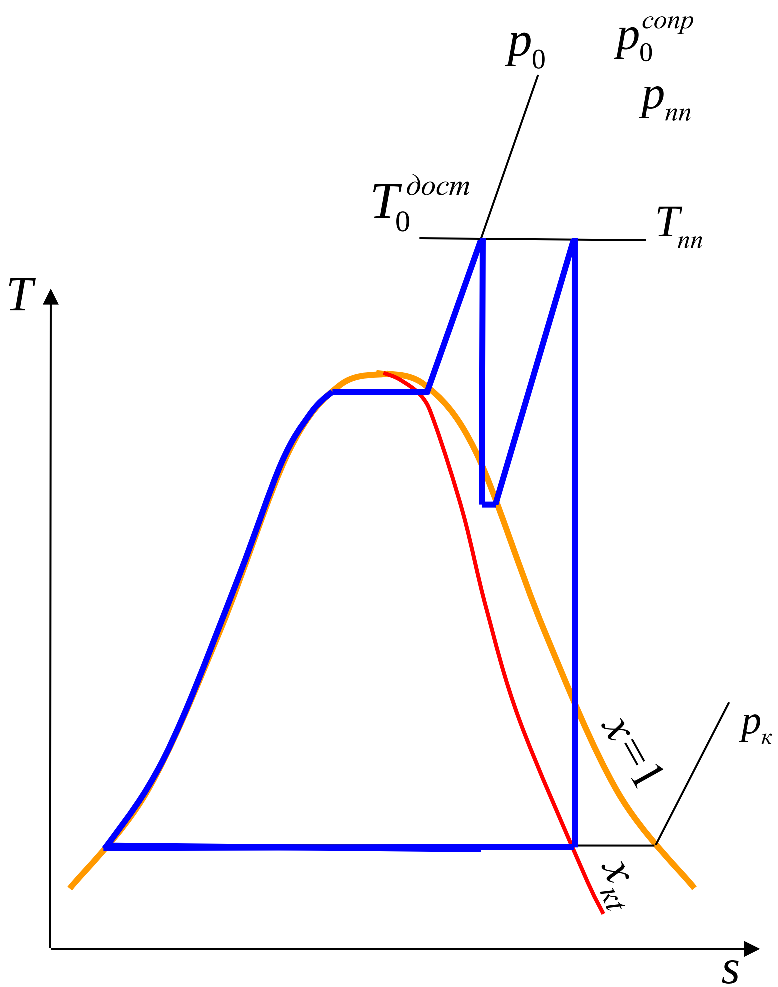
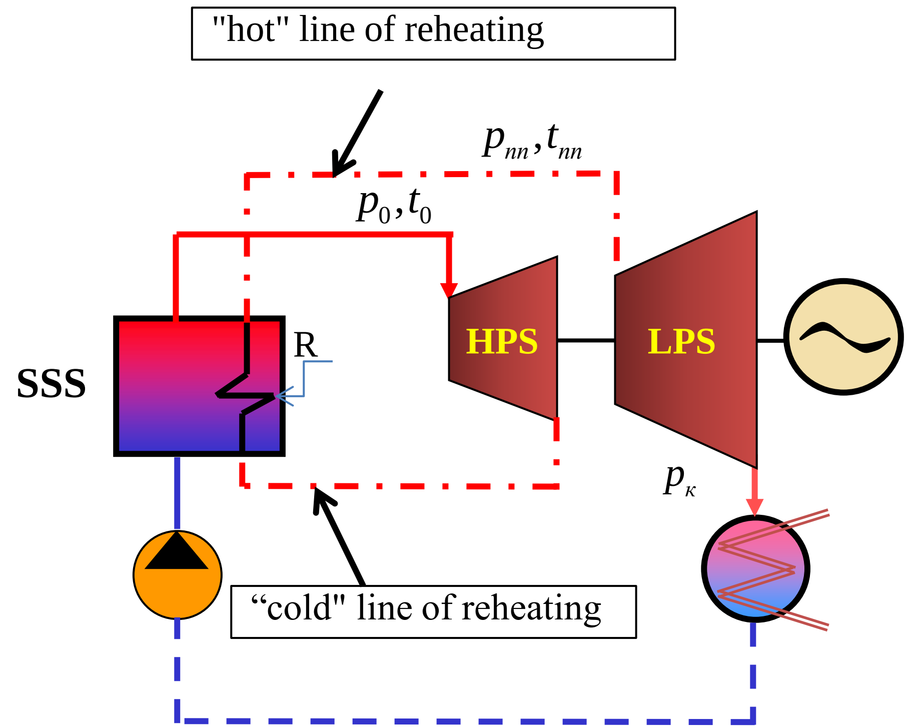
1. Schematic diagram and cycle of the turbine with the reheating stage





R – reheater

HPS – high-pressure section

LPS – low-pressure section

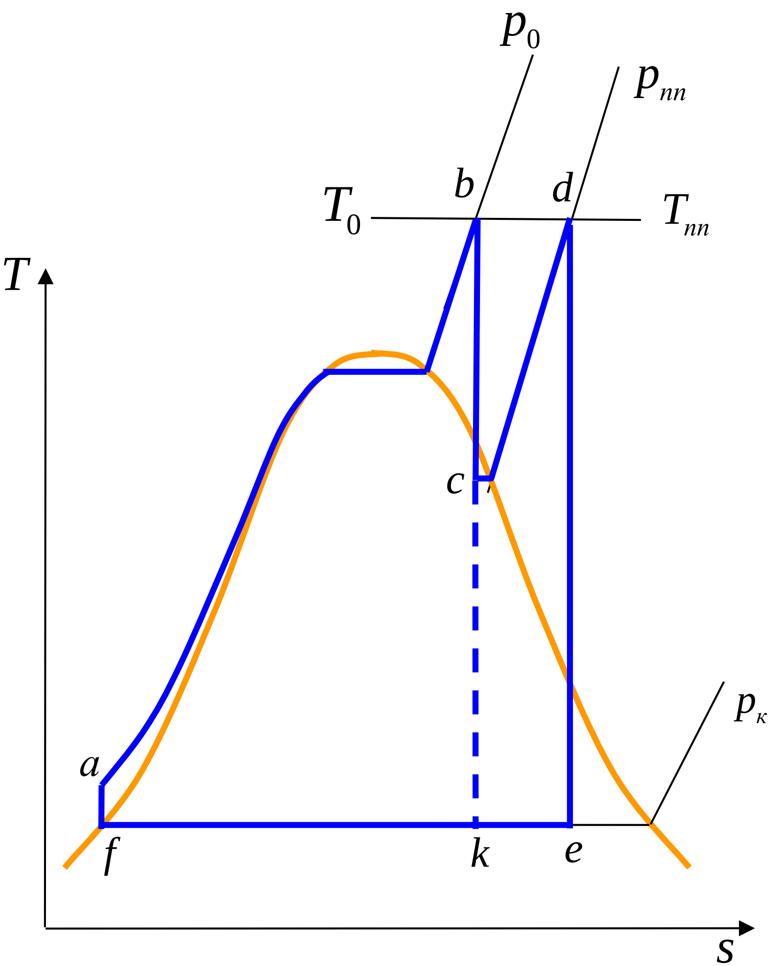
$$t_{пп}^{opt} \approx t_0$$

$$p_{пп}^{opt} = (0{,}15 \div 0{,}25)\, p_0$$

$$\delta\eta_t = \frac{\eta_t^{сПП} - \eta_t^{безПП}}{\eta_t^{безПП}} = 0{,}04 \div 0{,}06$$

The schematic diagram shows the so-called **fired** steam reheating

2. Impact of reheating on the cycle economy



Turbine cycle with reheating stage – *abcdefa*.

Divide this cycle into two parts:

- basic cycle *abkfa* – o
- additional cycle *cdekc* – Δ

The EF of the cycle with the reheating stage is:

$$\eta_t^{сПП} = \frac{l_ц}{q_{TE}}$$

$$l_ц = l_o + l_\Delta \qquad q_{TE} = q_o + q_\Delta$$

$l_ц$ – process (*bc*+*de*-*af*) $\qquad$ q_{TE} – process (*ab*+*cd*)

l_o – process (*bk*-*af*) $\qquad$ q_o – process (*ab*)

l_Δ – process (*de*-*ck*) $\qquad$ q_Δ – process (*cd*)

$$\eta_t^{сПП} = \frac{l_o + l_\Delta}{q_o + q_\Delta} = \frac{l_o}{q_o}\frac{1+\frac{l_\Delta}{l_o}}{1+\frac{q_\Delta}{q_o}}$$

$\frac{l_o}{q_o} = \eta_o$ – EF of the basic cycle

$\frac{l_\Delta}{l_o} = A_Э$ – energy efficiency of the additional cycle

$$\frac{q_\Delta}{q_o} = \frac{q_\Delta l_o l_\Delta}{q_o l_o l_\Delta} = A_Э \frac{\eta_o}{\eta_\Delta};$$

$\frac{l_\Delta}{q_\Delta} = \eta_\Delta$ – EF of the additional cycle

$$\eta_t^{сПП} = \eta_o \frac{1 + A_Э}{1 + A_Э \frac{\eta_o}{\eta_\Delta}}$$

$$\eta_t^{сПП} = \eta_o \frac{1 + A_Э}{1 + A_Э \dfrac{\eta_o}{\eta_\Delta}}$$

$$\delta\eta = \frac{\eta_t^{сПП} - \eta_t^{безПП}}{\eta_t^{безПП}} = \frac{\eta_t^{сПП} - \eta_o}{\eta_o} = \frac{1 + A_Э}{1 + A_Э \dfrac{\eta_o}{\eta_\Delta}} - 1 = \frac{A_Э - A_Э \dfrac{\eta_o}{\eta_\Delta}}{1 + A_Э \dfrac{\eta_o}{\eta_\Delta}}$$

$$\delta\eta = \frac{1 - \dfrac{\eta_o}{\eta_\Delta}}{\dfrac{1}{A_Э} + \dfrac{\eta_o}{\eta_\Delta}}$$

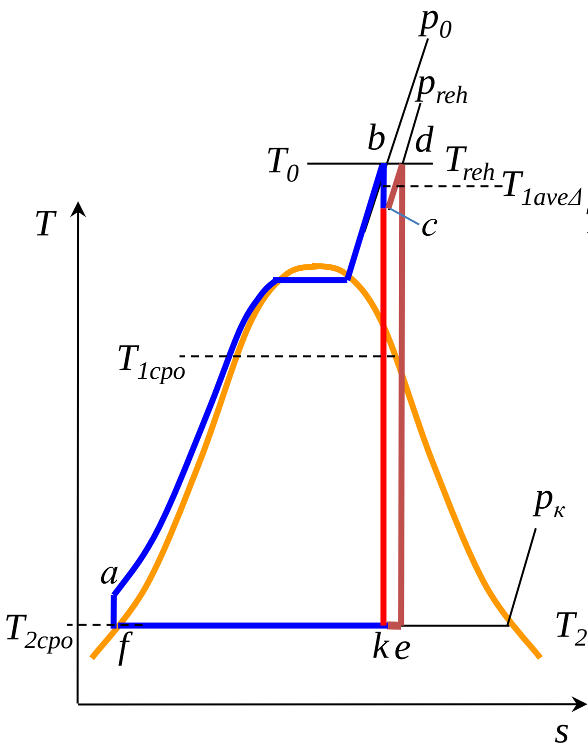
The numerator determines the sign of the $\delta\eta$ value.

if:

A. $\eta_\Delta > \eta_o$ ($\dfrac{\eta_o}{\eta_\Delta} < 1$, positive numerator) $\delta\eta > 0$

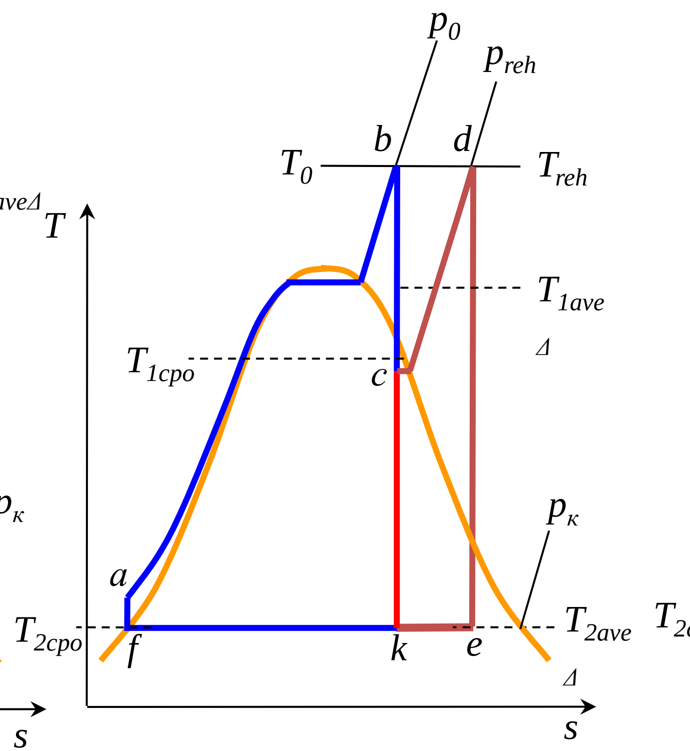
B. $\eta_\Delta < \eta_o$ ($\dfrac{\eta_o}{\eta_\Delta} > 1$, negative numerator) $\delta\eta < 0$

C. $\eta_\Delta = \eta_o$ ($\dfrac{\eta_o}{\eta_\Delta} = 1$, numerator equals zero) $\delta\eta = 0$



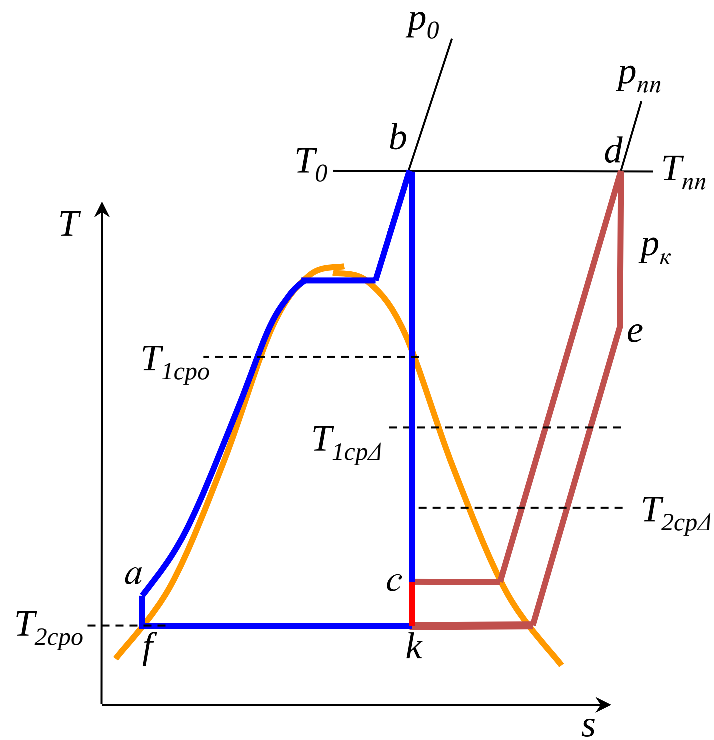
$\eta_\Delta > \eta_o$, as $T_{1ave\Delta} > T_{1cpo}$

$\delta\eta > 0$



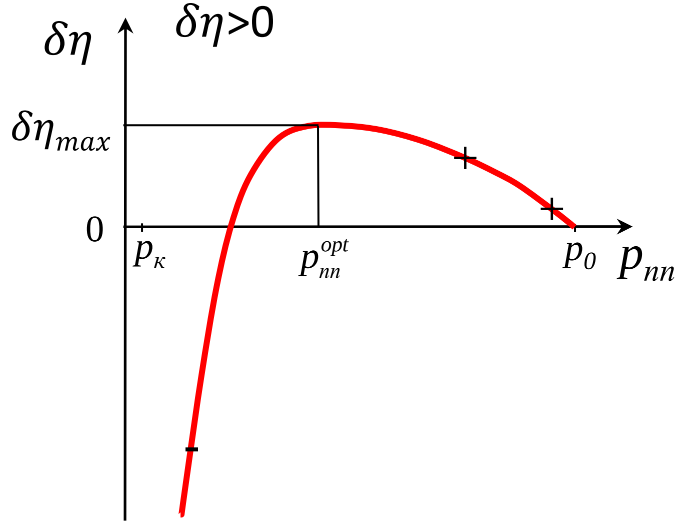
$\eta_\Delta > \eta_o$, as T_{1ave}

$\delta\eta > 0$

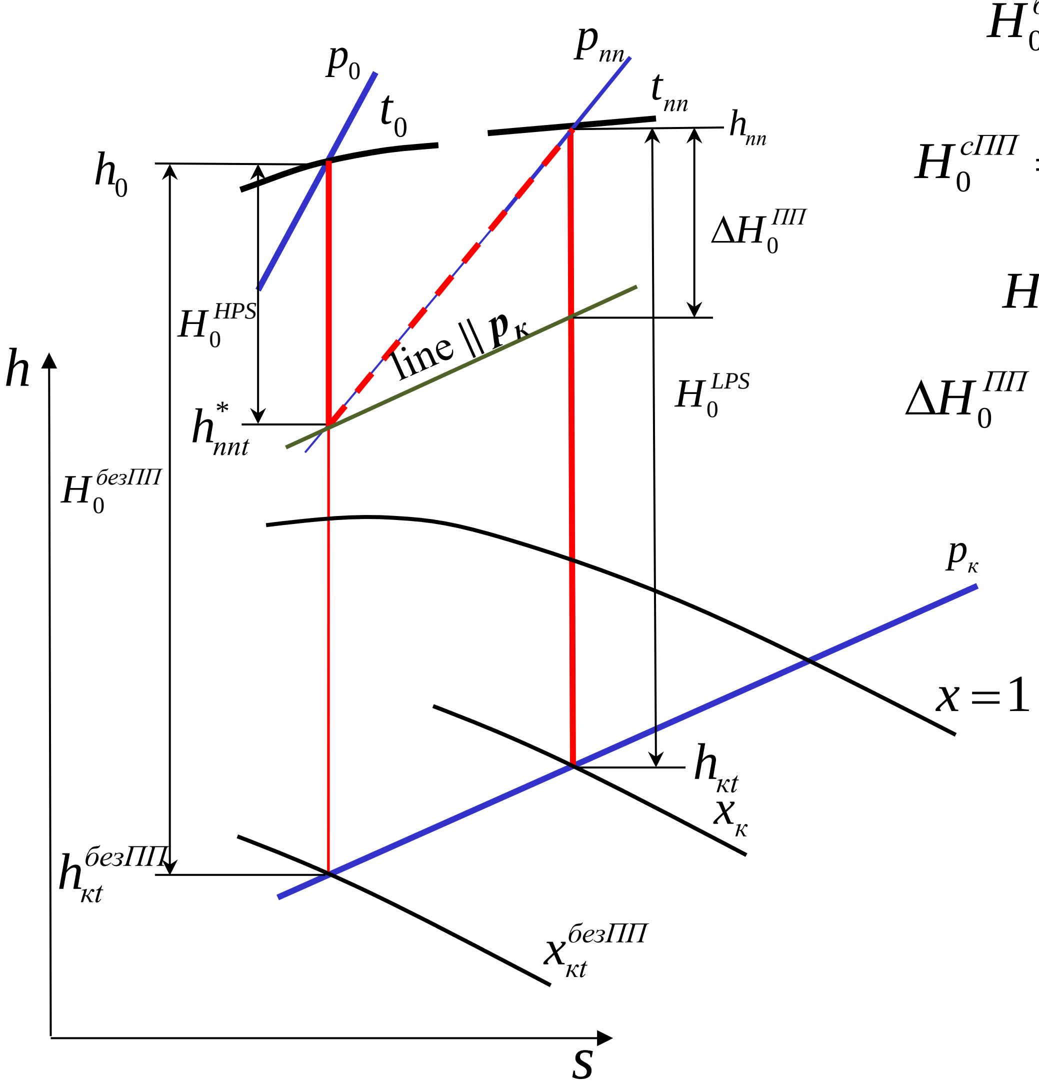


$\eta_\Delta < \eta_o$, s as $T_{1ave\Delta} < T_{1cpo}$
and $T_{2ave\Delta} > T_{2cpo}$

$\delta\eta < 0$



3. Available heat drop and the final dryness factor in the steam turbine with the reheating stage



$$H_0^{безПП} = h_0 - h_{кt}^{безПП}$$

$$H_0^{сПП} = H_0^{ЧВД} + H_0^{ЧНД} = h_0 - h_{ппt}^{*} + h_{пп} - h_{кt}$$

$$H_0^{сПП} == (h_0 - h_{кt}) + (h_{пп} - h_{ппt}^{*})$$

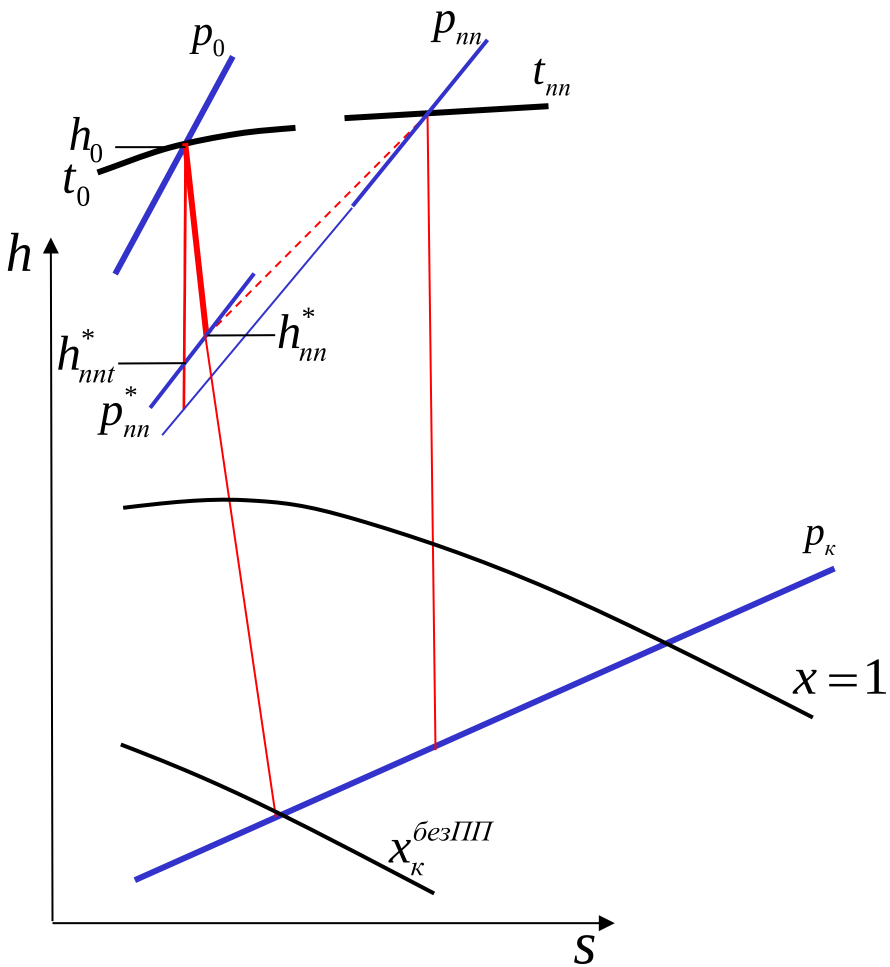
$\Delta H_0^{ПП}$ - increase in the available heat drop of the turbine with the reheating stage versus that of the turbine without the reheating stage, the initial parameters and final pressure being equal

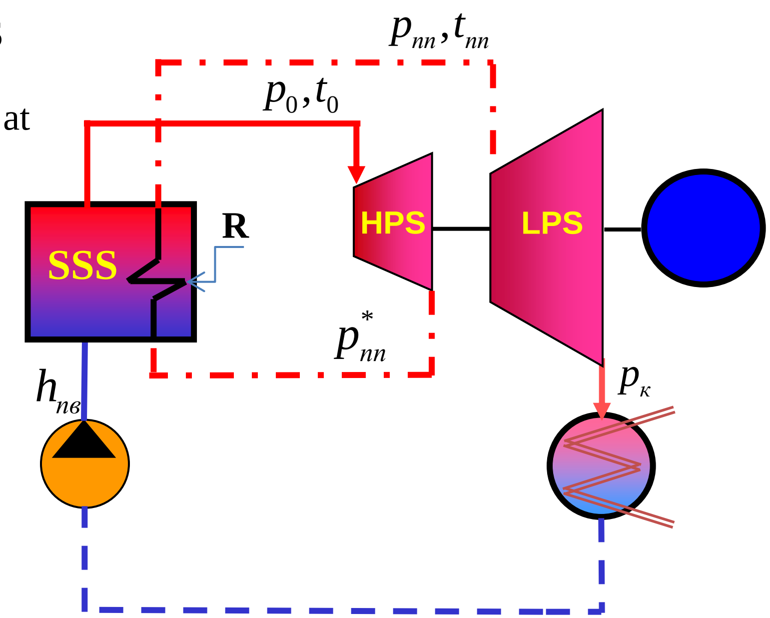
4. Real steam expansion in the turbine with the reheating stage

The parameters of the reheated steam $p_{пп}$ and $t_{пп}$ are set at the LPS inlet

The steam pressure at the outlet of HPS should be higher than that at the LPS inlet due to trunking losses:

$$p_{пп}^{*} = (1{,}07 \div 1{,}1)\, p_{пп}$$





h_0 is enthalpy of the starting point of steam expansion in the turbine, $= f(p_0,\, t_0)$

h_{nnt}^{*} is enthalpy at the end of theoretical steam expansion in HPS, $= f(p_{пп}^{*},\, s_0)$

Available heat drop in HPS

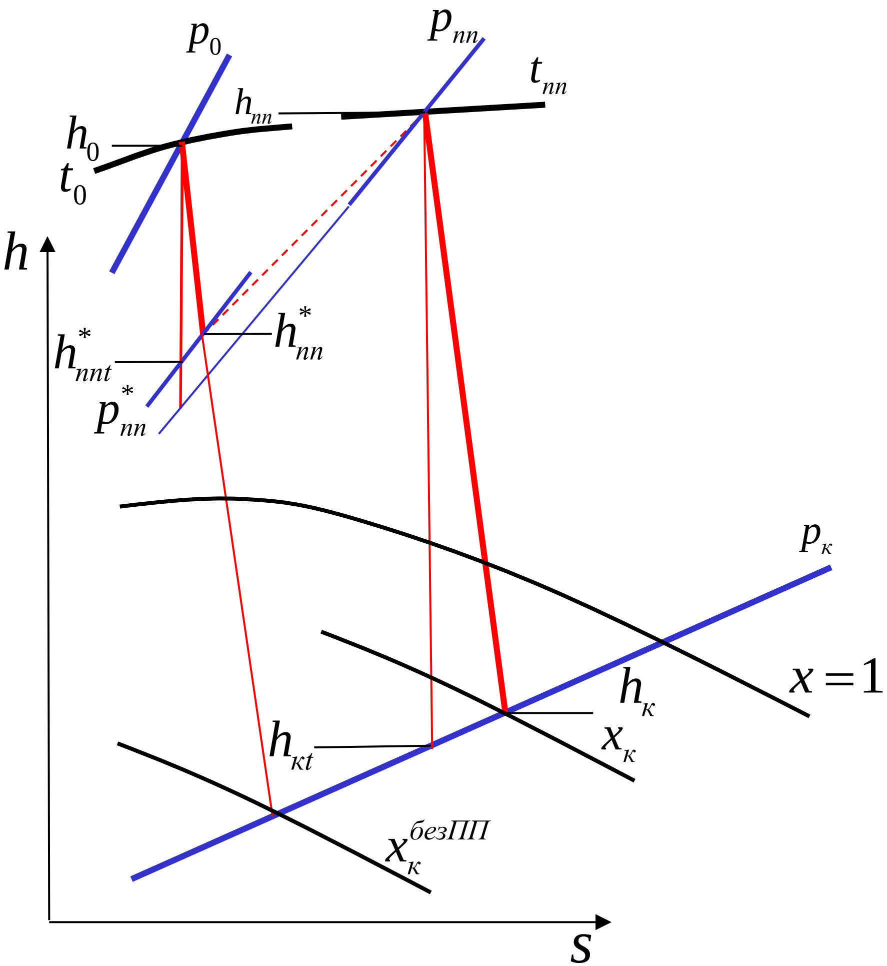
$$H_0^{HPS} = h_0 - h_{nnt}^{*}$$

Real heat drop in HPS:

$$H_i^{HPS} = H_0^{HPS}\eta_{oi}^{HPS} = h_0 - h_{пп}^{*}$$

η_{oi}^{HPS} is relative internal EF in HPS (is set).

Then: $$h_{пп}^{*} = h_0 - H_i^{HPS}$$



$h_{пп}$ is is enthalpy of the starting point of steam expansion in LPS, $=f(p_{пп}, t_{пп})$

$h_{кt}$ is enthalpy at the end of theoretical steam expansion in LPS, $=f(p_к, s_{пп})$

Available heat drop in LPS:

$$H_0^{LPS} = h_{пп} - h_{кt}$$

Real heat drop in LPS:

$$H_i^{LPS} = H_0^{LPS} \eta_{oi}^{LPS} = h_{пп} - h_к$$

η_{oi}^{LPS} – relative internal EF in HPS (is set).

Then: $$h_к = h_{пп} - H_i^{LPS}$$

Real heat drop in the turbine:

$$H_i = H_i^{HPS} + H_i^{LPS} = (h_0 - h^*_{пп}) + (h_{пп} - h_к)$$

$$H_i == (h_0 - h_к) + (h_{пп} - h^*_{пп})$$

Heat supplied to the turbine :

$$q_{TE} = (h_0 - h_{пв}) + (h_{пп} - h^*_{пп})$$

Absolute internal EF of the turbine:

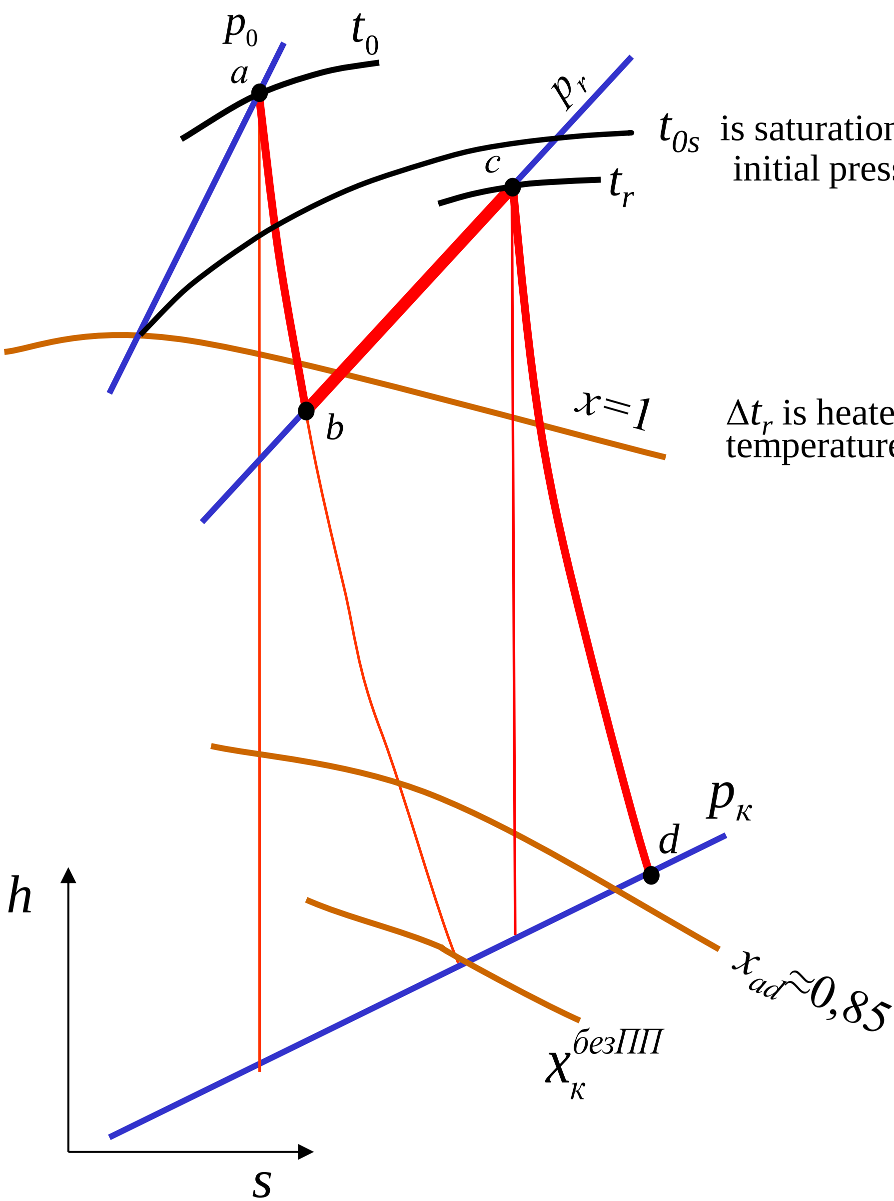
$$\eta_i = \frac{L_i}{q_{TE}} = \frac{(h_0 - h_к) + (h_{пп} - h^*_{пп})}{(h_0 - h_{пв}) + (h_{пп} - h^*_{пп})}$$

2.3.6. Steam reheating of steam

p_0, t_0, p_0 are set

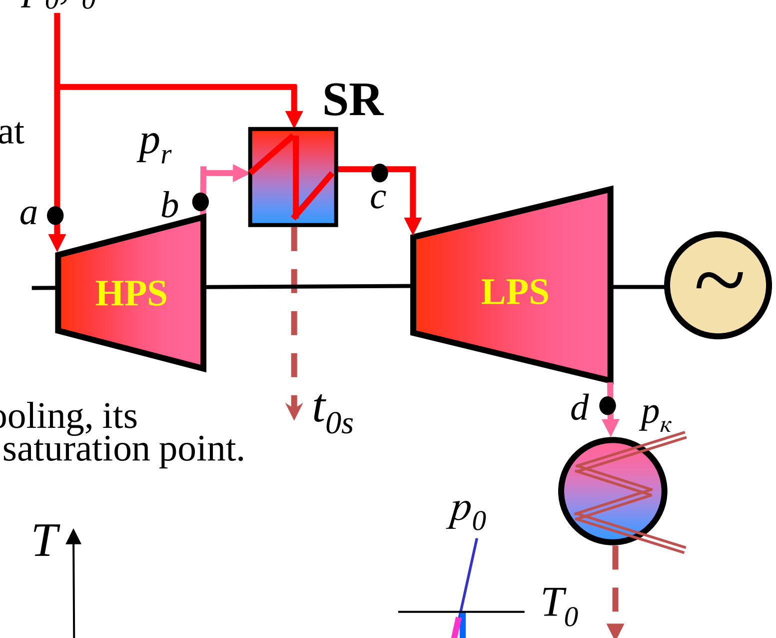
If these parameters are set for a simple steam turbine, inadmissible final degree of steam dryness will be obtained at the end of expansion

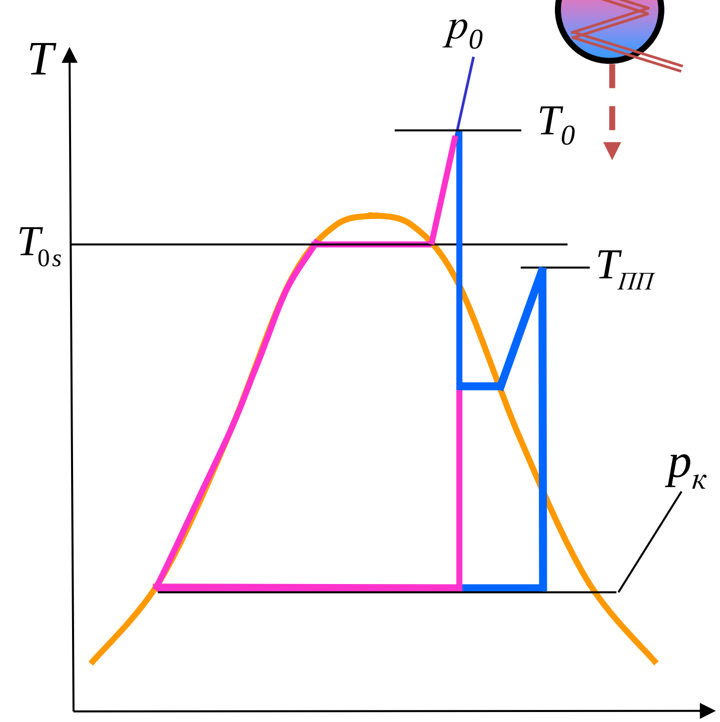
SR is steam reheater.

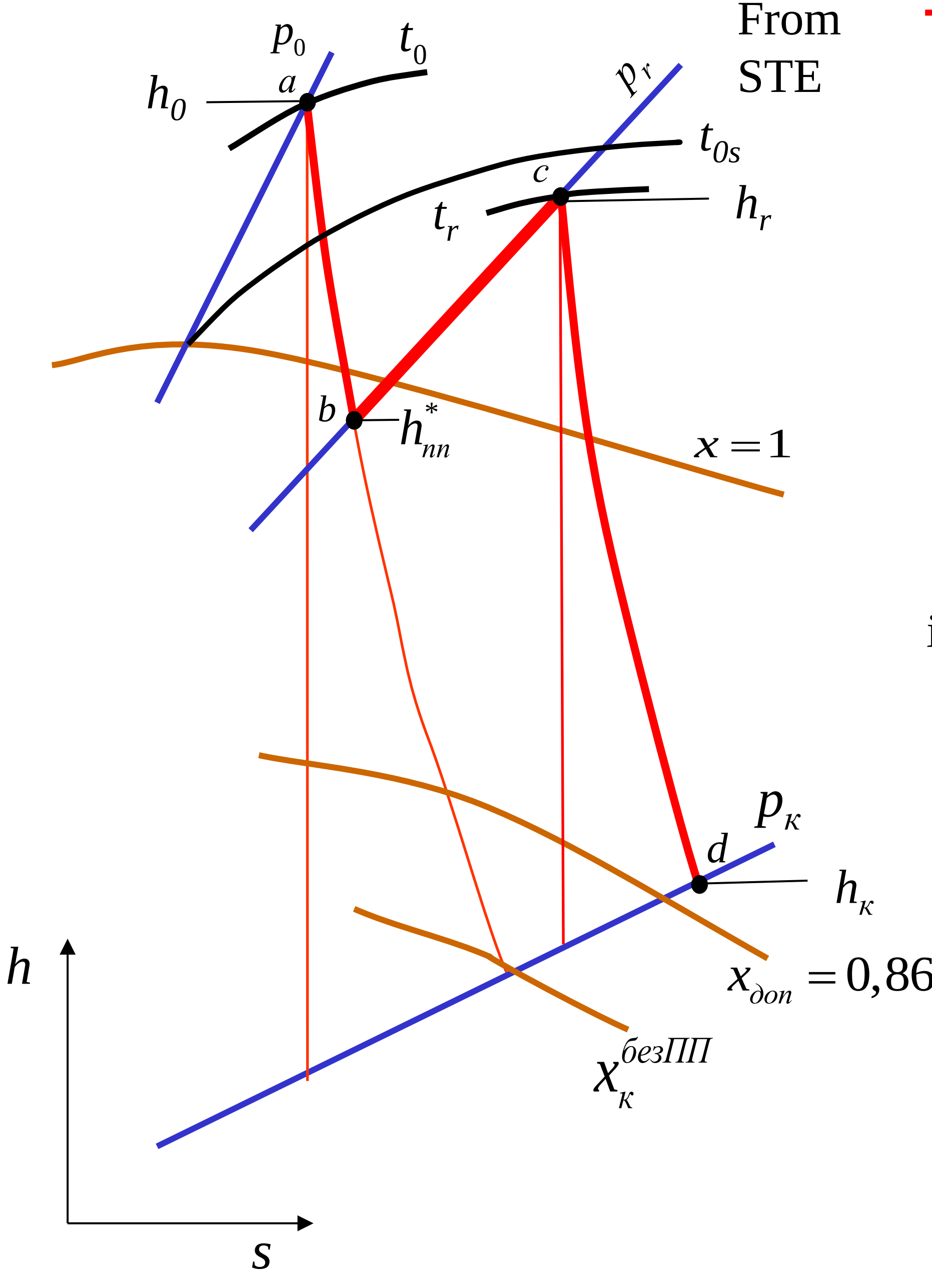


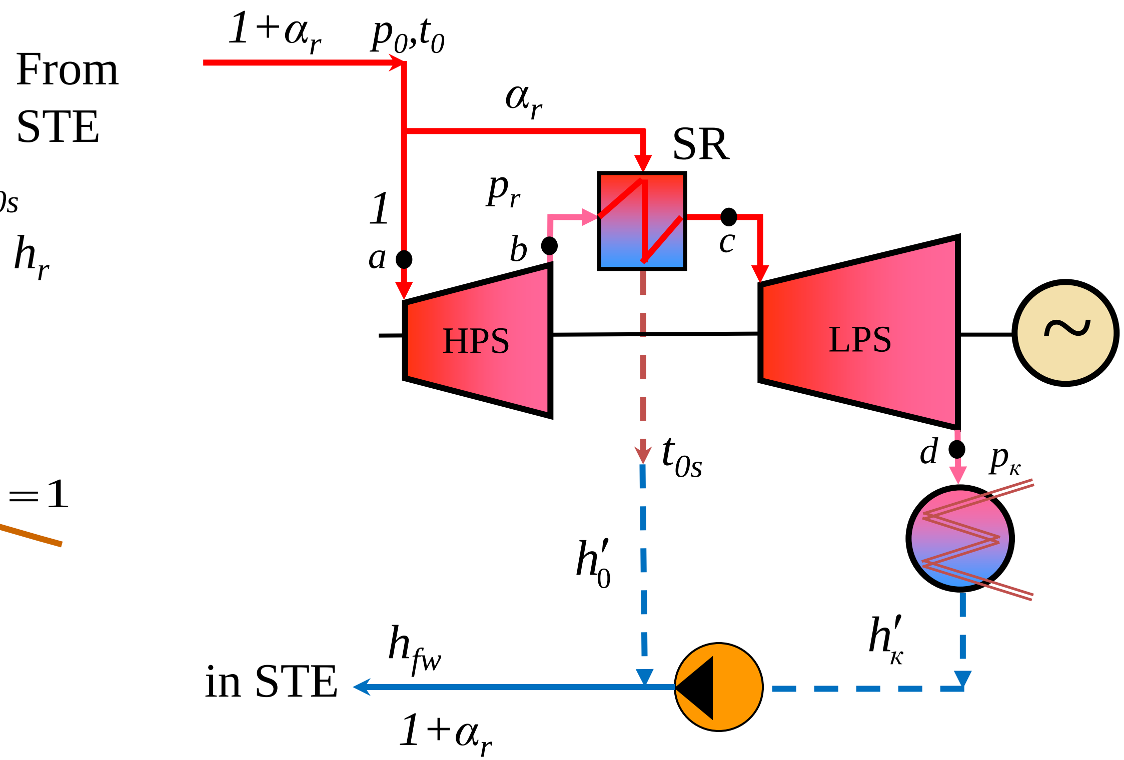
t_{0s} is saturation temperature at initial pressure

Δt_r is heated steam subcooling, its temperature is below the saturation point.









$$H_i = (h_0 - h^*_{пп}) + (h_{пп} - h_к) = H_i^{ЧВД} + H_i^{ЧНД};$$

$$q_{ТУ} = (1+\alpha_{пп})(h_0 - h_{пв});$$

$$\alpha_{пп} = \frac{h_{пп} - h^*_{пп}}{h_0 - h'_0}; \qquad h_{пв} = \frac{h'_к + \alpha_{пп} h'_0}{1+\alpha_{пп}};$$

$$\eta_i = \frac{L_i}{q_{ТУ}} = \frac{(h_0 - h_к) + (h_{пп} - h^*_{пп})}{(1+\alpha_{пп})(h_0 - h_{пв})}.$$