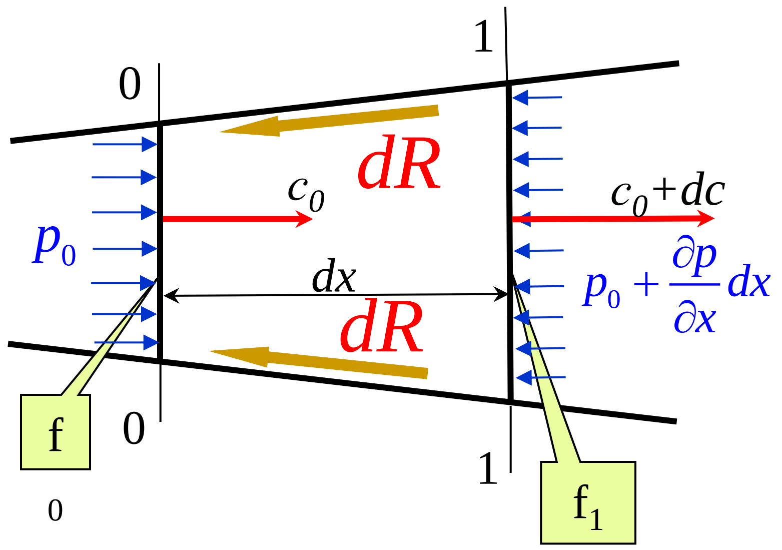


$$f_0 p_0 - f_1\left(p_0 + \frac{\partial p}{\partial x}dx\right) - dR = dm\frac{dc}{d\tau}$$

with $dx \to 0: \quad f_0 \to f_1 \to f$

$$-f\frac{\partial p}{\partial x}dx - dR = dm\frac{dc}{d\tau} \quad \Big| : dm = \frac{fdx}{\upsilon}$$

$$-\upsilon\frac{\partial p}{\partial x} - R = \frac{dc}{d\tau}$$

wh er $R = \frac{dR}{dm}$ is resistance force per 1 kg of flowing gas.

For steady state mode $\frac{\partial p}{\partial x} = \frac{dp}{dx}$

$$-\upsilon dp - Rdx = \frac{dx}{d\tau}dc \xrightarrow{\frac{dx}{d\tau}=c} \boxed{cdc = -\upsilon dp - Rdx}$$

The equation of the change in the amount of flow in unidirectional flow

Integrating from 0-0 to 1-1

$$\frac{c_1^2 - c_0^2}{2} = \int_{p_1}^{p_0}\upsilon dp - \int_{x_0}^{x_1} Rdx$$

$$\frac{c_1^2 - c_0^2}{2} = \int_{p_1}^{p_0} \upsilon dp - \int_{x_0}^{x_1} R dx$$

* Theoretical expansion

$$R(x) = 0$$

$$\frac{c_{1t}^2 - c_0^2}{2} = \int_{p_1}^{p_0} \upsilon dp \qquad \int_{p_1}^{p_0} \upsilon dp = l_{мехн} = h_0 - h_{1t}$$

$$\frac{c_{1t}^2 - c_0^2}{2} = h_0 - h_{1t}$$

** Real expansion

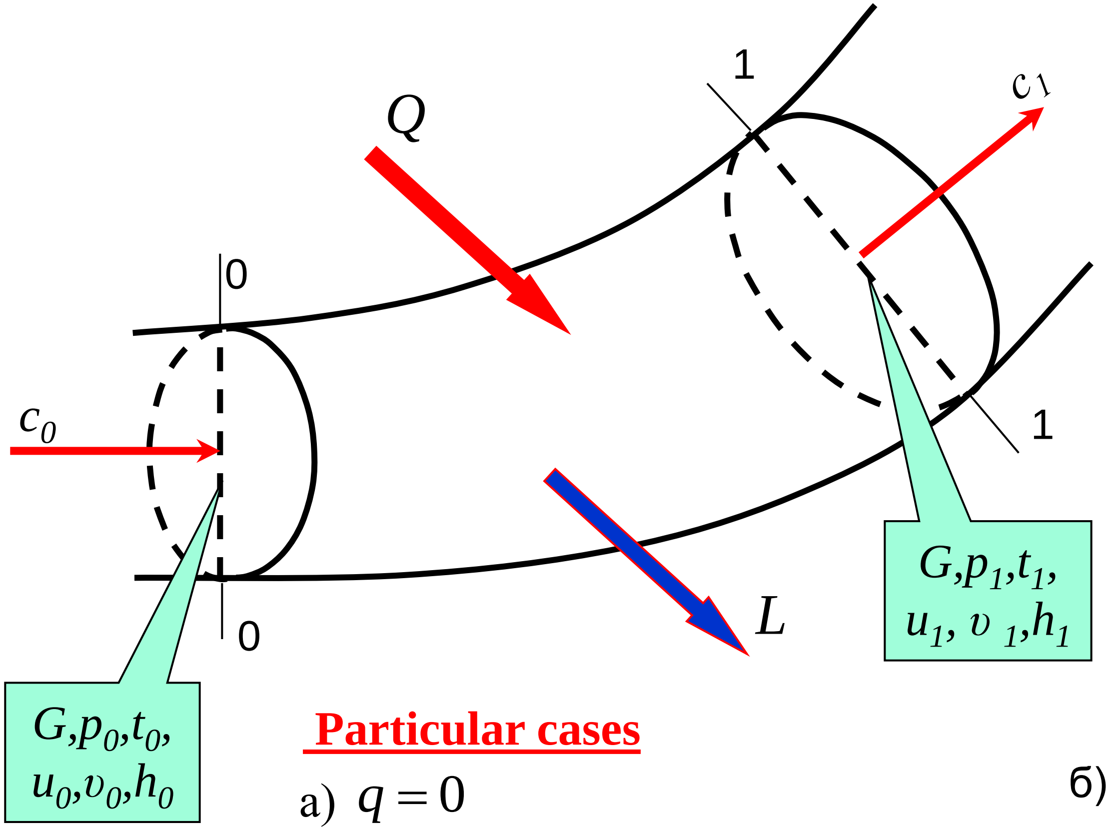
$R = f(x)$ It is known that $R = f(\Delta,\ \mathrm{Re} = \varphi(c, \nu, d),$ channel curvature, …)

in particular, the possibility of separation of the boundary layer under diffuse flow

In the turbine theory, the momentum equation for the flow in the channel in case of actual flow is replaced with the experimental data.

2.1.4. Energy-conservation equation

(for the flow)



Supplied energy

$$\frac{Gc_0^2}{2} + Gh_0 + Q$$

Withdrawn energy

$$\frac{Gc_1^2}{2} + Gh_1 + L$$

$$\frac{c_0^2}{2} + h_0 + q = \frac{c_1^2}{2} + h_1 + l$$

Particular cases

а) $q = 0$

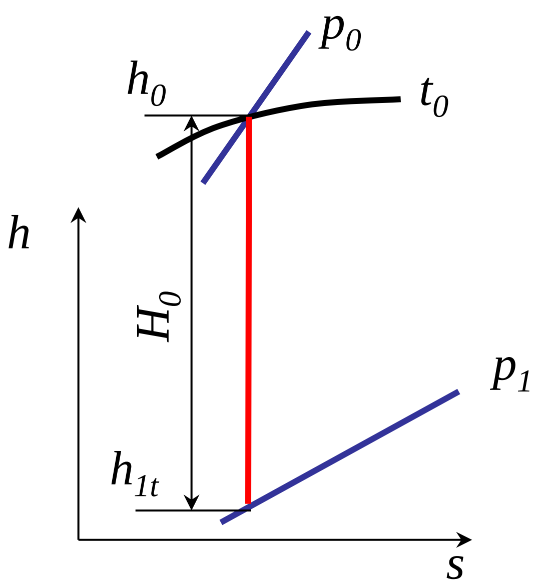
$$\frac{c_0^2}{2} + h_0 = \frac{c_1^2}{2} + h_1 + l$$

б) $q = 0, l = 0$

$$\frac{c_0^2}{2} + h_0 = \frac{c_1^2}{2} + h_1$$

p_0, t_0, p_1 are set. Determine the velocity at the channel outlet when $q = 0, l = 0$

* Theoretical expansion



$$\frac{c_0^2}{2} + h_0 = \frac{c_{1t}^2}{2} + h_{1t} \qquad \frac{c_{1t}^2 - c_0^2}{2} = h_0 - h_{1t}$$

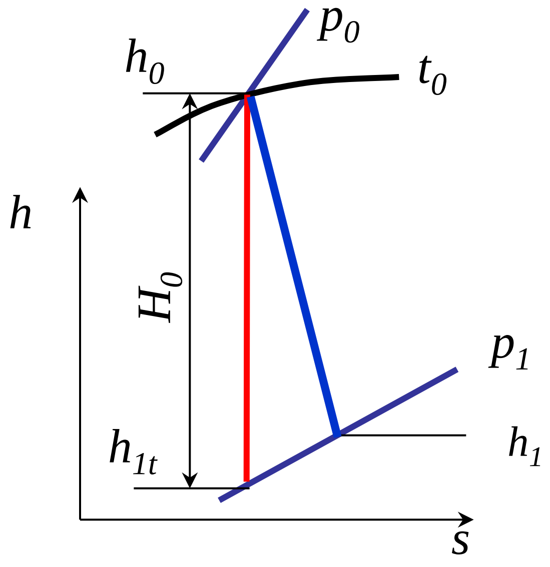
$$c_{1t} = \sqrt{2(h_0 - h_{1t}) + c_0^2}$$ ⟵ h в Дж/кг

If h in kJ/kg ⟶ $c_{1t} = \sqrt{2000(h_0 - h_{1t}) + c_0^2}$

$$c_{1t} = 44,7\sqrt{(h_0 - h_{1t}) + \frac{c_0^2}{2000}}$$

$H_0 = h_0 - h_{1t}$ is available heat drop per channel

** Real expansion



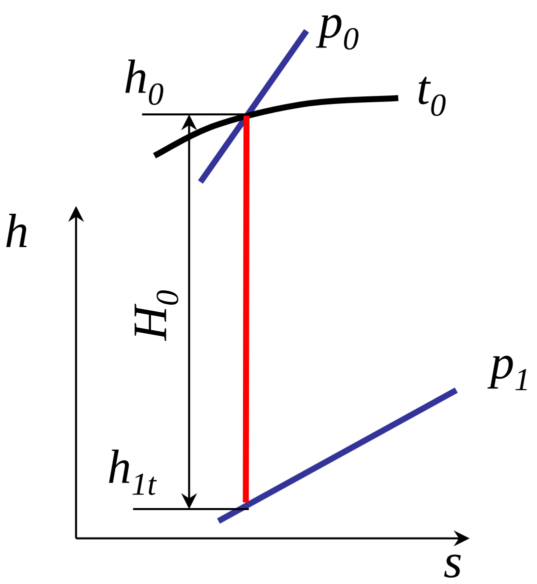
$$\frac{c_0^2}{2} + h_0 = \frac{c_1^2}{2} + h_1$$

$$c_1 = 44,7\sqrt{(h_0 - h_1) + \frac{c_0^2}{2000}}$$

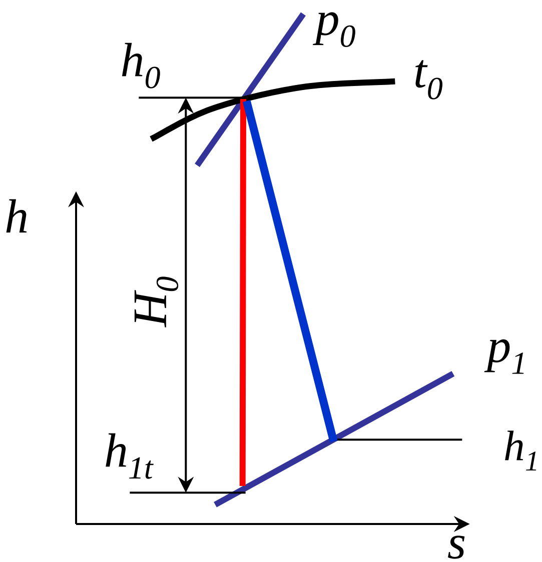
$H_i = h_0 - h_1$ is real heat drop per channel

Comparison of application of the equation of momentum and energy conservation equation

Theoretical expansion



Real expansion



The equation of the amount of motion

$$\frac{c_{1t}^2 - c_0^2}{2} = h_0 - h_{1t}$$

$$c_{1t} = \sqrt{2\left(h_0 - h_{1t}\right) + c_0^2}$$

$$\frac{c_1^2 - c_0^2}{2} = \int_{p_1}^{p_0} \upsilon dp - \int_{x_0}^{x_1} R dx$$

It is necessary to know the thermodynamic process along the channel

Energy conservation equation

$$\frac{c_{1t}^2 - c_0^2}{2} = h_0 - h_{1t}$$

$$c_{1t} = \sqrt{2\left(h_0 - h_{1t}\right) + c_0^2}$$

$$\frac{c_1^2 - c_0^2}{2} = h_0 - h_1$$

$$c_1 = \sqrt{2\left(h_0 - h_1\right) + c_0^2}$$

It is necessary to know the initial and final state

*** Flow acceleration

$$\frac{c_1^2 - c_0^2}{2} = h_0 - h_1$$

If $h_1 < h_0$, $c_1 > c_0$ the flow accelerates (convergent low)

If $h_1 > h_0$, $c_1 < c_0$ the flow decelerates (divergent flow)

2.2. The flow characteristics during isentropic expansion of gas in the channels

The channel, in which the flow smoothly accelerates, is called a **nozzle one** or a **nozzle**.

The channel, in which the flow smoothly slows down, is called a **diffusion one** or a **diffuser.**