Impact of the feedwater temperature and the number of stages on the effectiveness of RFWH

To make an analysis, we use the following expressions :

Relative change in EF:
$$\delta\eta^R = \frac{1-\eta}{\frac{1}{A_{ЭR}}+\eta};$$

Energy regeneration coefficient
$$A_{ЭR} = \frac{\sum \alpha_j H_j}{\alpha_к H_к};$$

Heat drop of the steam of the *j*-th extraction:
$$H_j = \left(h_0 - h_j\right);$$

Heat drop of the steam flowing in the condenser:
$$H_к = \left(h_0 - h_к\right);$$

Steam flow rate in the *j*-th preheater: α_j depends on the performance characteristic of the *j*-th preheater

Condenser flow rate:
$$\alpha_к = 1 - \sum \alpha_j$$

Any number of preheaters can be used to heat water up to the predetermined temperature if the pressure in the first preheater corresponds to this temperature.

The water temperature at the preheater outlet is set as $t_{вj}$.

The saturated heating steam temperature should be $t_{sj} = t_{вj} + \vartheta_{nj}$.

The extraction pressure should correspond to this temperature $p_j = f(t_{sj})$.

Single-stage heating:

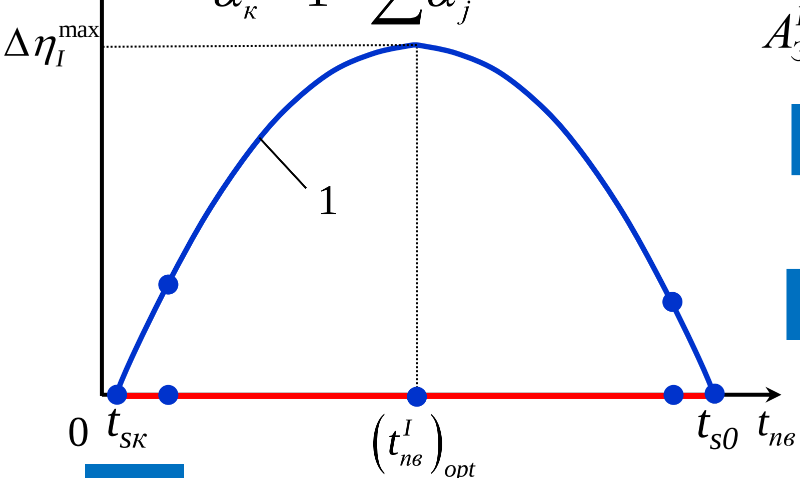
$$\delta\eta^{R}=\frac{1-\eta}{\frac{1}{A_{ЭR}}+\eta};$$

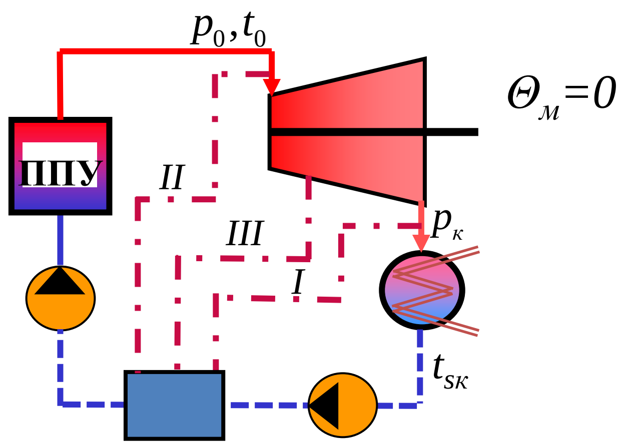
$$A_{ЭR}=\frac{\sum\alpha_j H_j}{\alpha_к H_к};$$

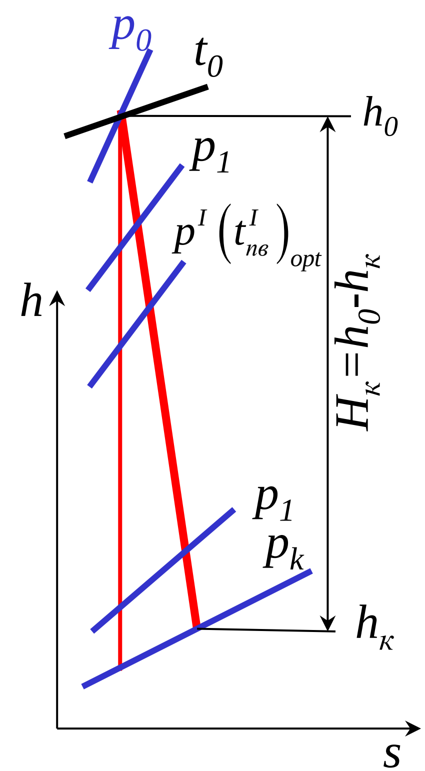
$$H_j=\left(h_0-h_j\right);\ H_к=\left(h_0-h_к\right);$$

α_j depends on the j-th preheater-performance characteristic

$$\alpha_к=1-\sum\alpha_j$$







$$A^{I}_{ЭR}=\frac{\alpha_1^I H_1}{\alpha_к H_к};\qquad \alpha_к=1-\alpha_1^I.$$

I. $t_{пв}=t_{sк}$

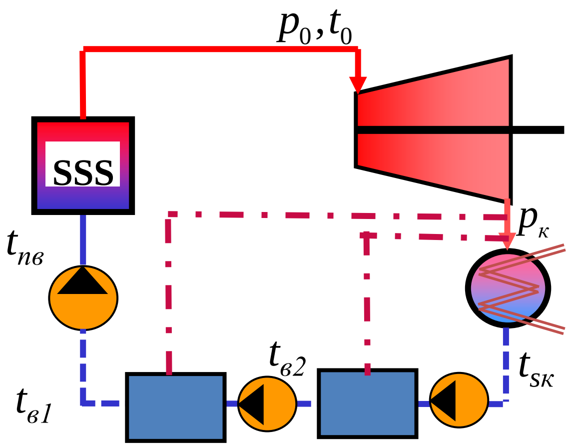
$t_{s1}=t_{sк}\rightarrow p_1=p_к\rightarrow H_1=H_к,\ \alpha_1^I=0\rightarrow A_{ЭR}=0\rightarrow\Delta\eta=0.$

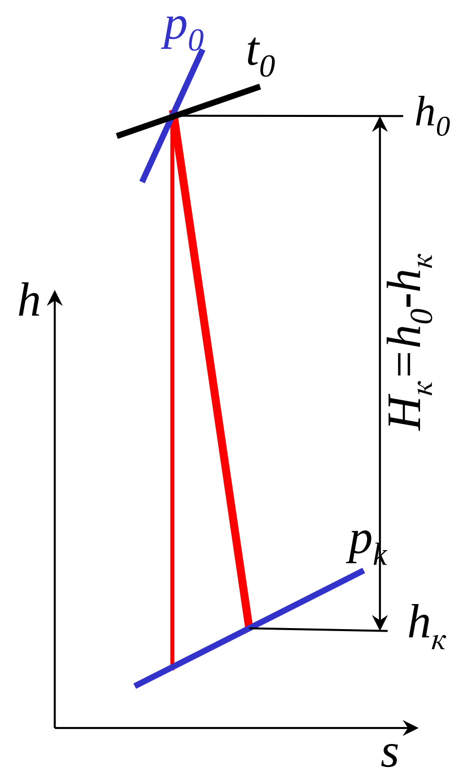
II. $t_{пв}=t_{s0}$

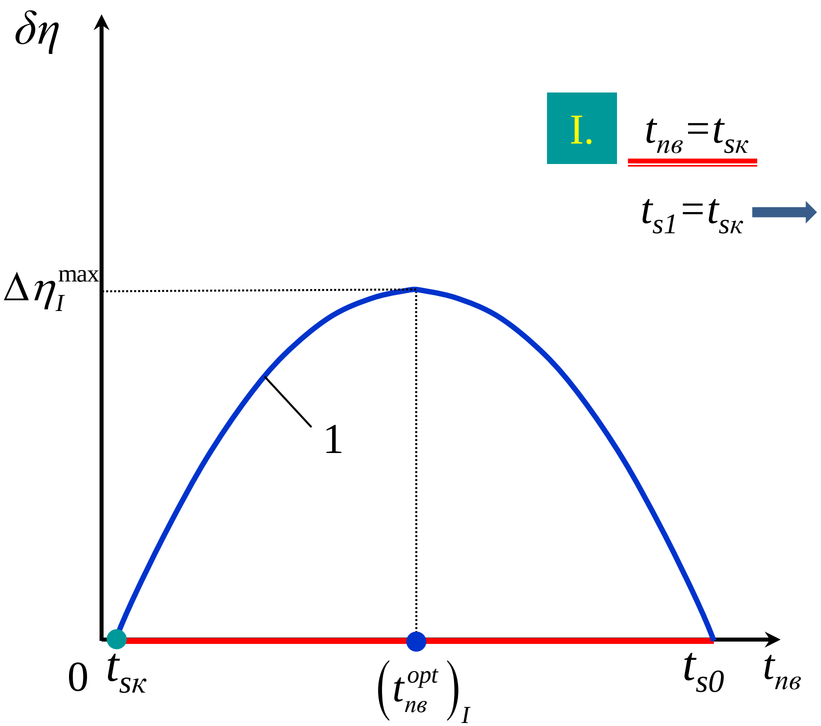
$t_{s1}=t_{s0}\rightarrow p_1=p_0\rightarrow H_1=0,\ \alpha_1^I=\left(\alpha_1^I\right)_{\max}\rightarrow A_{ЭR}=0\rightarrow\Delta\eta=0.$

III. $t_{sк}<t_{пв}<t_{s0}\rightarrow t_{sк}<t_{s1}<t_{s0}\rightarrow p_к<p_1<p_0\rightarrow 0<H_1<H_к,\ 0<\alpha_1^I<\left(\alpha_1^I\right)_{\max}\rightarrow A_{ЭR}>0\rightarrow\Delta\eta>0.$

Two-stage heating:

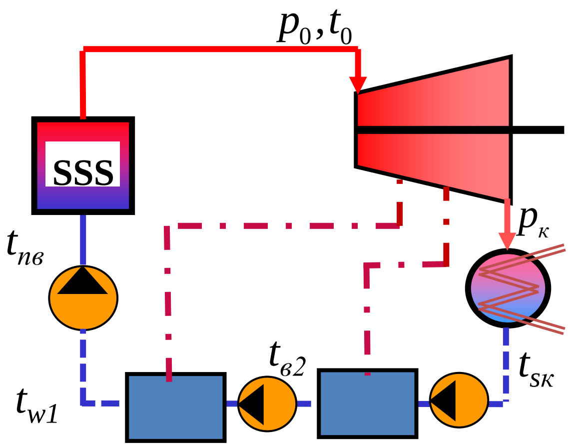


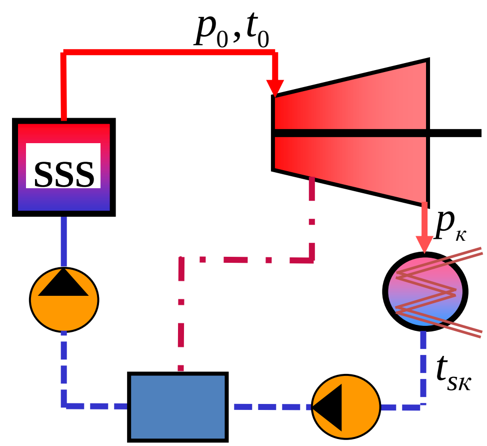


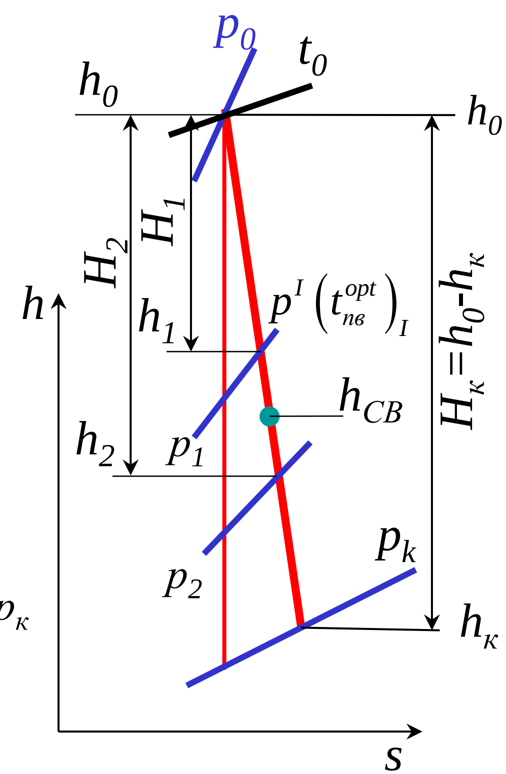


I. $t_{пв}=t_{sк}$

$t_{s1}=t_{sк}$ → $p_1=p_к=p_2$ → $H_1=H_2=H_к$, $\alpha_1^{II}=\alpha_2^{II}=0$ → $A_{ЭR}=0$ → $\Delta\eta=0.$



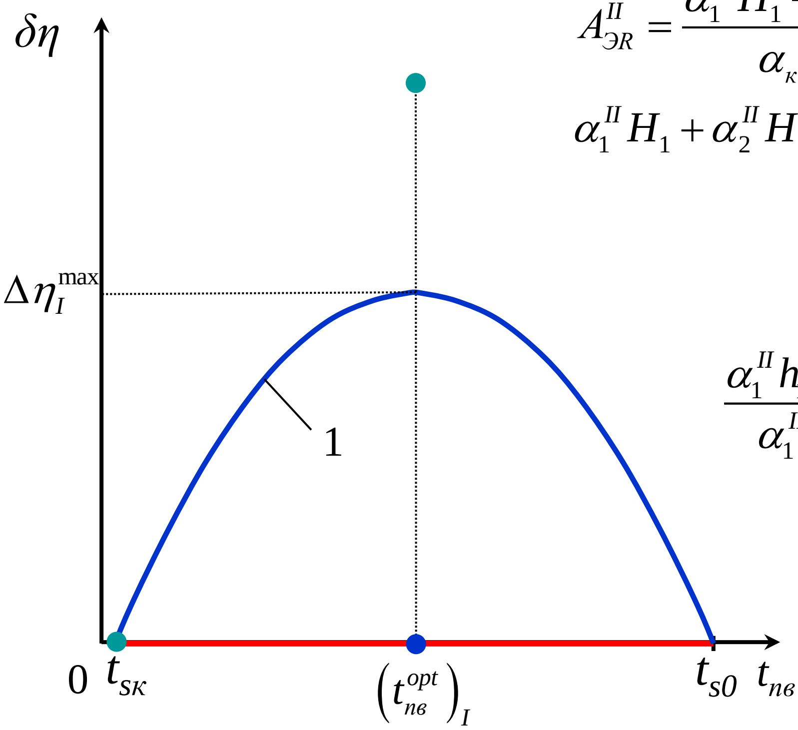




II. $t_{пв} = \left(t_{пв}^{opt}\right)_I$ $\quad t_{в1} = \left(t_{пв}^{opt}\right)_I \longrightarrow p_1 = p^I\left(t_{пв}^{opt}\right)_I; \quad t_{в1} > t_{в2} > t_{sк} \longrightarrow p_1 > p_2 > p_к$

$$A_{ЭR}^{II} = \frac{\alpha_1^{II} H_1 + \alpha_2^{II} H_2}{\alpha_к H_к}; \qquad \alpha_к = 1 - \alpha_1^{II} - \alpha_2^{II}.$$

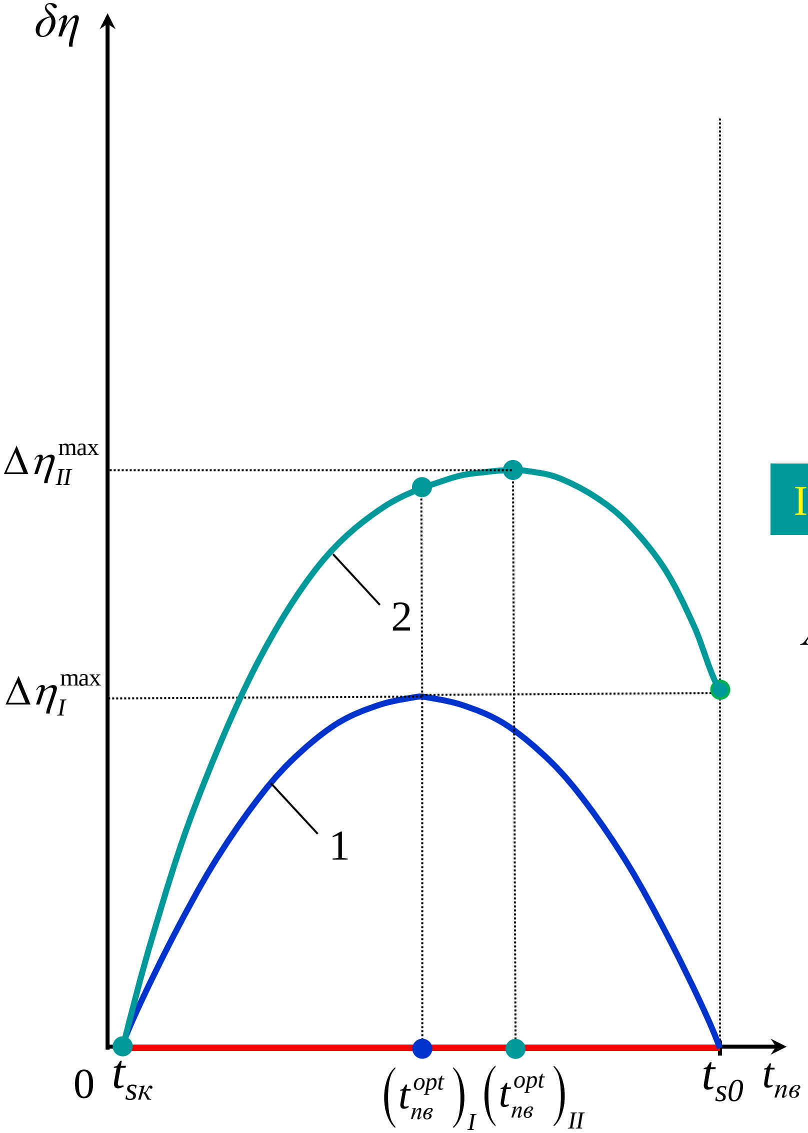
$$\alpha_1^{II} H_1 + \alpha_2^{II} H_2$$

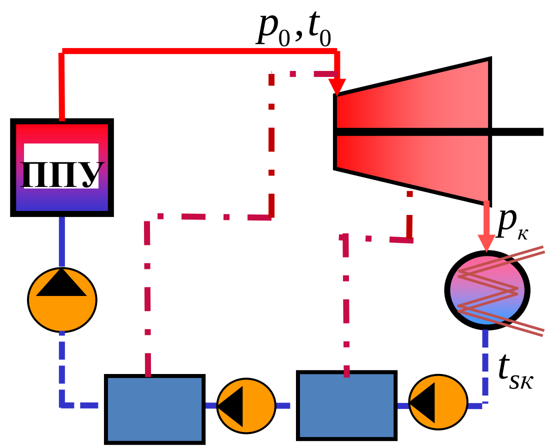


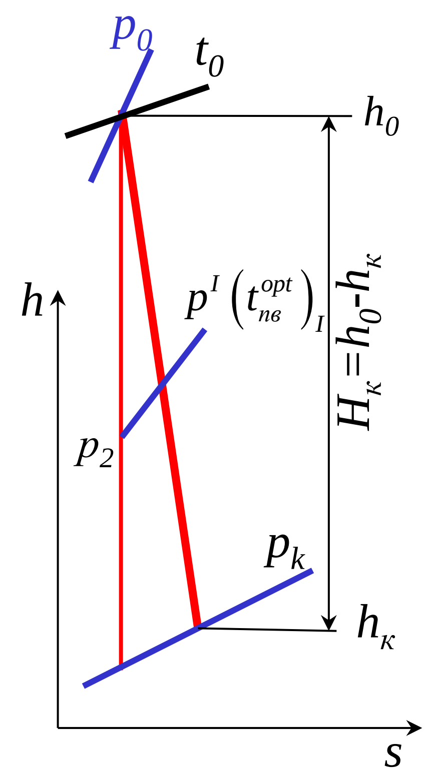
$$\frac{\alpha_1^{II} h_1 + \alpha_2^{II} h_2}{\alpha_1^{II} + \alpha_2^{II}}$$ weighted enthalpy of extraction steam.

$$A_{ЭR}^{I} = \frac{\alpha_1^{I} H_1}{\alpha_к H_к}; \quad \alpha_к = 1 - \alpha_1^{I}. \qquad A_{ЭR}^{II} = \frac{\left(\alpha_1^{II} + \alpha_2^{II}\right) H_{CB}}{\left(1 - \alpha_1^{II} - \alpha_2^{II}\right) H_к}.$$

$$A_{ЭR}^{II} > A_{ЭR}^{I}$$







III. $t_{пв}=t_{s0}$

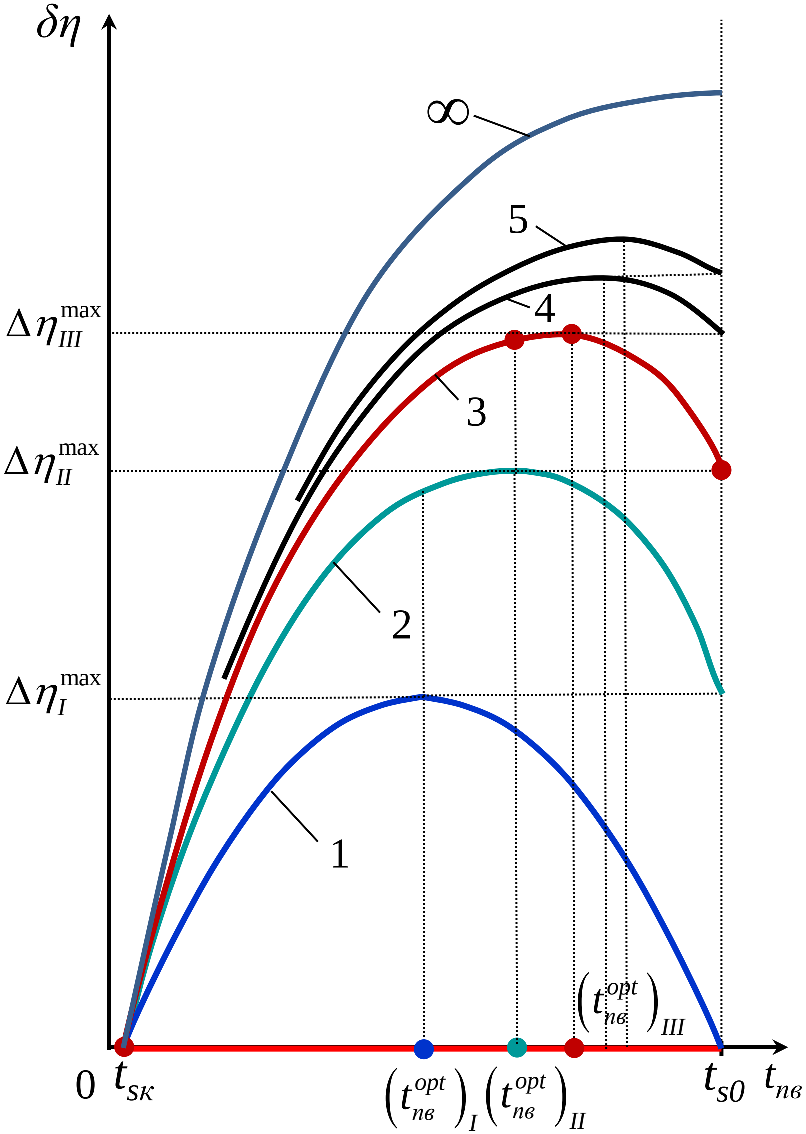
$$A^{II}_{ЭR} = \frac{\alpha^{II}_1 H_1}{\alpha_к H_к} + \frac{\alpha^{II}_2 H_2}{\alpha_к H_к} = A_{ЭR1} + A_{ЭR2}$$

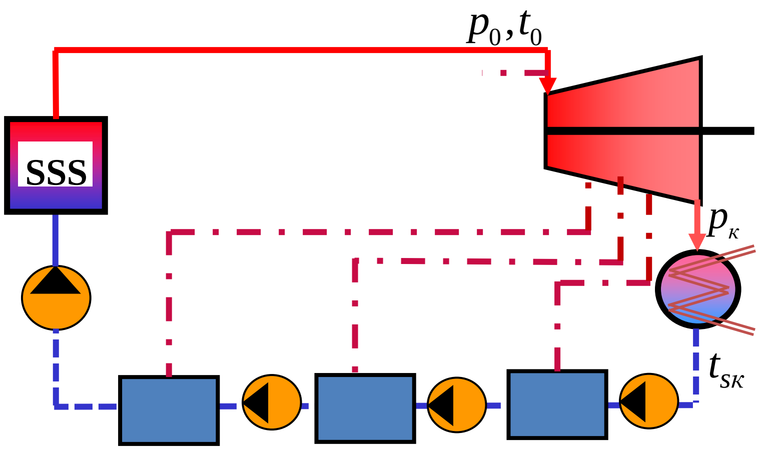
$t_{в1}=t_{s0} \rightarrow p_1=p_0 \rightarrow H_1 = 0,\ \alpha^I_1 = \left(\alpha^I_1\right)_{max} \rightarrow A_{ЭR1}=0$

$t_{в2} = \left(t^{opt}_{пв}\right)_I \rightarrow p_2 = p^I\left(t^{opt}_{пв}\right)_I;\quad A_{ЭR2} = A^I_{ЭR}$

$$A^{II}_{ЭR} = A^I_{ЭR}$$

Three-stage heating:



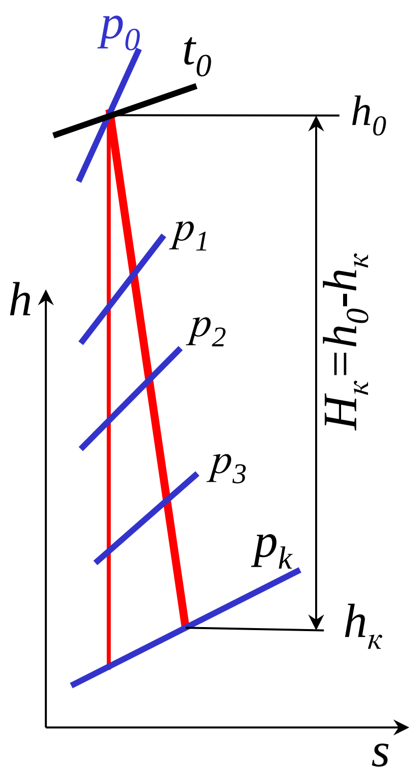


Four-stage …:

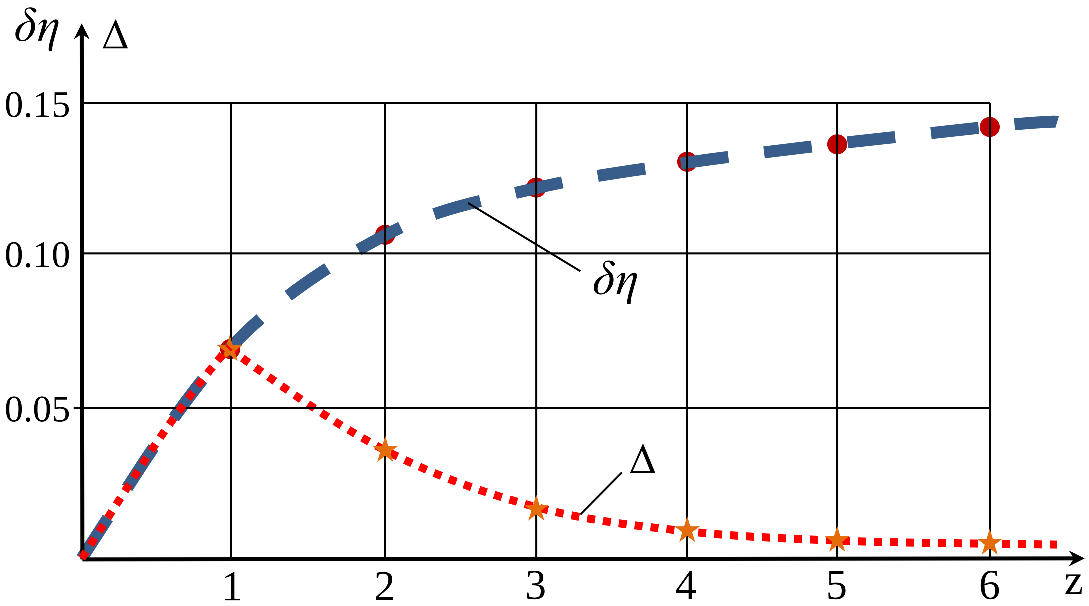
Five-stage …:

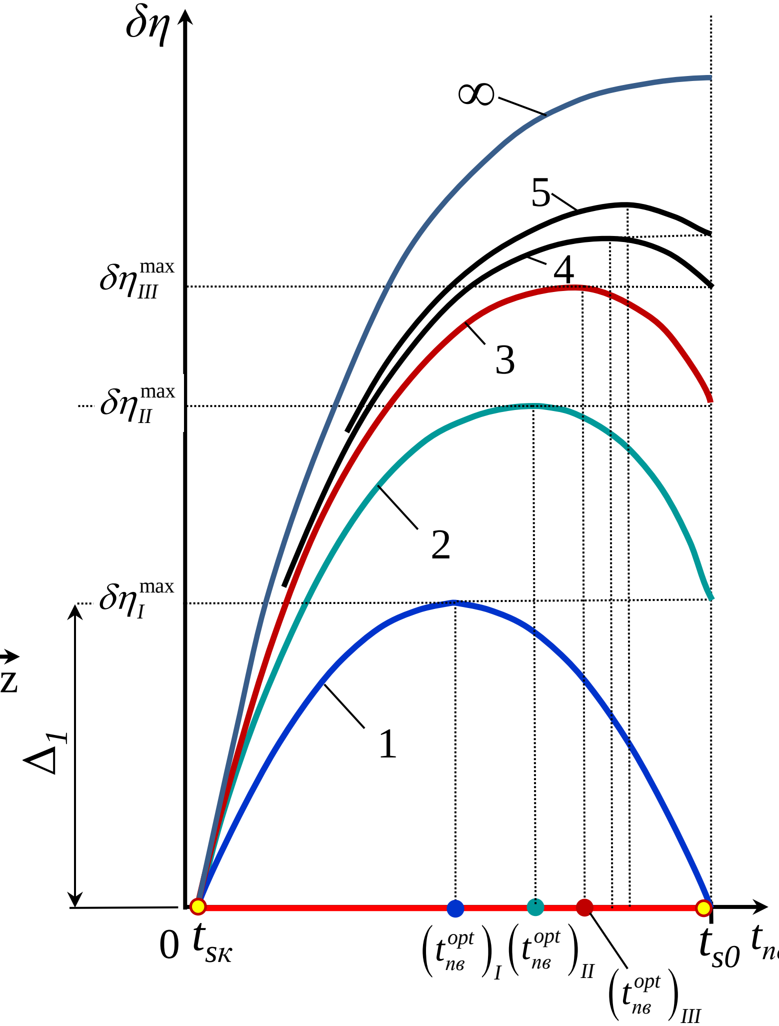
…. …:

An infinite number of stages …:



Generalizing conclusions





$$\Delta = \delta\eta_j - \delta\eta_{(j-1)}$$

$$\left(t_{пв}^{opt}\right)_Z = t_{s\kappa} + \frac{z}{z+1}\left(t_{s0} - t_{s\kappa}\right)$$