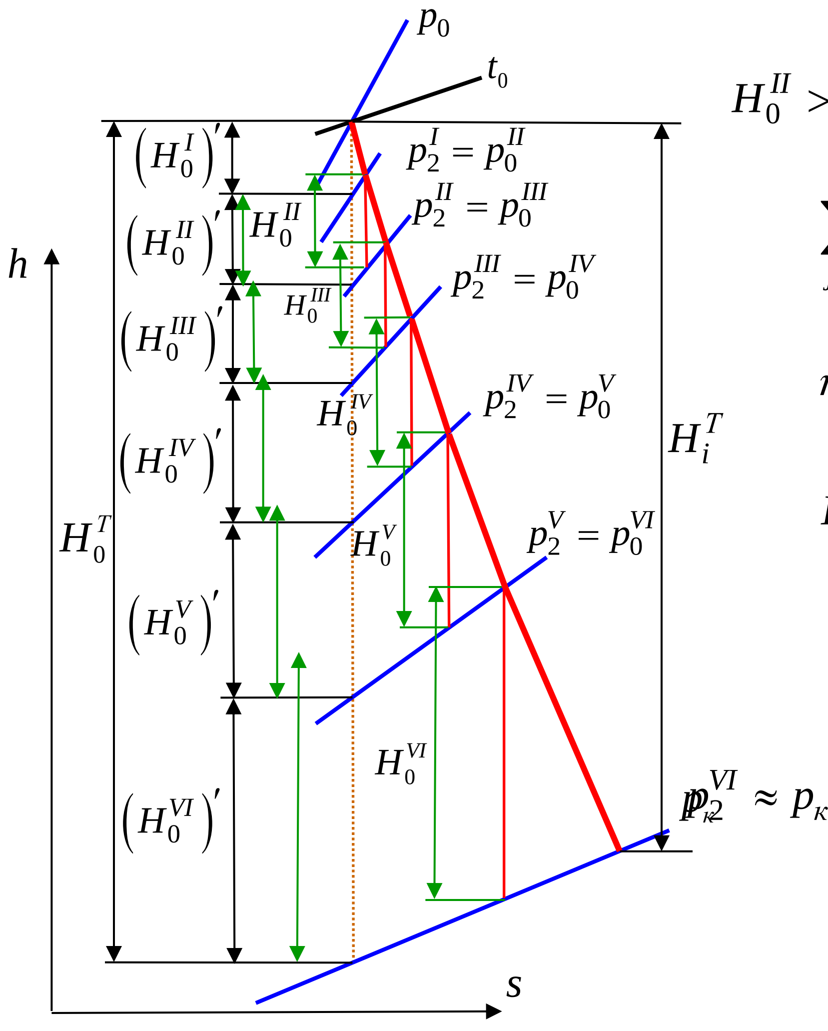
4.2. Reheat factor



$$H_0^{II} > \left(H_0^{II}\right)'; \quad H_0^{III} > \left(H_0^{III}\right)' \quad \dots \quad H_0^{IV} > \left(H_0^{IV}\right)'.$$

$$\sum_{j=1}^{z} H_0^j - H_0^T = Q$$

$$\eta_{oi}^T = \frac{H_i^T}{H_0^T} = \frac{\sum_{j=1}^{z} H_i^j}{H_0^T} = \frac{\sum_{j=1}^{z} H_0^j \eta_{oi}^j}{H_0^T};$$

$$H_i^j = H_0^j \eta_{oi}^j$$

Предположим: $\eta_{oi}^I = \eta_{oi}^{II} = \dots = \eta_{oi}^z = \eta_{oi}^{cm}$

$$\eta_{oi}^T = \frac{\eta_{oi}^{cm} \sum_{j=1}^{z} H_0^j}{H_0^T} = \eta_{oi}^{cm} \frac{H_0^T + Q}{H_0^T}$$

$$q_t = \frac{Q}{H_0^T}$$ - reheat factor

$$\boxed{\eta_{oi}^T = \eta_{oi}^{cm}\left(1 + q_t\right)}$$

For practical calculations, formula for determining the reheat factor is commonly used:

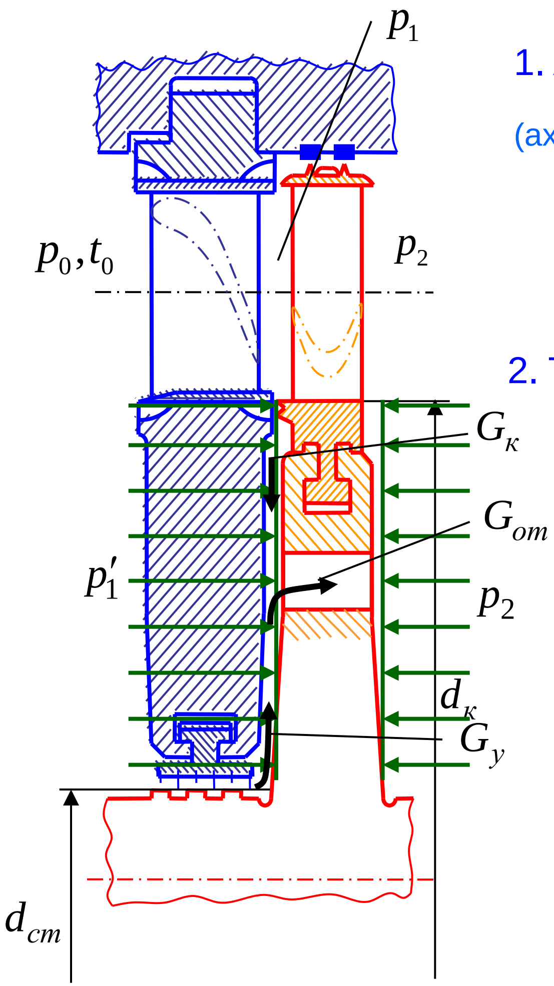
$$q_t = k_t \left(1 - \eta_{oi}\right) H_0^T \frac{z-1}{z}$$

for superheated steam: $k_t = 4{,}8 \times 10^{-4}$

For wet steam: $k_t = 2{,}8 \times 10^{-4}$

4.1.3. Axial thrust on the turbine rotor

A. Axial thrust imposed on the turbine rotor within one stage



1. Axial thrust imposed on rotor

(axial component of the steam force in rotor blades)

$$R_a^I = G(c_1 \sin\alpha_1 - c_2 \sin\alpha_2) + (p_1 - p_2)\Omega$$

$\Omega = \pi d l_2$ - area swept by rotor blades

2. Thrust imposed on the disc ring:

$$R_a^{II} = (p_1' - p_2)\frac{\pi}{4}(d_к^2 - d_{ст}^2)$$

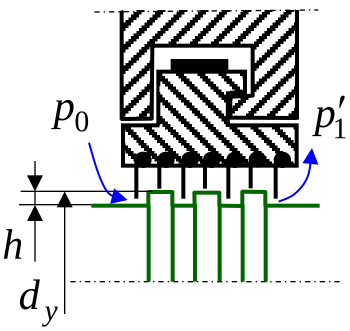
$$(p_1' - p_2) = k(p_1 - p_2)$$

a) No steam balance holes: $p_1' = p_1$

b) Presence of steam balance holes: $k \approx 0,5$

$$G_{от} = \pm G_к + G_y$$

3. Thrust imposed on the stepped seal protrusions



$$R_a^{III} = \frac{1}{2}\left(p_0 - p'_1\right)\pi d_{cm} h$$

The overall axial thrust imposed on the rotor within the j-th stage:

$$R_a^j = \sum_{i=1}^{n} R_a^i$$

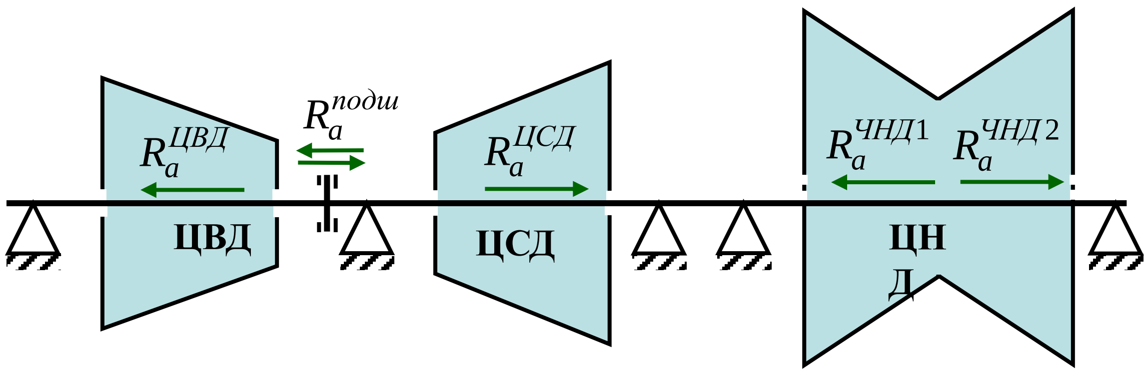
i – number of the axial thrust component

Direction of axial thrust is (mostly) towards the steam flow motion

B. Techniques for balancing the axial thrust

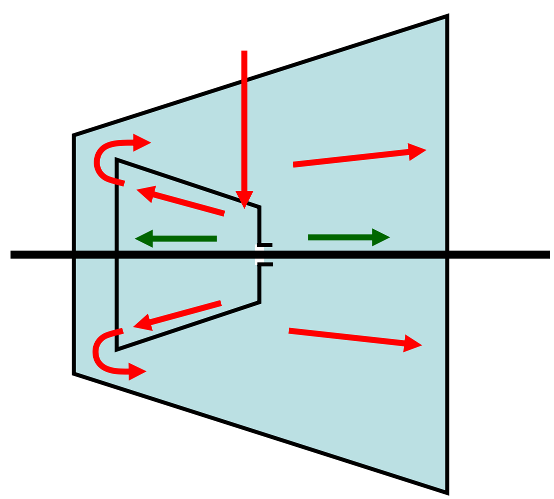
Axial thrust is absorbed by ***thrust bearing***

1. Counter-flow through individual sections of steam turbines:



$$R_a^{подш} = R_a^{ЦВД} - R_a^{ЦСД}$$

2. The loop flow of steam in the cylinder with inner casing:

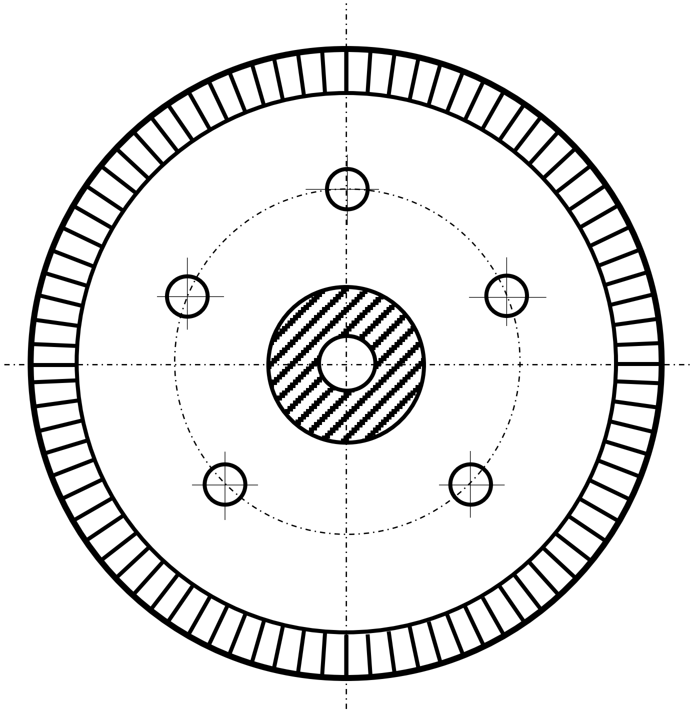


1. Reduction of the axial thrust HPC rotor

2. Reduction of steam leakage through the front end seal

3. Reduction of pressure and temperature acting on the outer housing

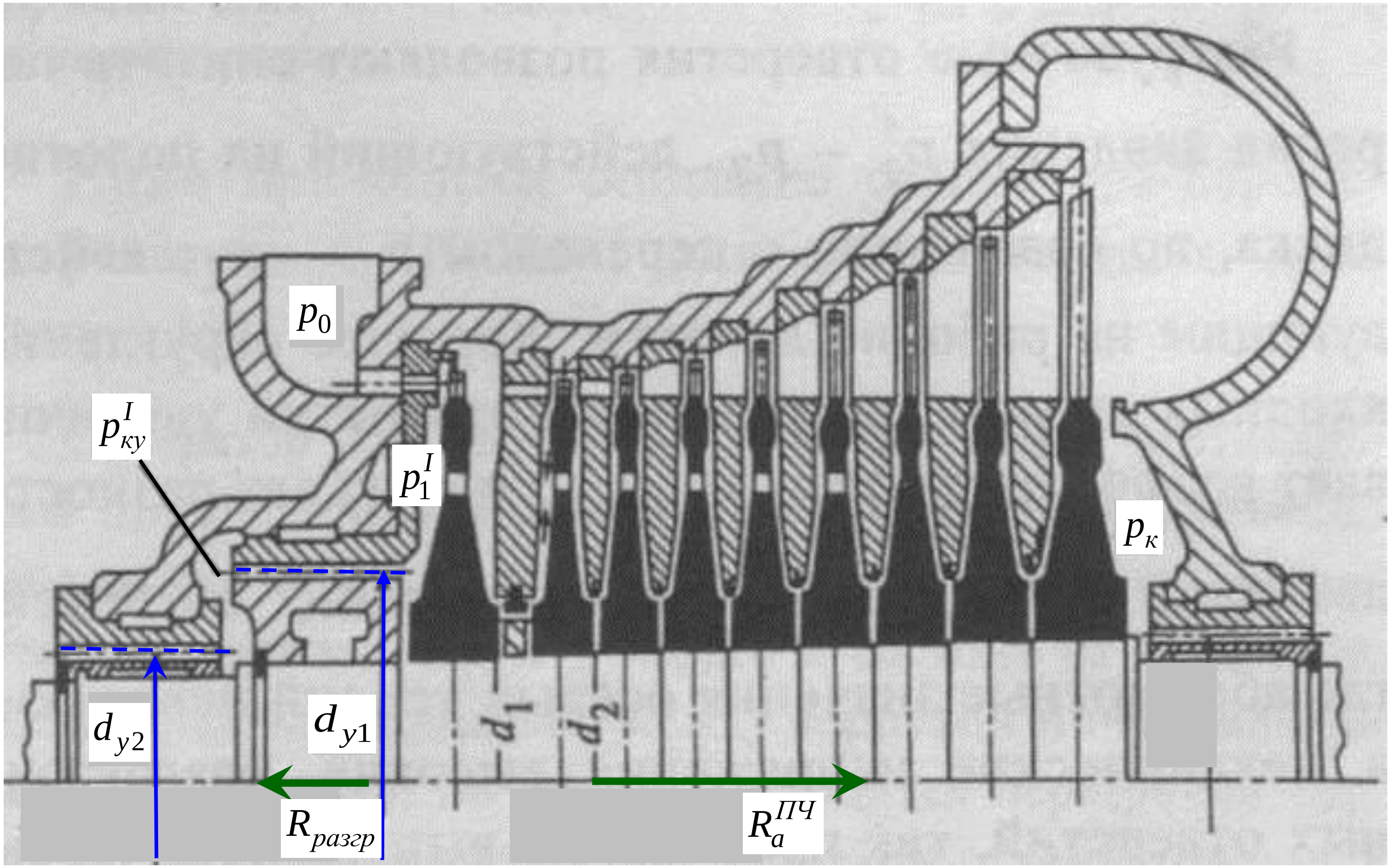
3. Implementation of steam balance holes



The reaction of steam balance holes may be up to $\rho_{cp} \approx 0,25$

Why?

4. Implementation of balancing drum (dummy chamber)



$$R_{разгр} = \frac{\pi\left(d_{у1}^2 - d_{у2}^2\right)}{4}\left(p_1^I - p_{ку}^I\right)$$

5.3. Decision on the number of stages and distribution of heat drops for turbine stages

Basic requirements to be performed:

High efficiency, which can be ensured through the following conditions:

- dimensionless ratio of the velocities at all stages should be close to the optimal one:

$$\left(\frac{u}{c_{\phi}}\right)^{opt} = \frac{\varphi \cos \alpha_1}{2\sqrt{1-\rho}}$$

- the height of the blades must be above the minimum permissible height

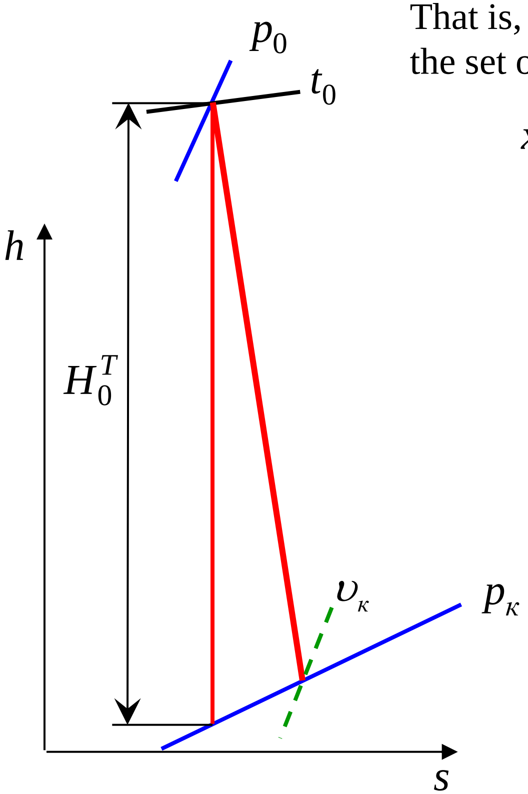
$$l_1 = \frac{F_1}{\pi d_{cp} \sin \alpha_1} = \frac{G \upsilon_{1t}}{\pi d_{cp} c_{1t} \mu_c \sin \alpha_1}; \qquad l_2 = \frac{F_2}{\pi d_{cp} \sin \beta_2} = \frac{G \upsilon_{2t}}{\pi d_{cp} w_{2t} \mu_p \sin \beta_2};$$

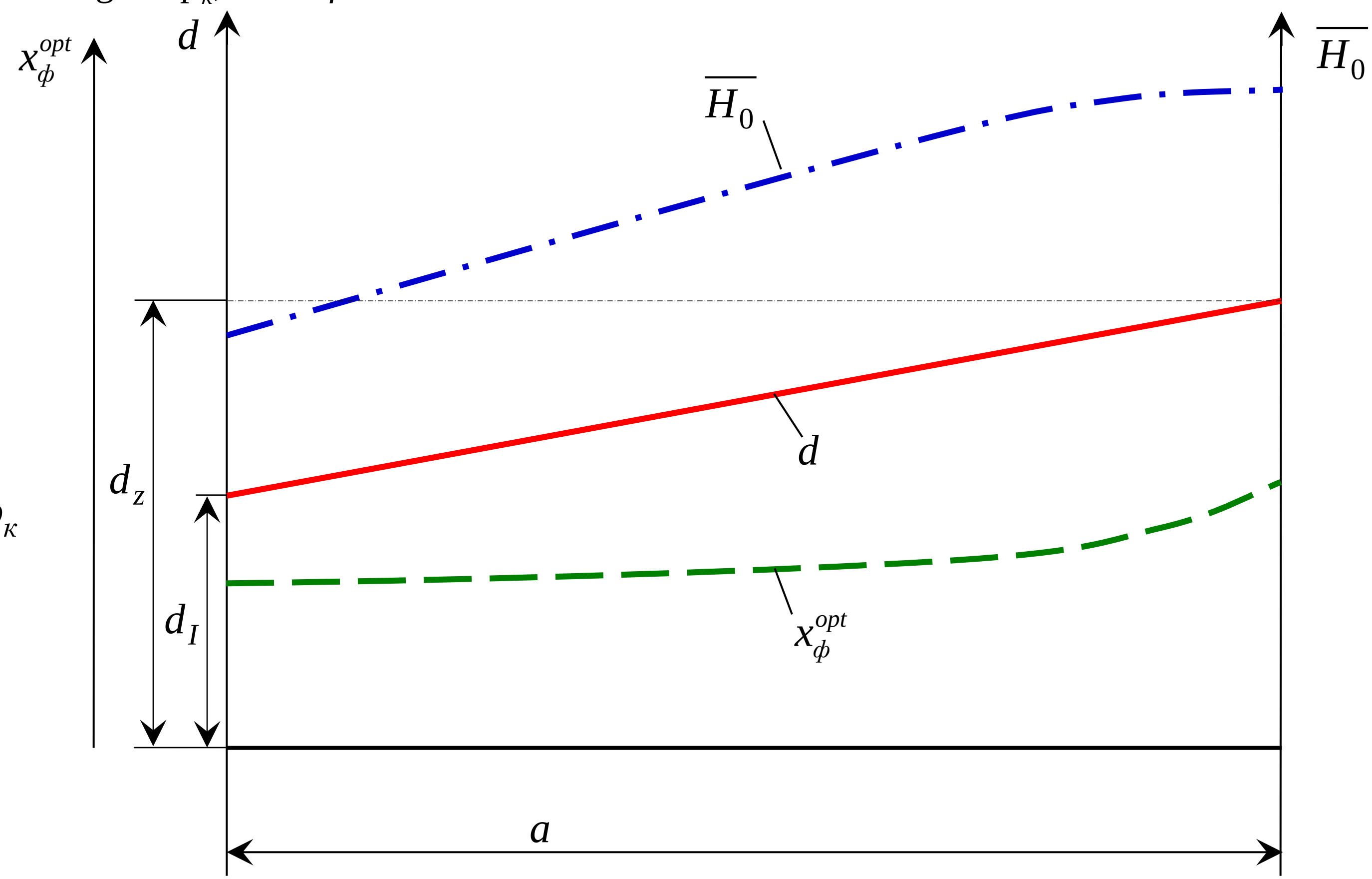
- smooth opening of the turbine wheel space in the meridional plane (this allows you to make full use of the loss with the exhaust velocity of the previous stage in the next stage)

Securing high reliability

The problem is solved for a set of stages !

That is, the data to be known: initial parameters before the set of stages - p_0, t_0; pressure after the set of stages – $p_к$; *steam flow in the section.*





$$\overline{H}_0^{\,opt} = \frac{\pi^2 d^2 n^2}{2000\left(x_ф^{opt}\right)^2};$$

0. Choose an arbitrary interval a on the x-axis

1. Accept (select, set, etc.) d_1 and d_z.

Plot a line indicating the change in stage diameters

2. Plot a line indicating the change in the optimal ratio of velocities

$$x_ф^{opt} = f(\rho) \implies d \uparrow \Rightarrow \rho_{cp} \uparrow \Rightarrow x_ф^{opt} \uparrow$$

The only creative process in designing the wheel space of the turbine турбины.

3. Determine the optimal heat drops and plot the line indicating the changes $\overline{H}_0$

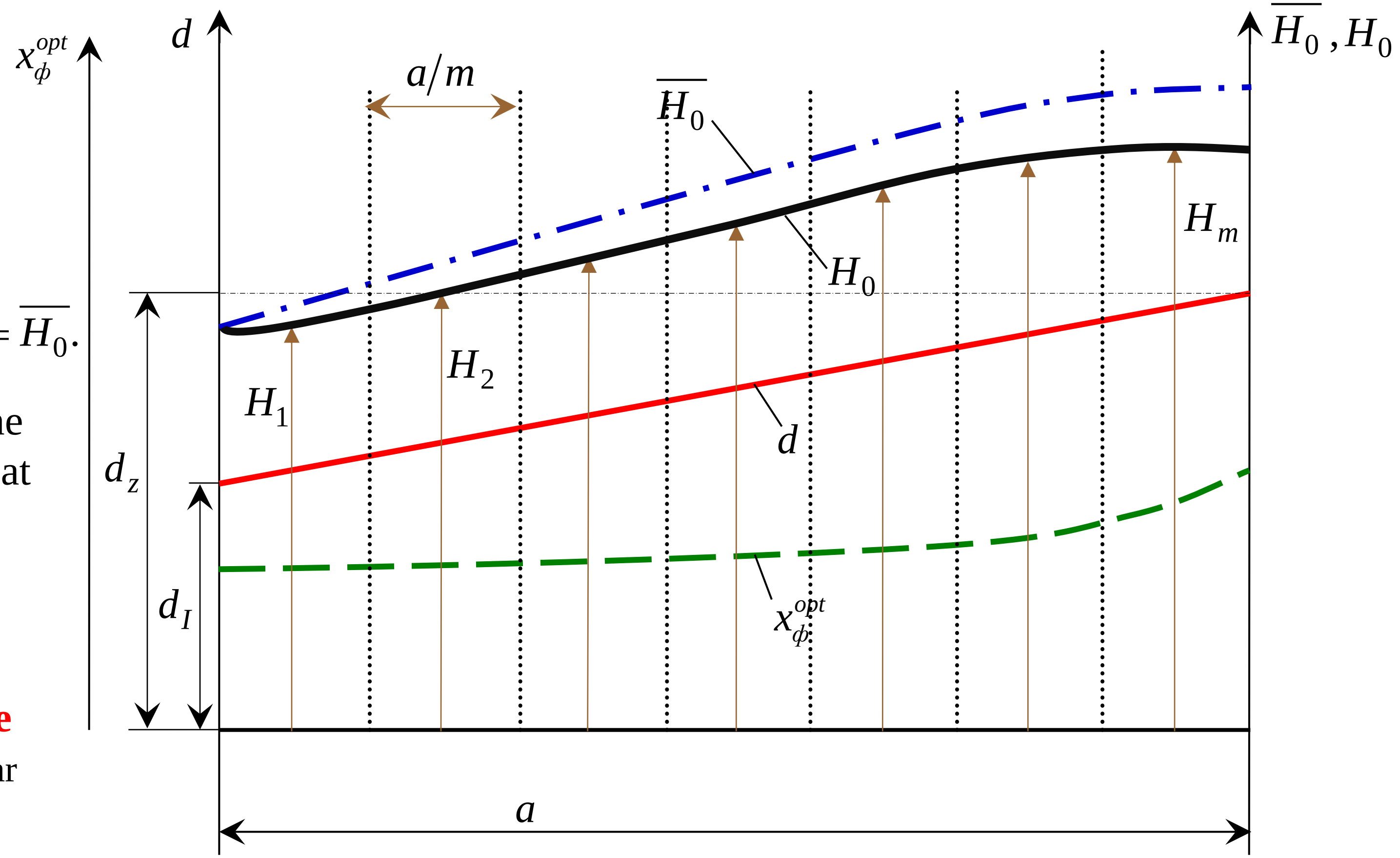
4. $\overline{H_{0j}} = H_{0j} + \frac{c_{0j}^2}{2};$

$H_0 = (0{,}92 \div 0{,}96)\overline{H_0}$

For the 1-st stage

$\chi = 0; \Rightarrow \frac{c_{01}^2}{2} = 0; \Rightarrow H_{01} = \overline{H_0}.$

Plot the dependence for the change in the available heat drop in static parameters



5. **Determine the average available heat drop** (linear dependence).

Divide the interval ***a*** into arbitrary number **m** of segments ***m***=(6÷8).

$$H_0^{cp} = \frac{\sum_{j=1}^{m} H_j}{m}$$

6. Determine the number of stages:

$$z = \frac{H_0^T(1+q_t)}{H_0^{cp}}$$

z – round up to the nearest whole by arithmetic rounding rules