

Kritični toplotni tok

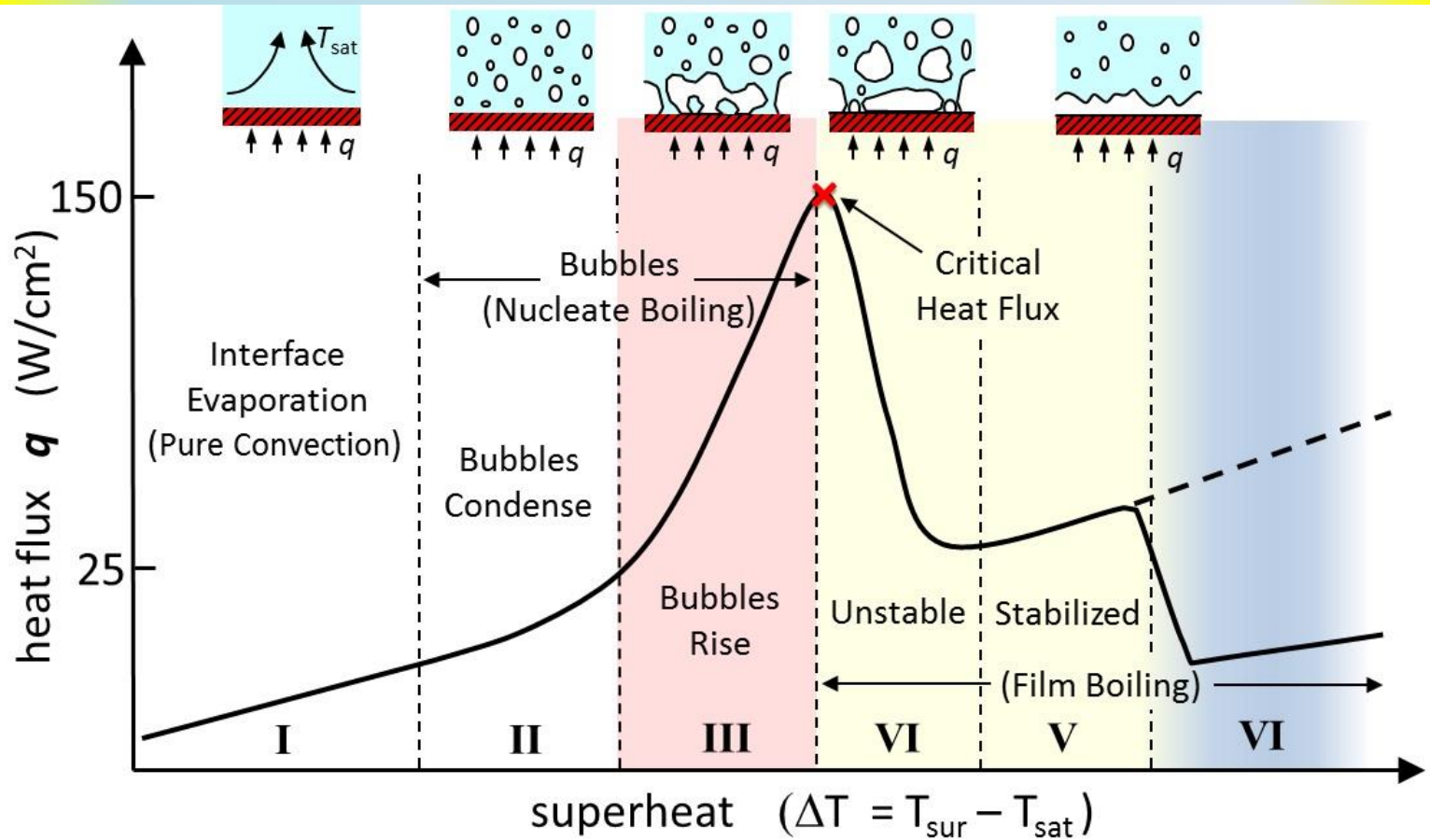
Seminar pri Reaktorski tehniki
12. 12. 2013

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Mentor: prof. Tiselj

Kritični toplotni tok

- CHF critical heat flux
- Nad kritičnim toplotnim tokom voda NE zmore več odvajati toplote dovolj hitro, zato zavre. Kar še zmanjša toplotno prevodnost.
- Pride do pregrevanja in lahko celo do taljena sredice.



Empirične enačbe

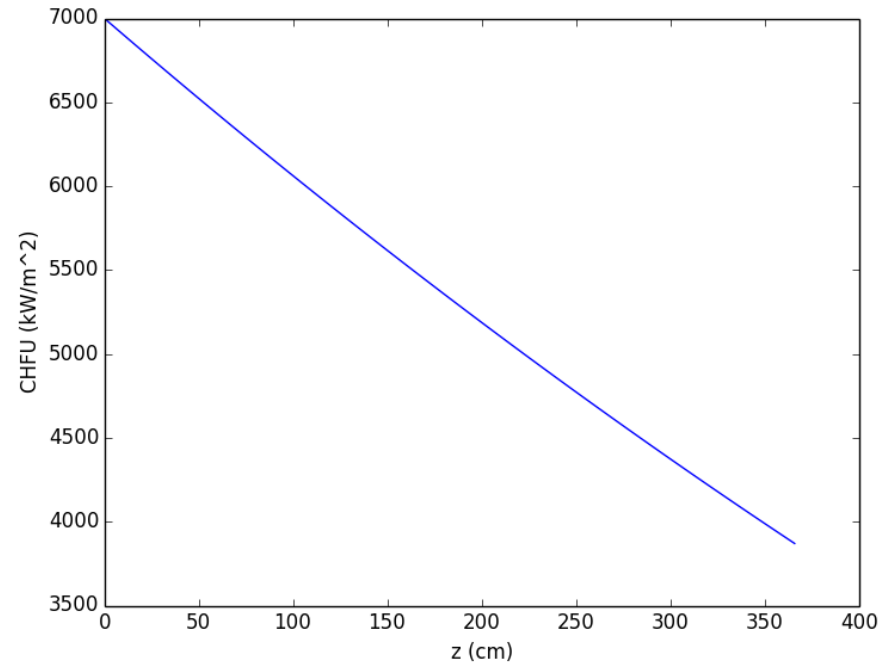
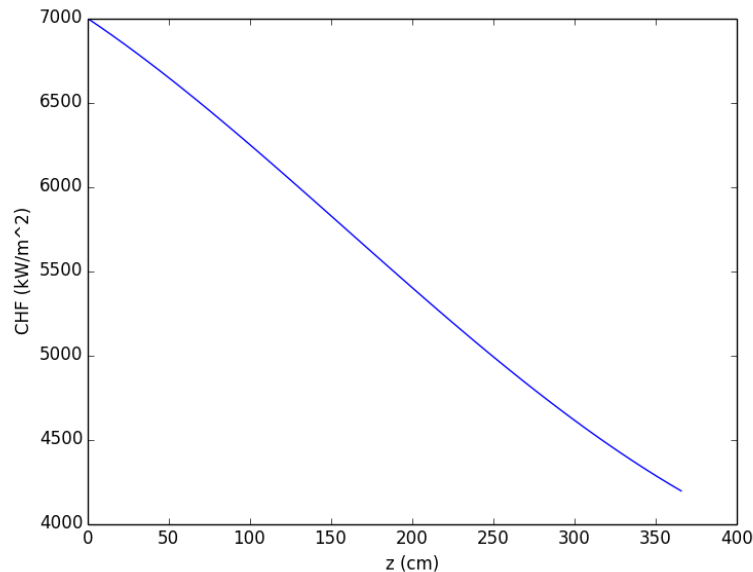
- Thong 1967 (PWR) W-3
- $$CHF = 3,1546 * (2,022 - 0,0624 * P) + (0,172 - 0,0143 * P) * e^{(18,177 - 0,599 * p) * X} * ((0,109 - 1,173 * X + 0,127 * X * |X|) * G + 1,037) * (1,157 - 0,869 * X) * (0,266 + 0,836 * e^{-0,124 * D}) * (0,826 + 0,341 * 10^{-6} * (h_{sat} - h_{in}))$$
- Levitan 1975 (BWR)
- $$CHF = \left(10,3 - 17,5 * \frac{P}{P_C} + 8 * \left(\frac{P}{P_C} \right)^2 \right) * G^{\left(0,68 \left(\frac{P}{P_C} \right) - 1,2 * X - 0,3 \right)} * e^{-1,5 * X} * \left(\frac{D}{8} \right)^{0,5}$$

Enakomerno gret kanal (PWR)

- $q''_{er} = \left((2,022 - 0,06238 * P) + (0,172 - 0,01427 * P) * e^{(18,177 - 0,5987 * P) * X} \right) * \left((0,1484 - 1,596 * X + 0,1729 * X * |X|) * 2,326 * G + 3271 \right) * (1,157 - 0,869 * X) * (0,2664 + 0,8357 * e^{-124,1 * D}) * (0,8258 + 0,3413 * 10^{-3} * (h_f - h_{in}))$
- *Tlak P (Mpa), 15,5*
- *Masni pretok G (kg/m²s), 3800*
- *Entalpija h (kJ/kg),*
 - $h_f(p=155\text{bar in } T=280^\circ\text{C})=1589 \text{ kJ/kg}$
 - $h_{in}(p=155\text{bar in } T=280^\circ\text{C})=1232 \text{ kJ/kg}$
- *Ekvivalent preseka gretega kanala D (m) 0,011*
- *Lokalna termodinamična kvaliteta pare X (masa pare/masa mešanice)*
- *CHF (kW/m²)*

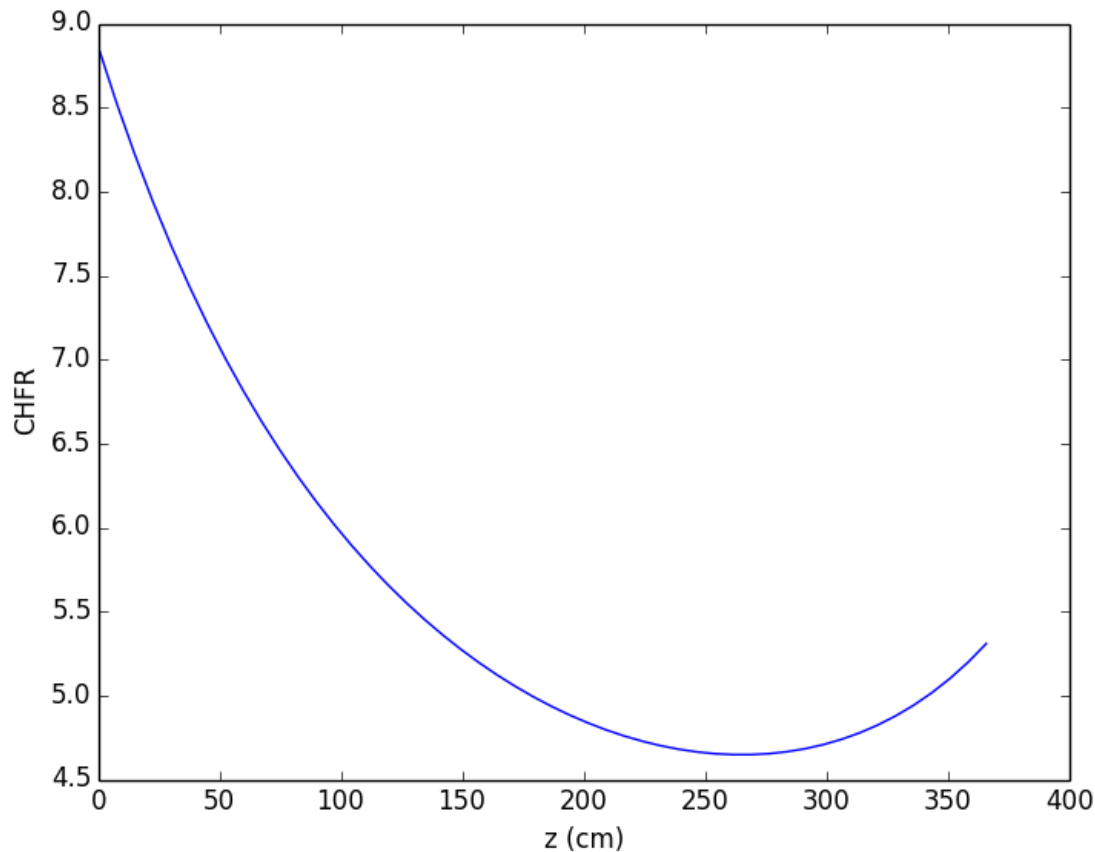
Zakaj enakomerno gret kanal?

- Za določanje CHF se uporablja predvsem empirične meritve
- ZDA 2x
- Indija
- Francija



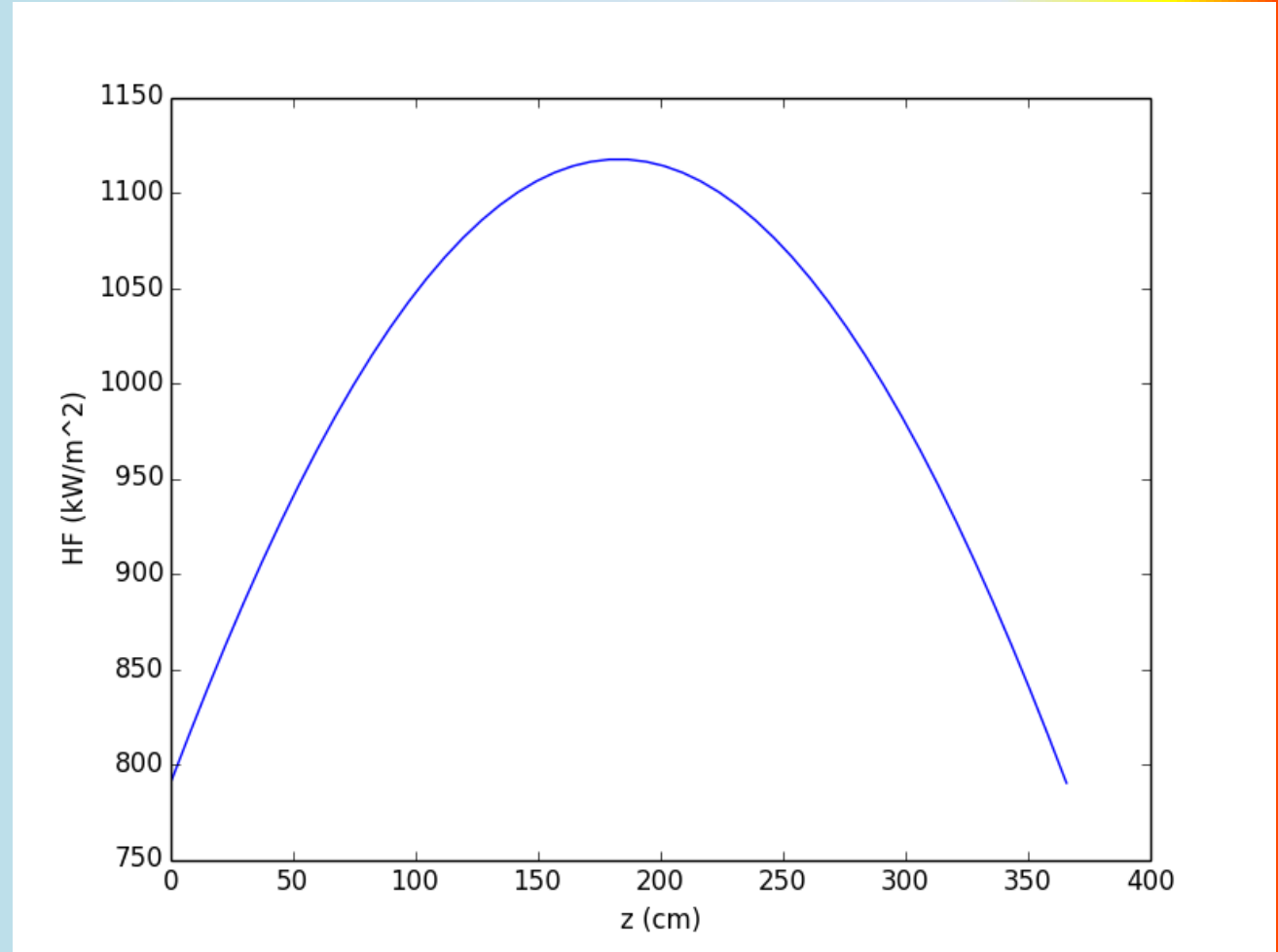
Critical heat factor ratio

- Kritični toplotni tok / dejanski toplotni tok



Popravek za neenakomerno gretje

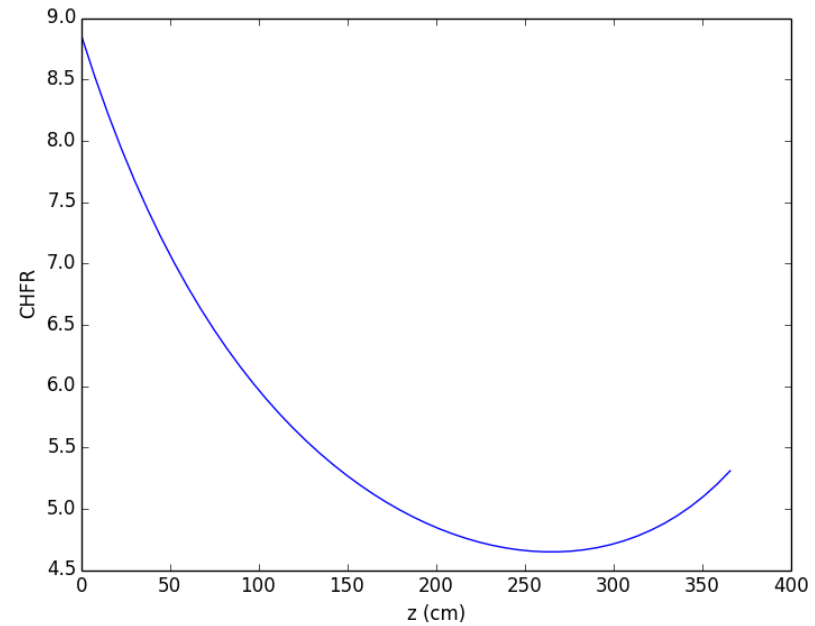
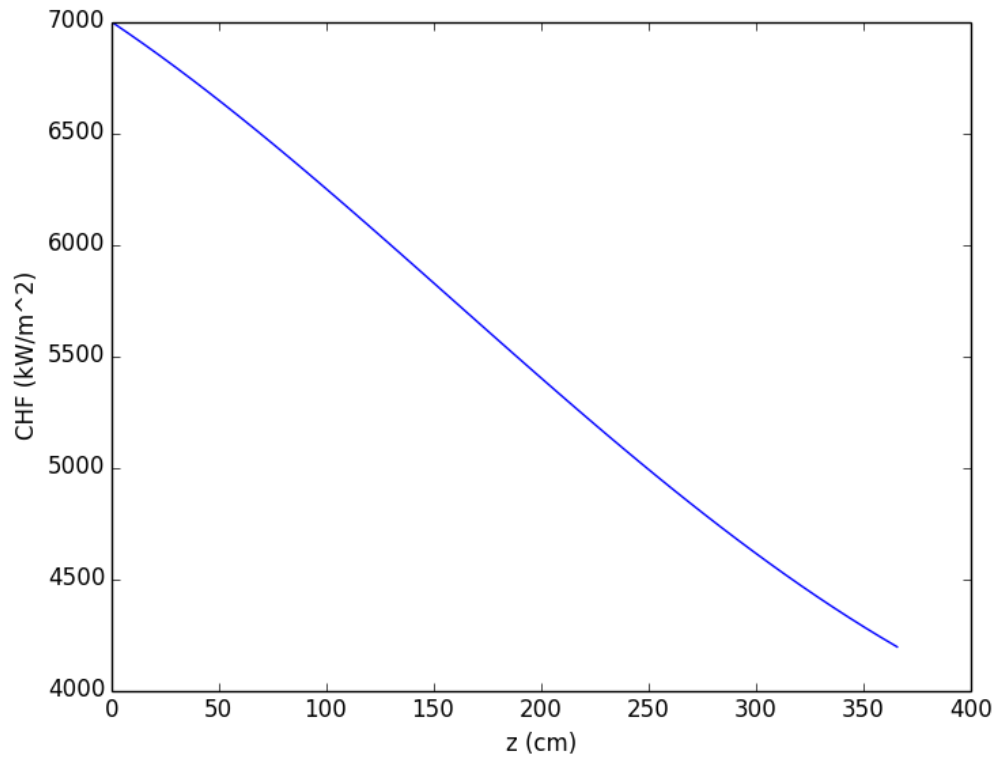
- $q''_{er,n} = \frac{q''_{er}}{F}$

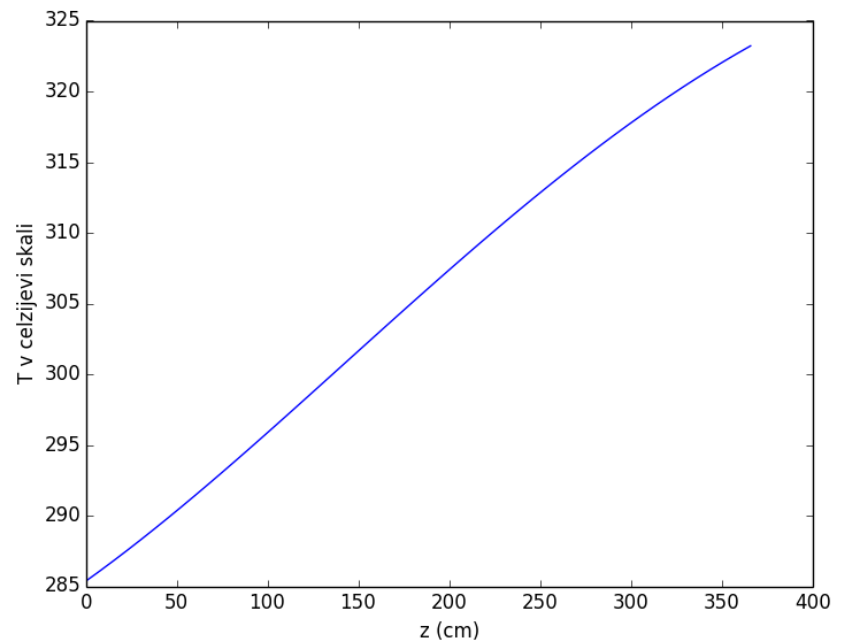
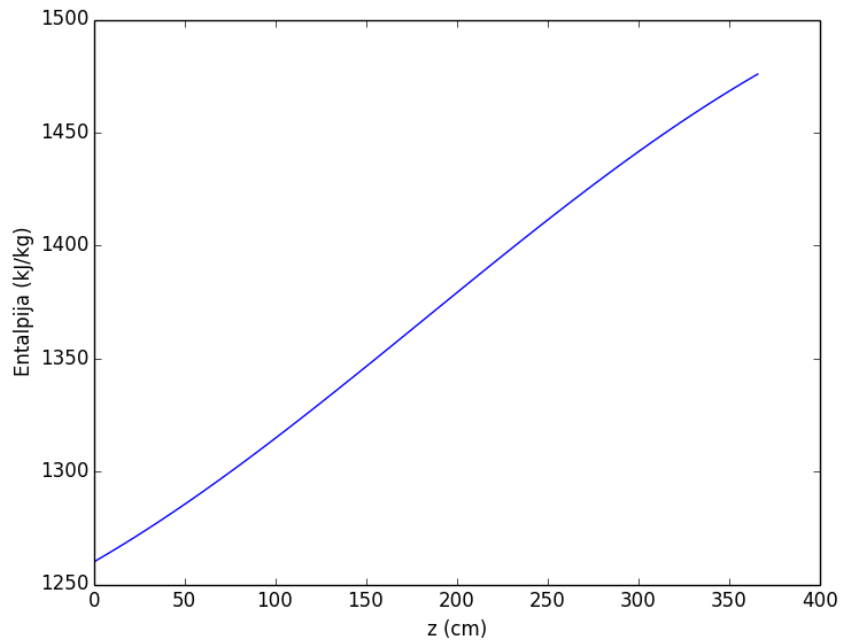
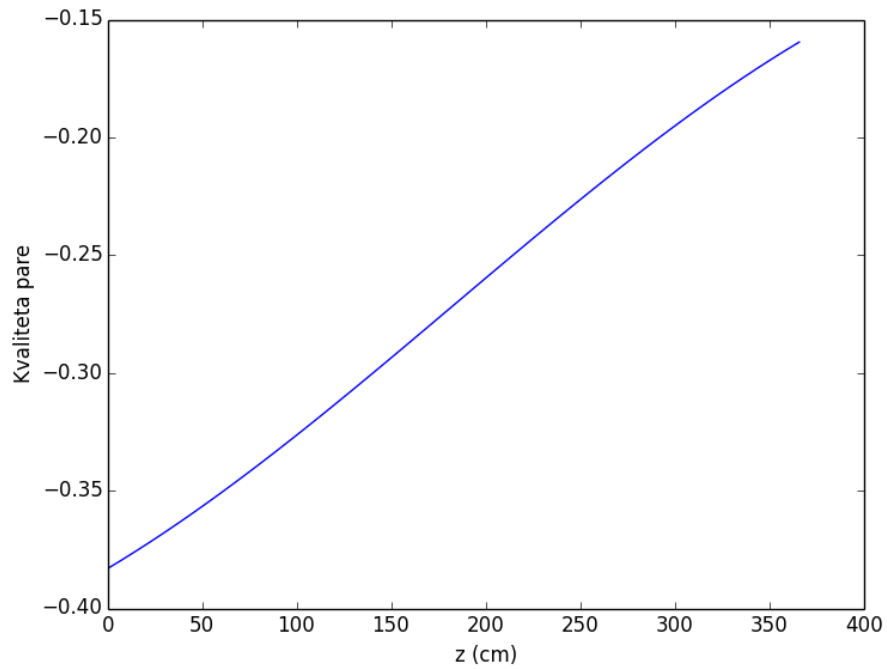


- $F = \frac{C \cdot \int_0^l q''(z') \cdot e^{-C(l-z')} \cdot dz'}{q''(l)(1-e^{-Cl})}$

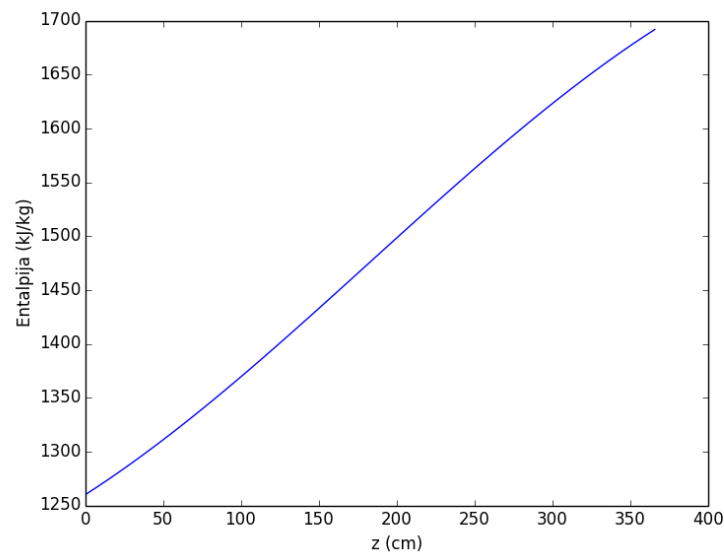
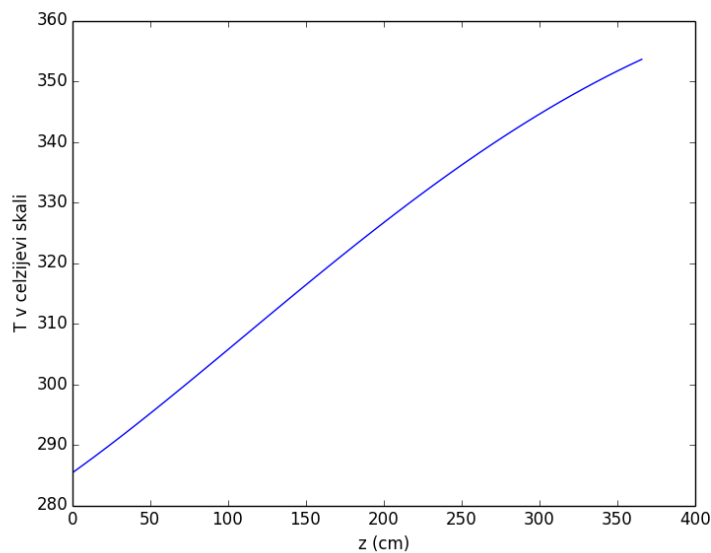
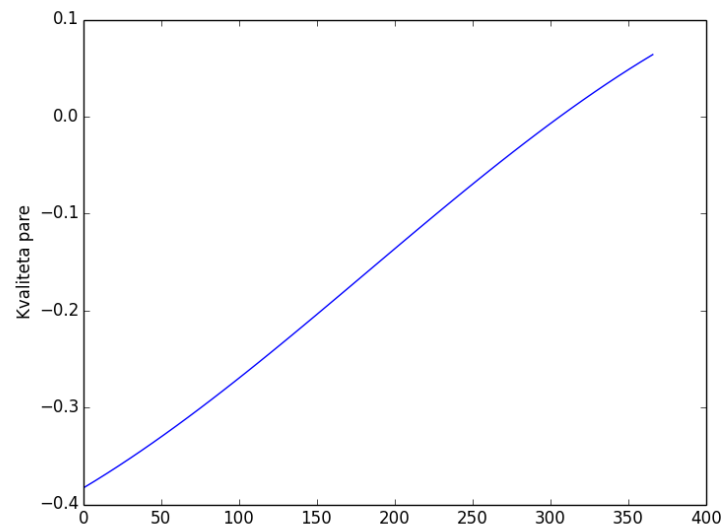
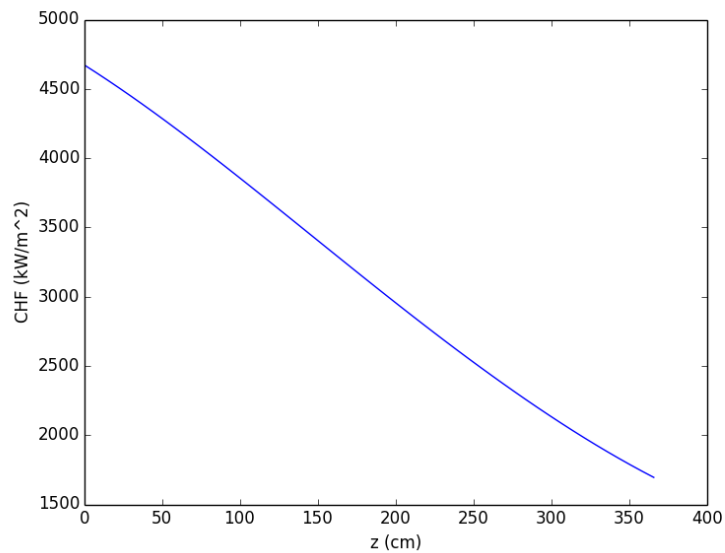
$$C = \frac{4,23 \cdot 10^6 \cdot (1-X(l)^{7,9})}{G^{1,72}} m^{-1}$$

Rezultati za Krško

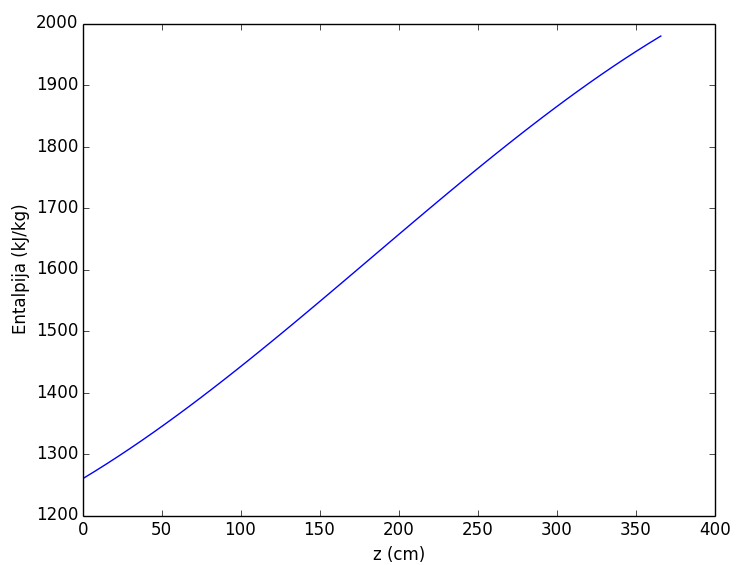
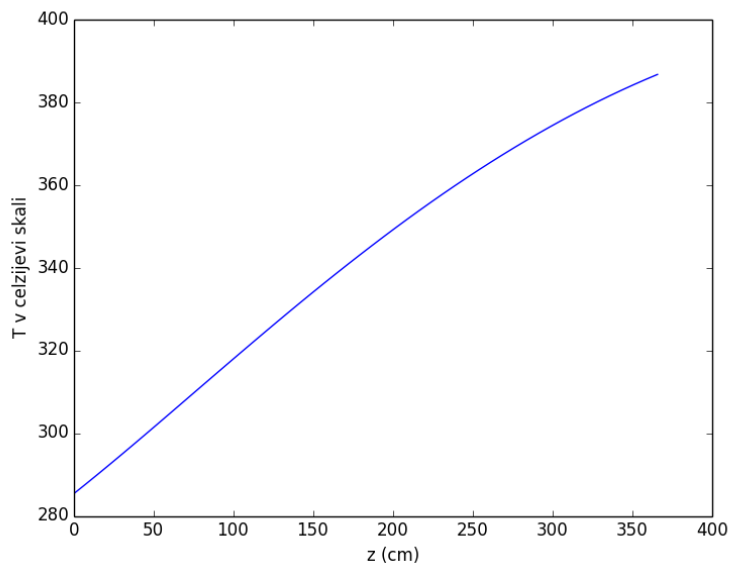
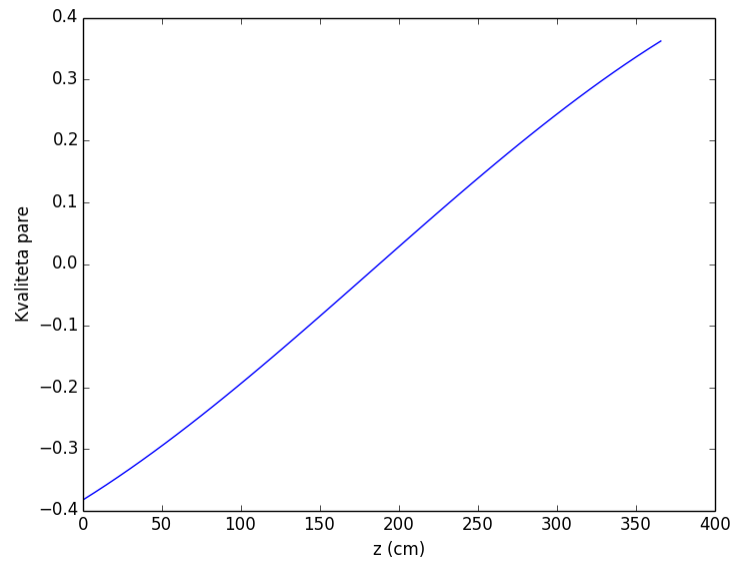
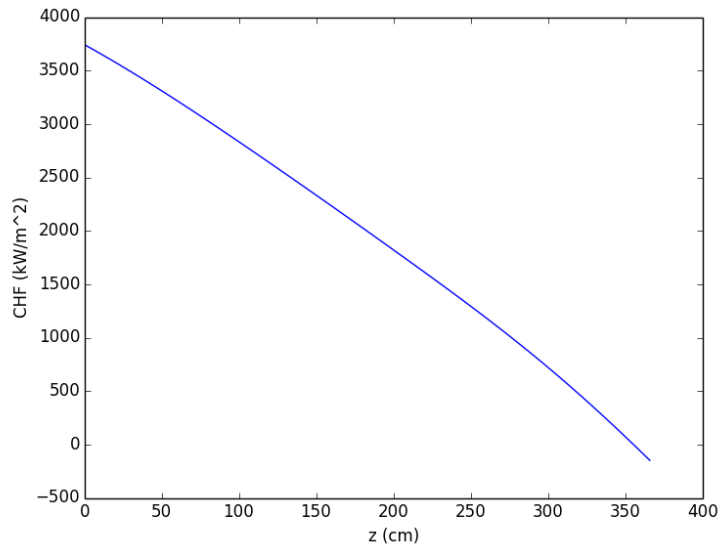




Polovična moč črpalk



Še hitro za 30 procentov



Povzetek

- Kritični toplotni tok nam pove, pri katerem toplotnem toku hladilo ne more več dovolj učinkovito odvajati toplote, zato začne vreti in toploto odvaja še slabše, kar hitro pripelje do taljenja sredice.
- Nauk: Sredico MORAMO vseskozi hladiti, najpomembnejši je pretok hladila.

Viri:

- Todreas, Kazimi, Nuclear systems, TH I. part

- Podatki o NEK

http://www.nek.si/sl/o_jedrski_tehnologiji/tehnichni_podatki/

- Entalpija vode

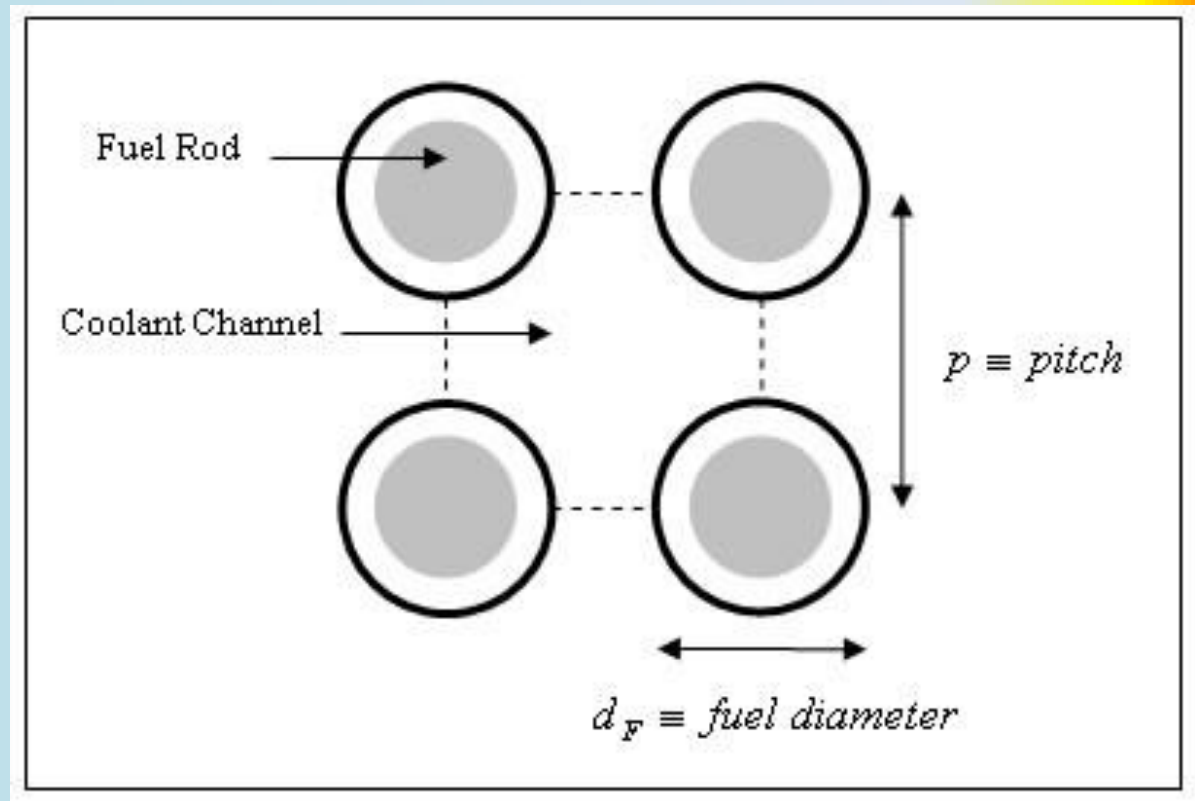
http://www.peacesoftware.de/einigewerte/wasser_dampf_e.html

- Ekvivalentni preseki kanala

<http://syelendrapramuditya.wordpress.com/2009/08/25/the-concept-of-equivalent-hydraulic-diameter/>

Ekvivalenti preseki kanala

- $D = d \left(\frac{1}{\pi} \left(\frac{2p}{d} \right)^2 - 1 \right)$
- NEK
- $p = 1,25 \text{ cm}$
- $d = 1,05 \text{ cm}$
- $D = 1,1 \text{ cm}$



BWR

- Za $X < 0,197 - 0,108 * (G/106)$
– $q''/106 = 0,705 + 0,237 * (G/106)$
- Za $0,197 - 0,108 * (G/106) < X < 0,254 - 0,026 * (G/106)$
– $q''/106 = 1,634 - 0,27 * (G/10^6) - 4,71X$
- $X > 0,254 - 0,026 * (G/106)$
– $q''/106 = 0,705 + 0,237 * (G/10^6) - 0,653X$
- + še popravka za različen tlak od 1000 psi in za preseke kanala večjega od 0,6 inch.