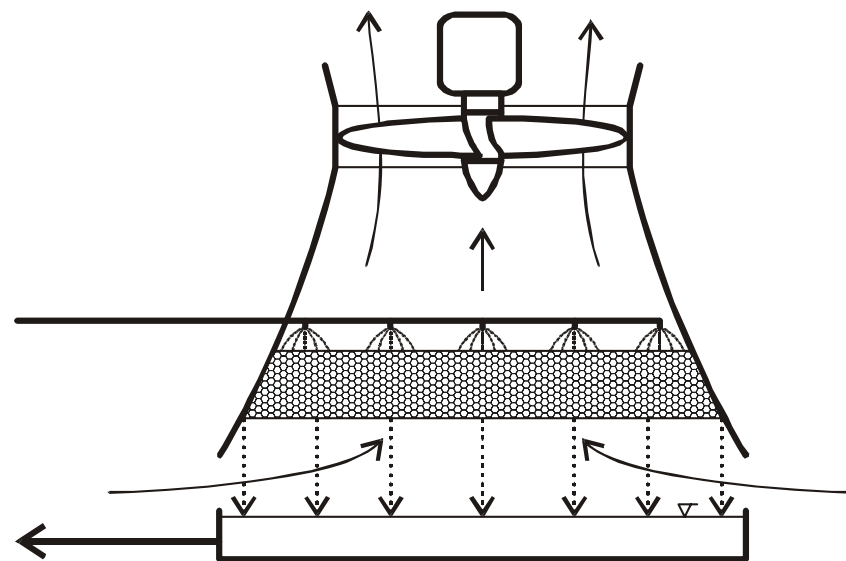
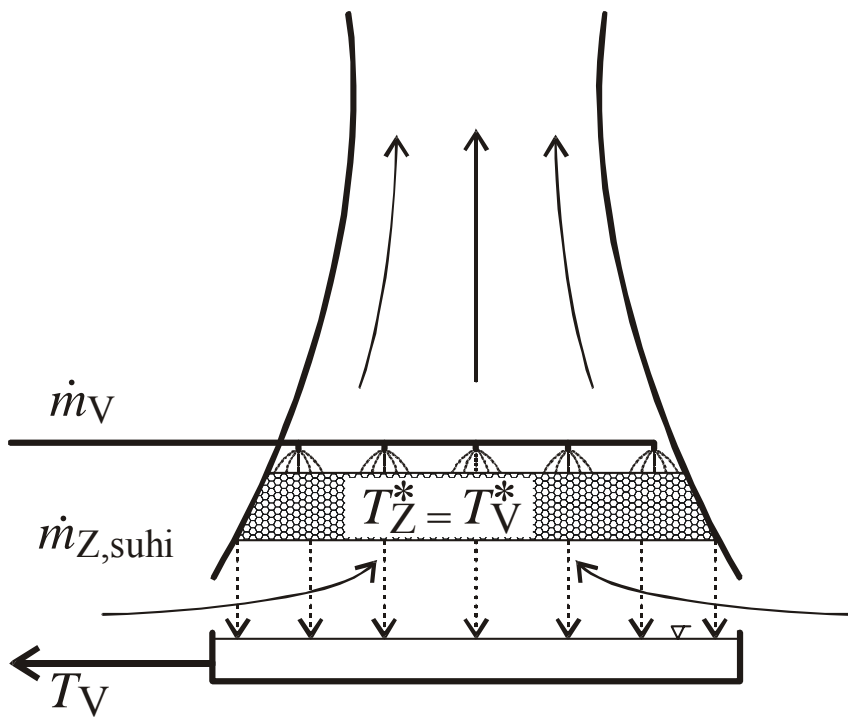
Zaprta sistem

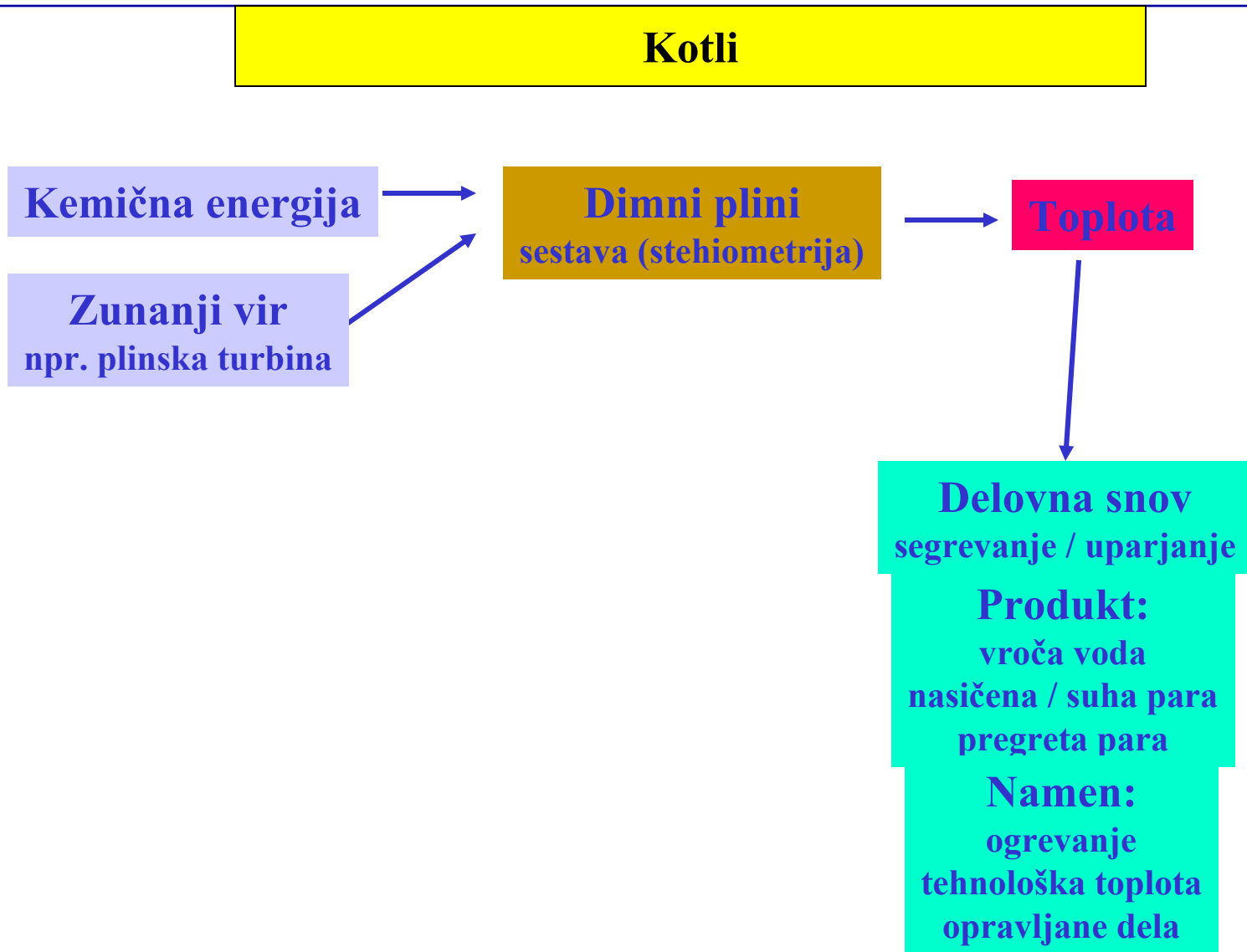


Odprti sistem



Hladilni stolpi





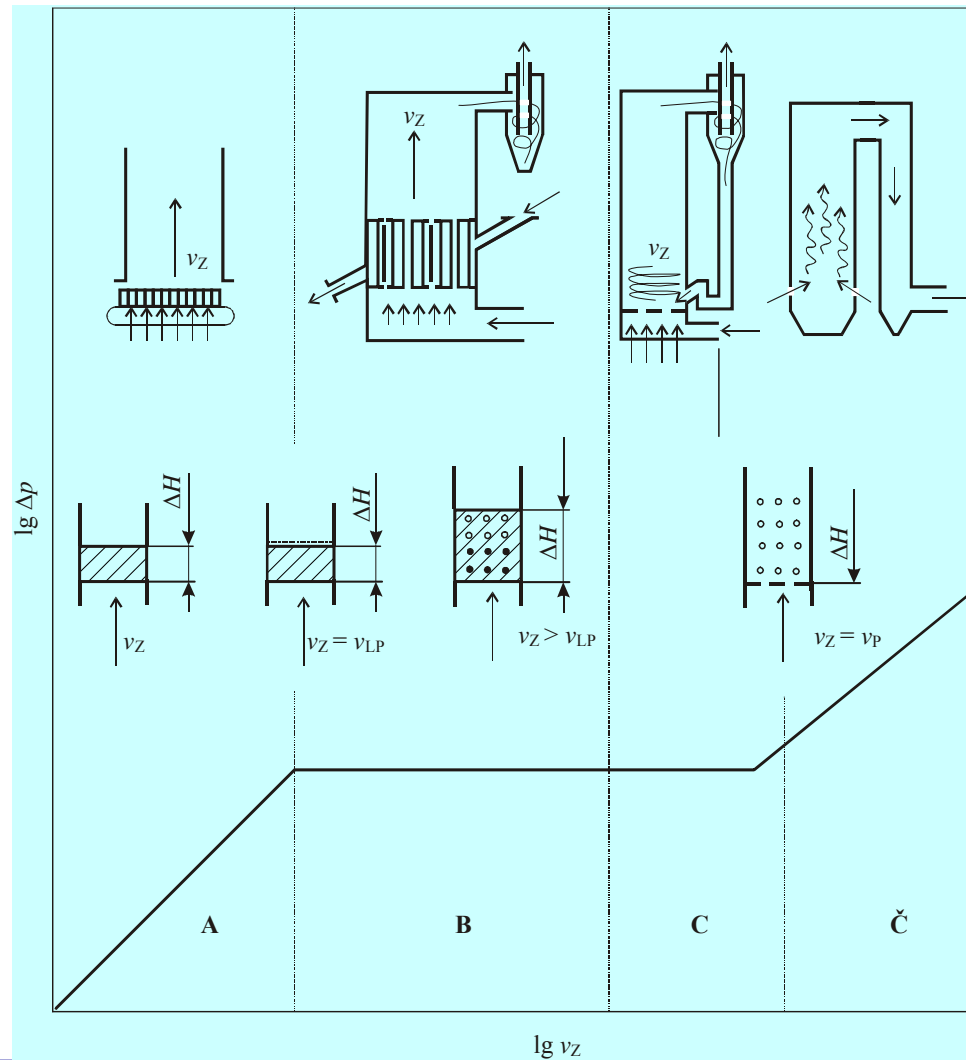
Kotli, sestavni deli

A – kurjenje na rešetki

B – stac. lebdeča plast

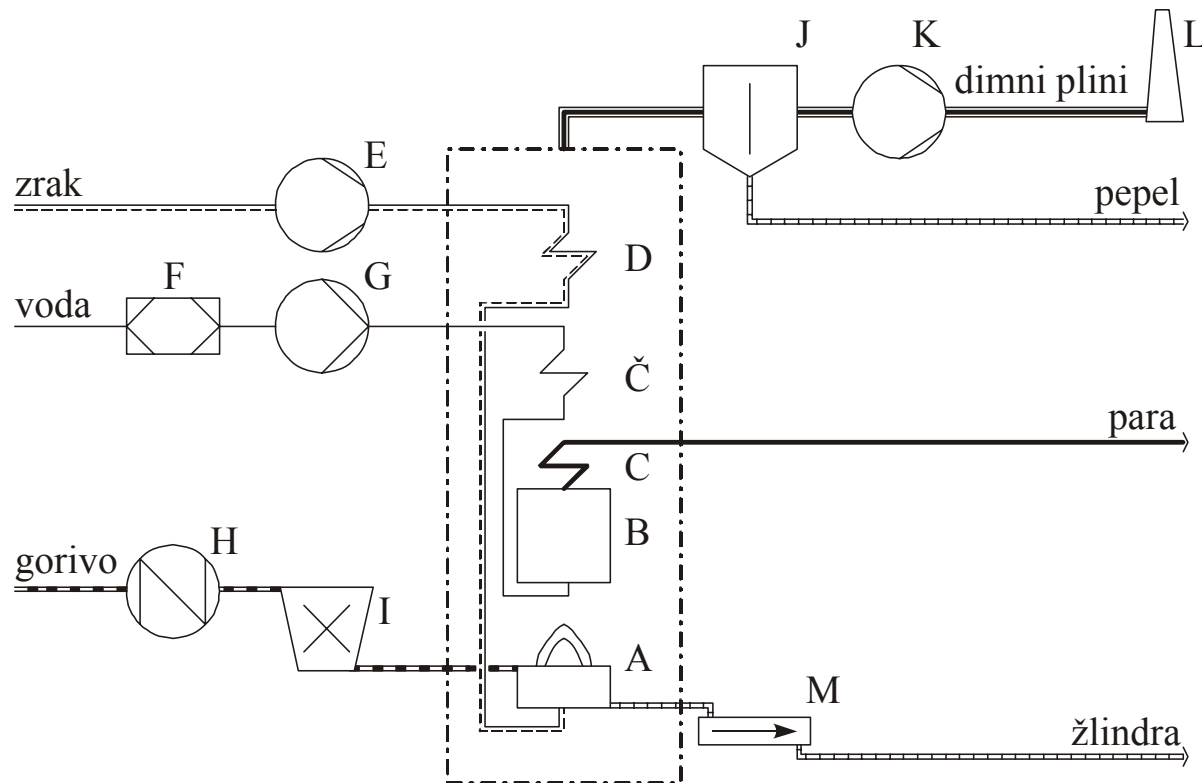
C – vrtnična lebdeča plast

Č – prašna kurjava



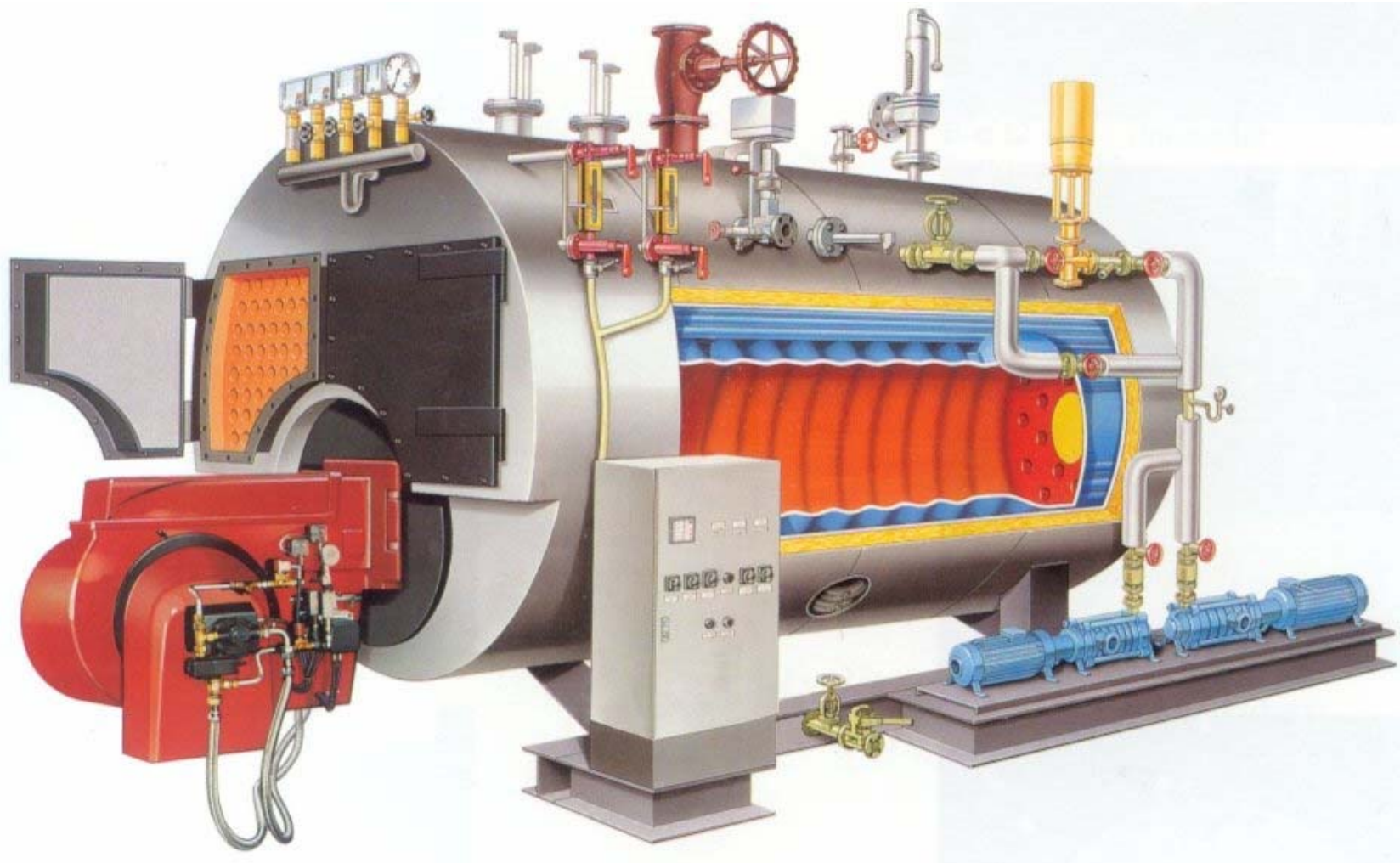
Kotli, sestavni deli

**Kurilna naprava: kurišče, kurilni pripomočki (rešetke, mlini, gorilniki,...)
prenosniki toplote (prehod toplote s plinov na delovno snov)**

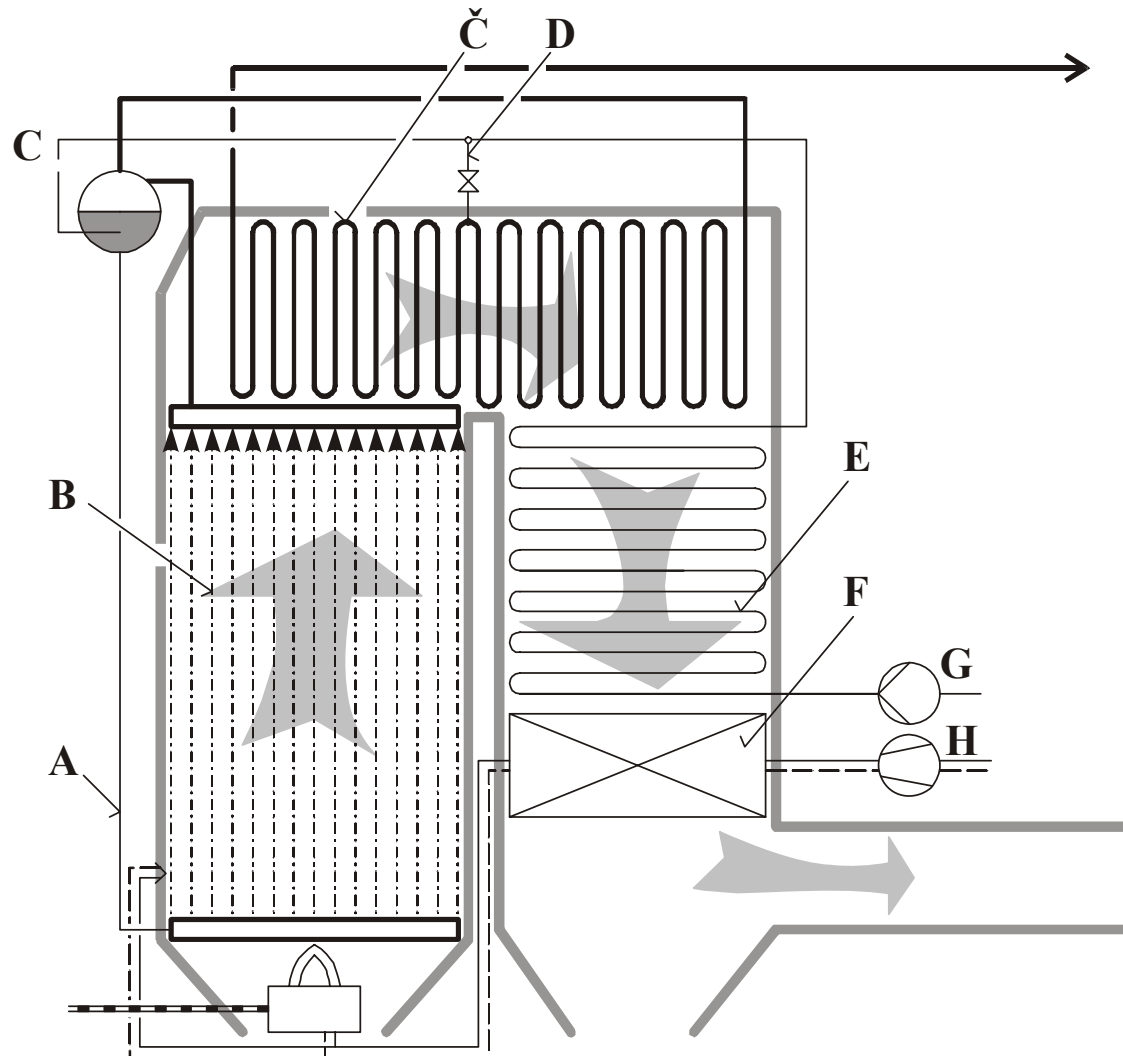


Geometrijska zasnova kotla = f(gorivo, toplotna moč)

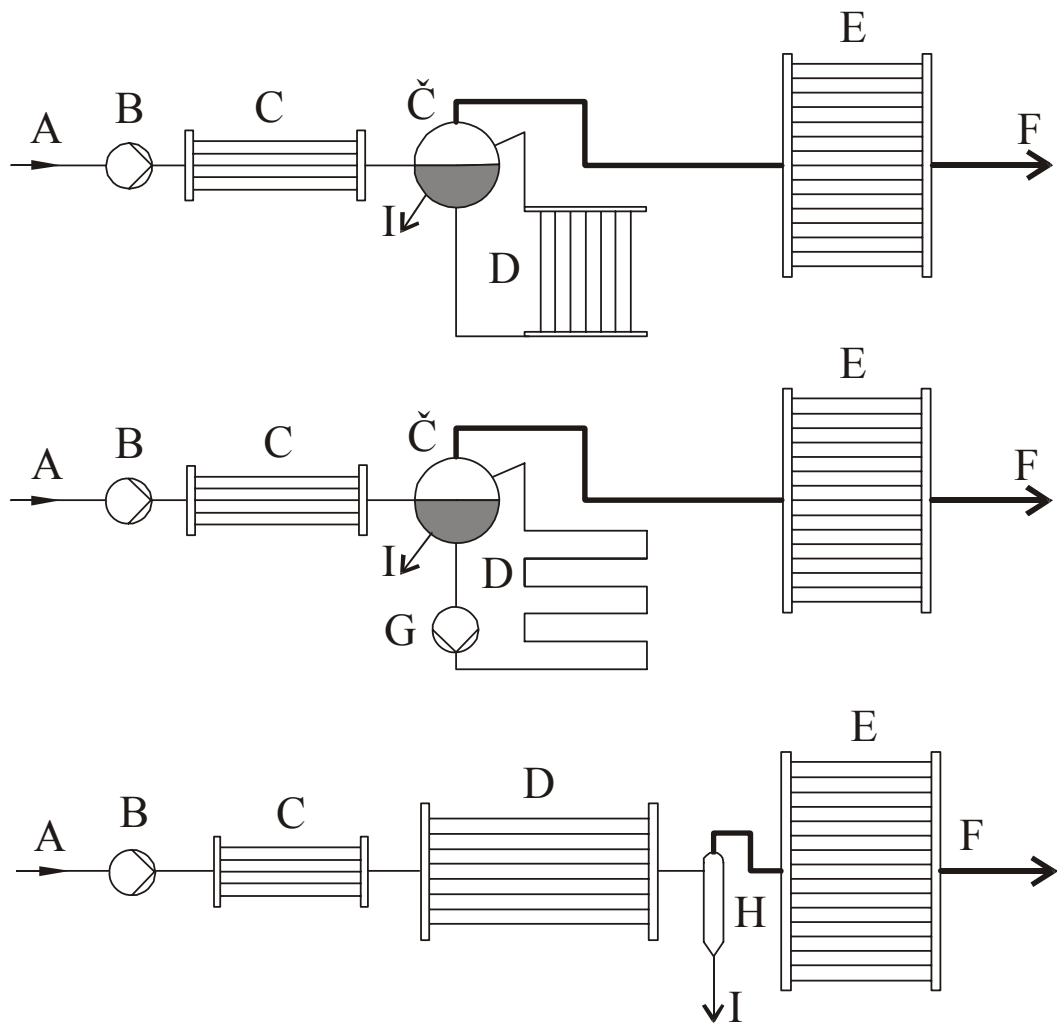
Mnogovodni ali dimnocevni kotel



Malovodni ali vodnocevnni kotli



Malovodni ali vodnocevnni kotli

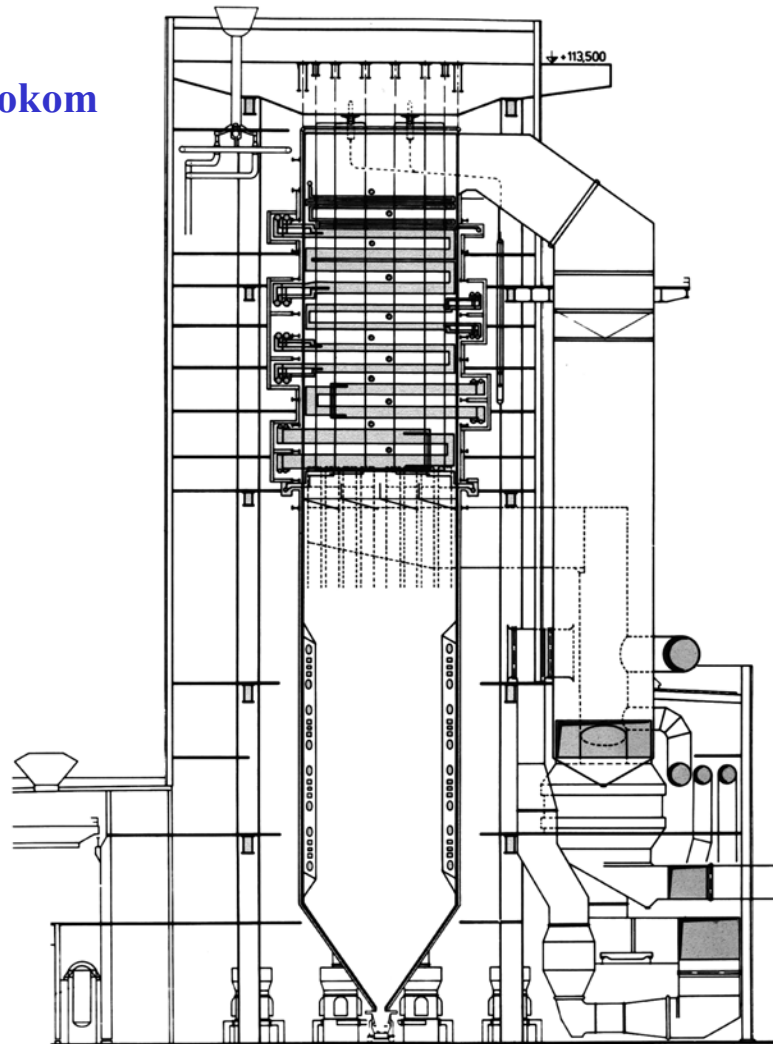


Zgorevanje mazuta in premogovega prahu

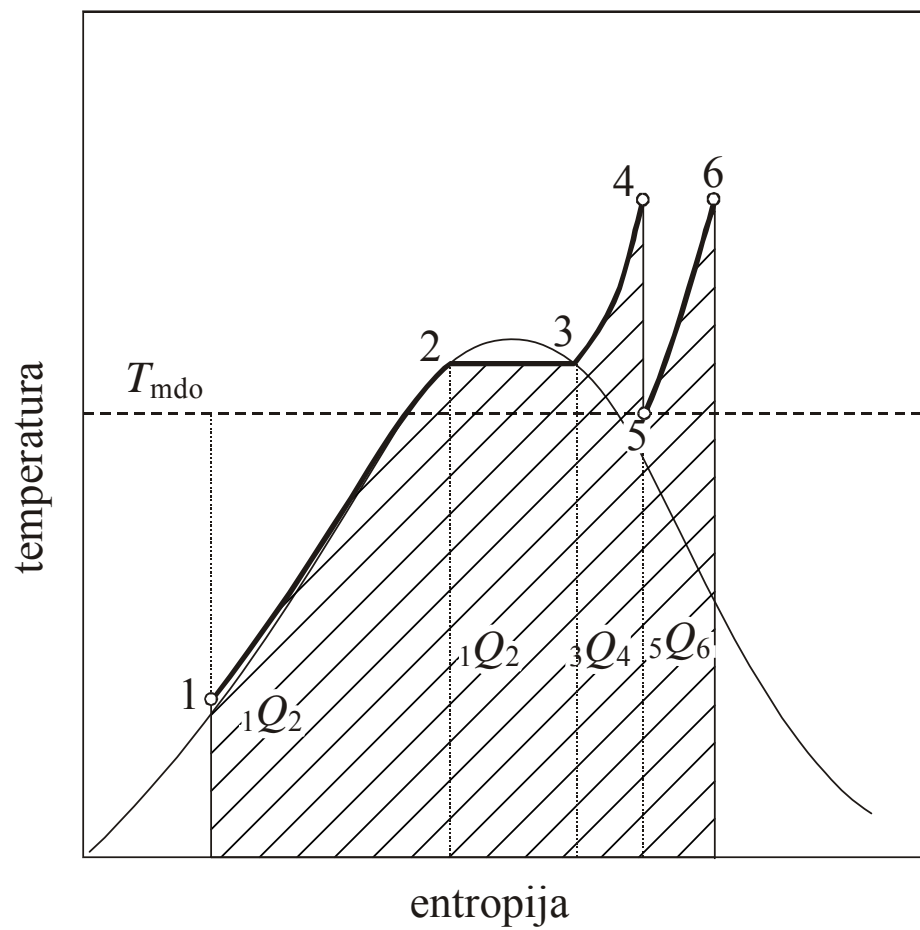
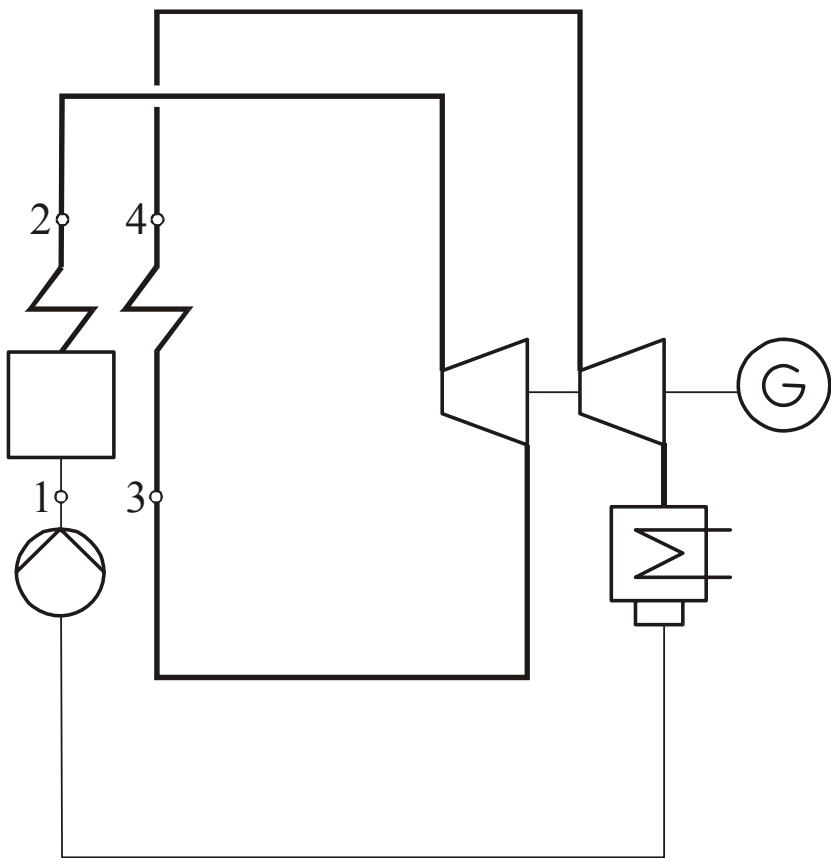


Vodno cevni kotli

Kotel s prisilnim pretokom



Moč in izkoristek



Moč in izkoristek

$$q_V = h_2 - h_1$$

grelnik vode

$$r = h_3 - h_2$$

uparjalnik

$$q_P = h_4 - h_3$$

pregrevalnik

$$q_{PP} = h_6 - h_5$$

ponovni pregrevalnik

Toplotna moč kotla:

$$\dot{Q} = \dot{m}_{SP} \cdot (h_4 - h_1) + \dot{m}_{PP} \cdot (h_6 - h_5)$$

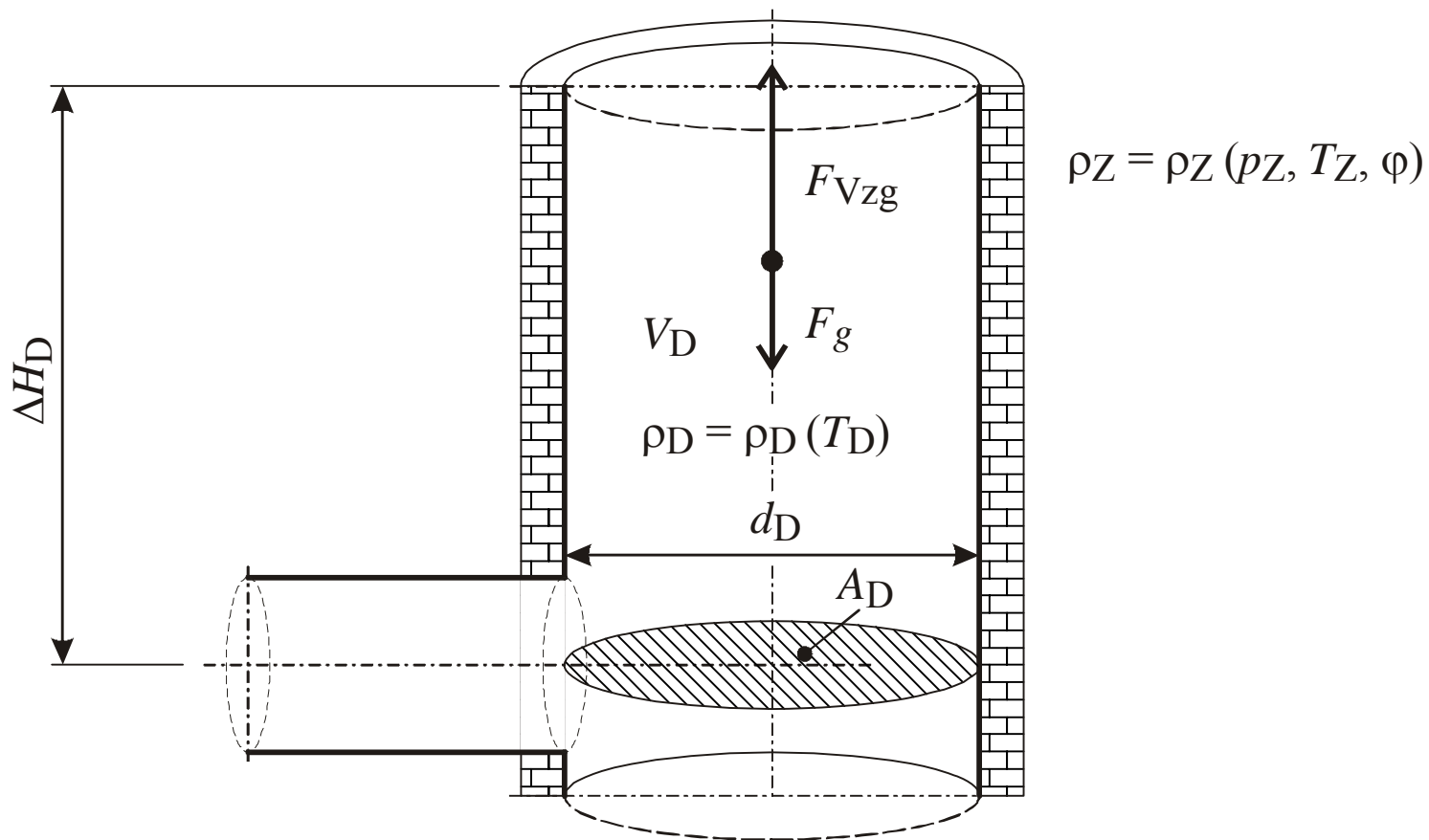
Energijski izkoristek kotla

$$\eta_K = \frac{\dot{Q}_K}{\dot{Q}_{do}}$$

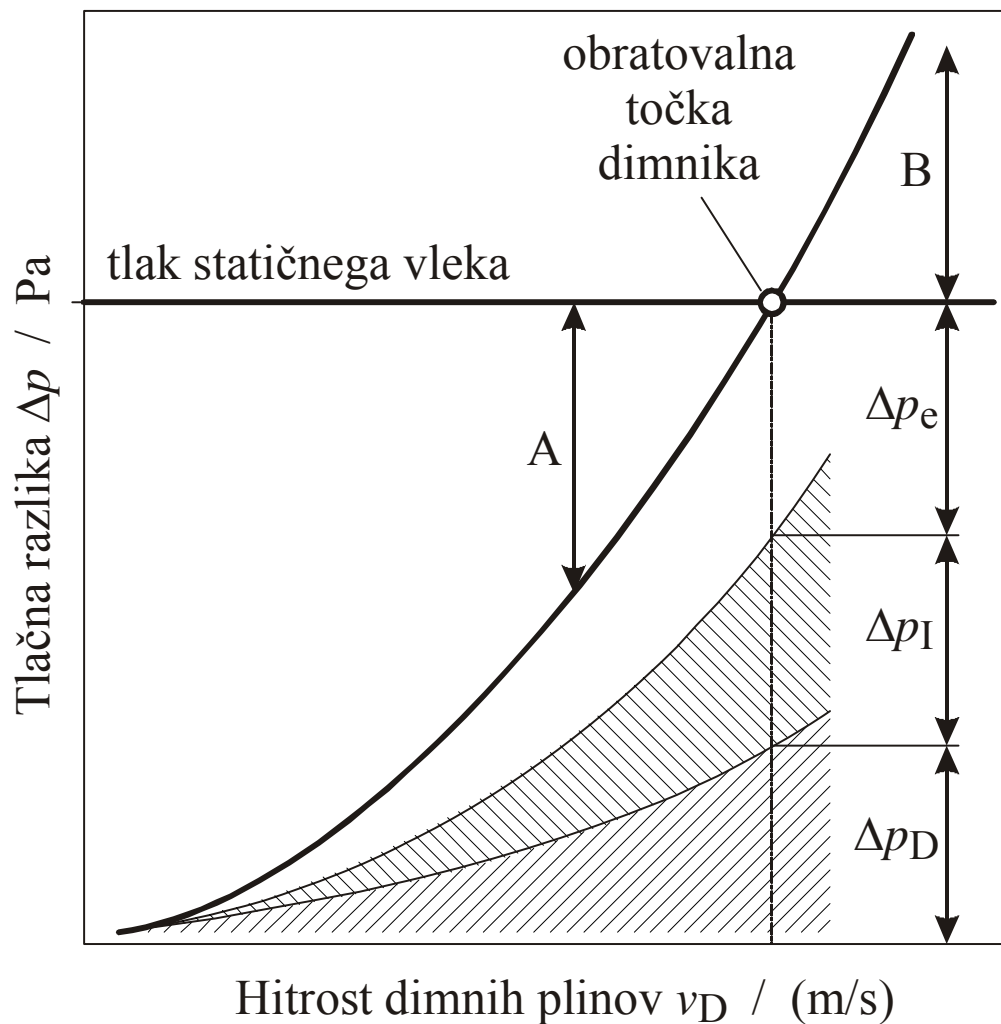
Eksergijski izkoristek kotla

$$\zeta_K = \frac{\dot{E}_K}{\dot{E}_{do}}$$

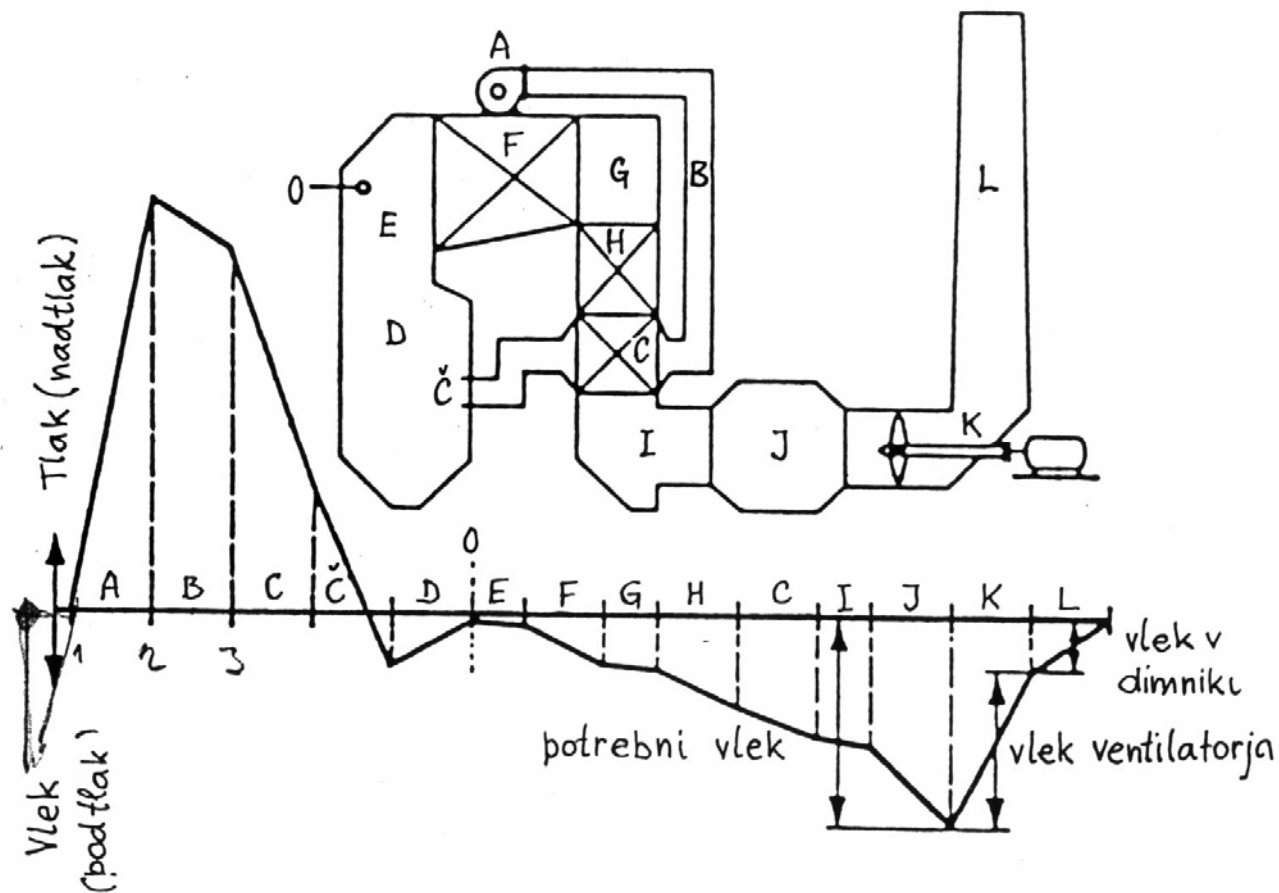
Vlek v dimniku



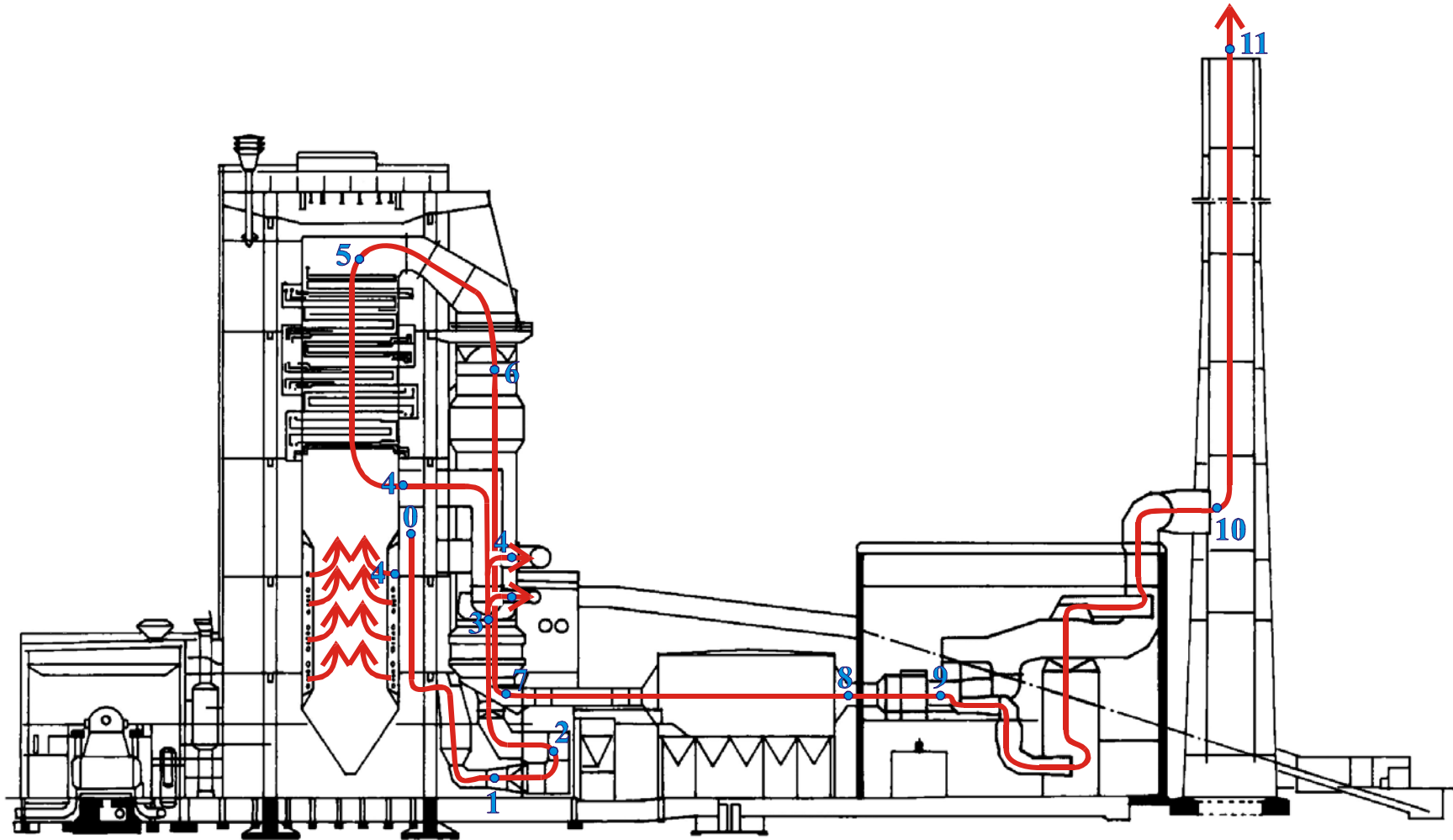
Vlek v dimniku



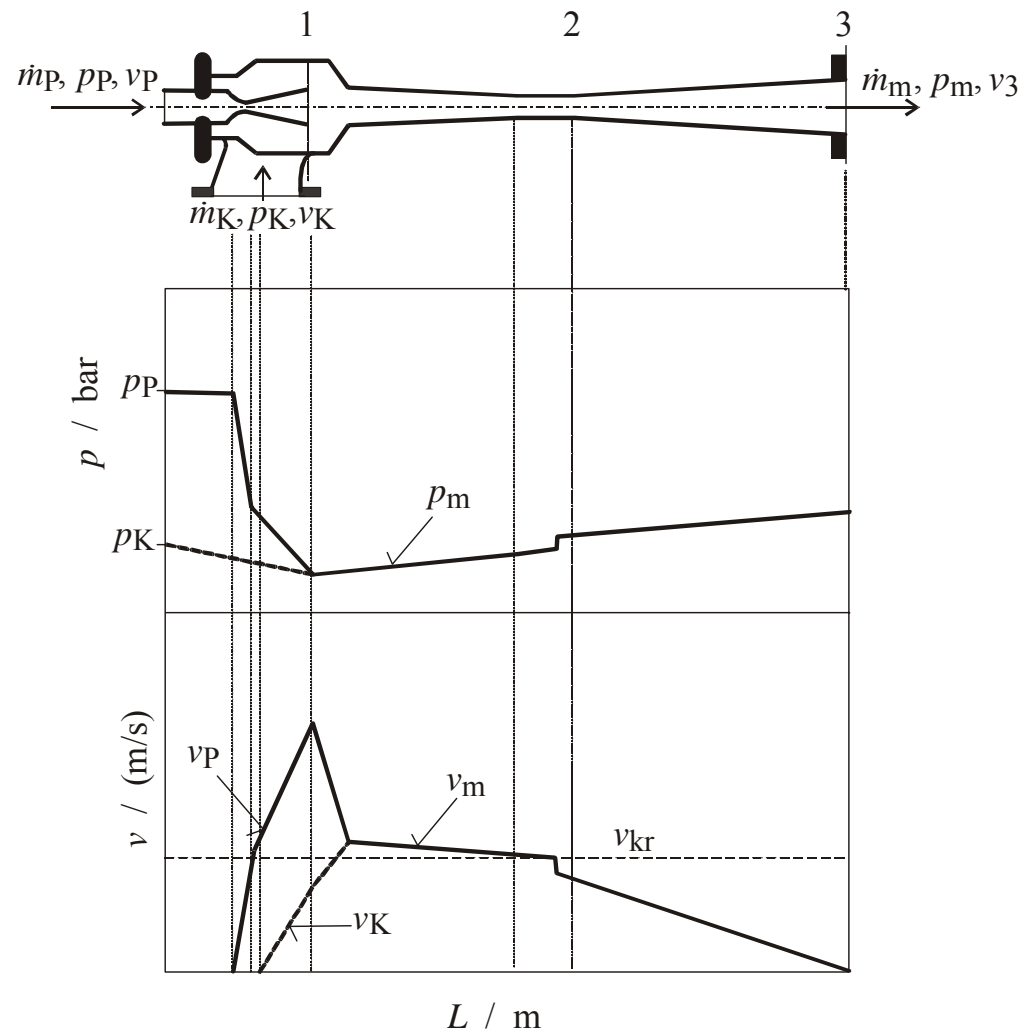
Vlek v dimniku



Vlek v dimniku



Ejektorji



Ejektorji

