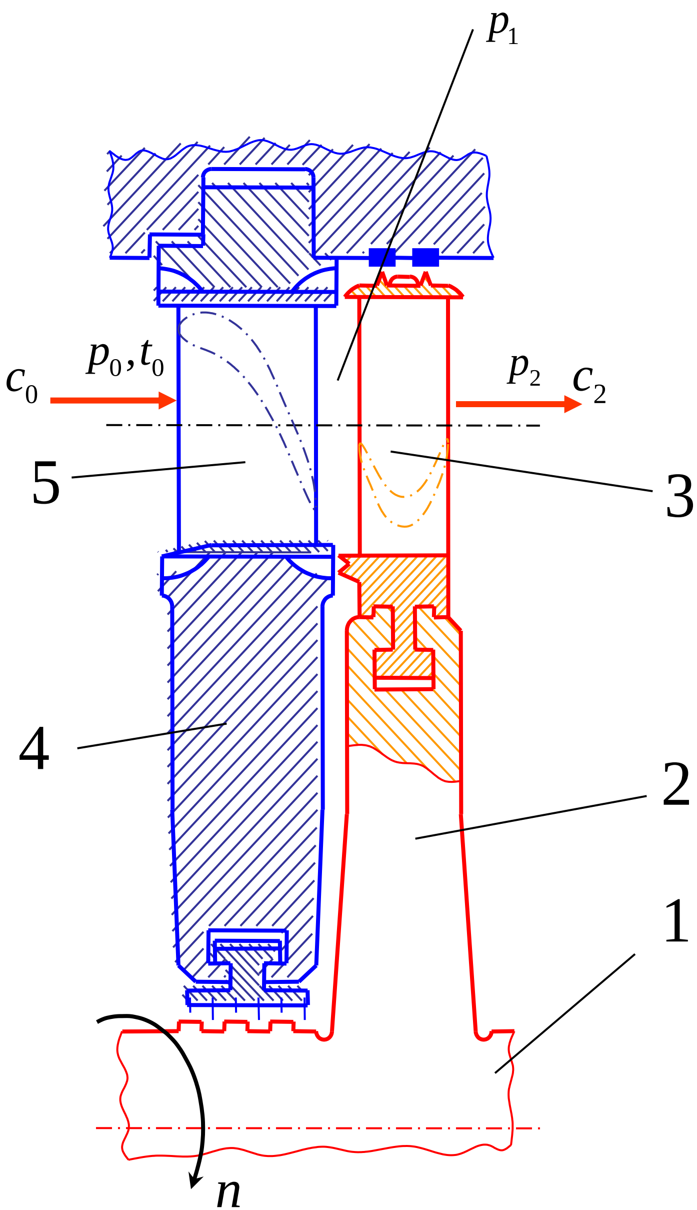
3. Energy conversion in the turbine stage (TS)

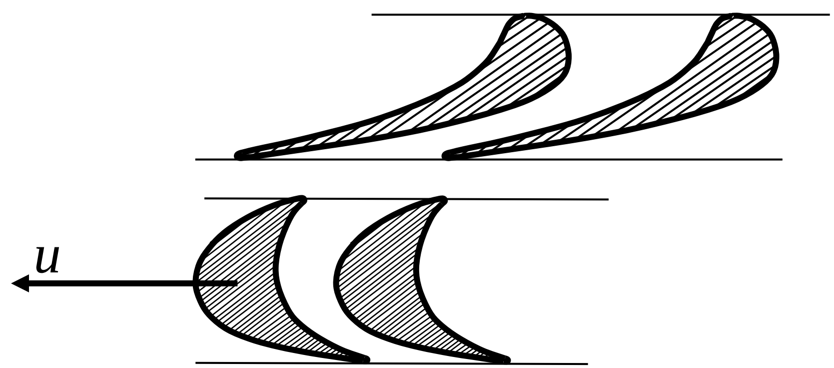
The TS design, depending on the direction of gas flow relative to the rotation axis, may be:

- Axial
- Chamber
    - Drum
- Radial
- Axial-radial



1. Turbine shaft
2. Disk
3. Rotor blade
4. Diaphragm
5. Turbine nozzle ring (the guide vane)

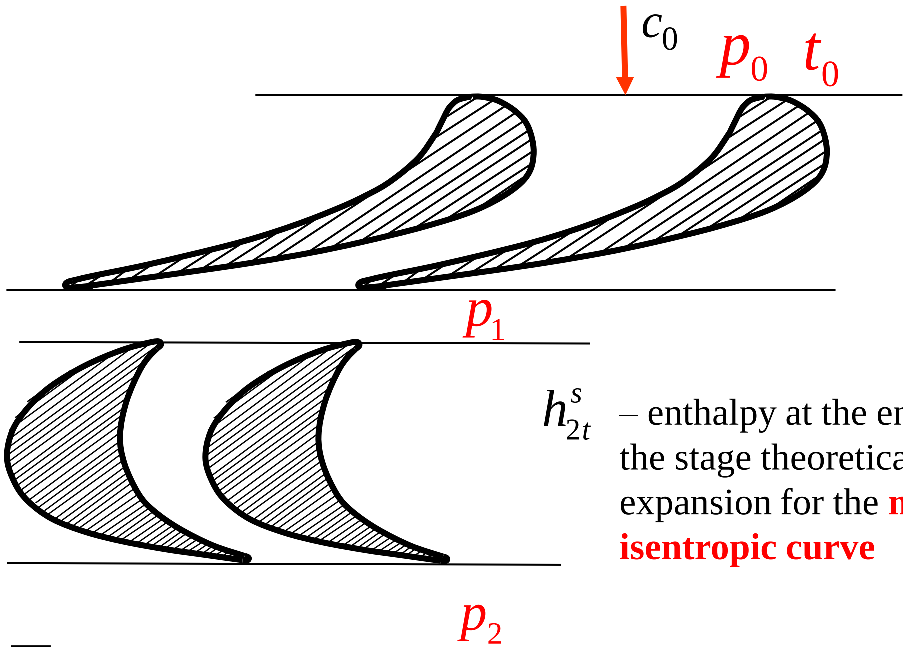
The guide vane and rotor blades – wheel space



$u = \pi d n$ – speed of the rotor blades of pitch diameter

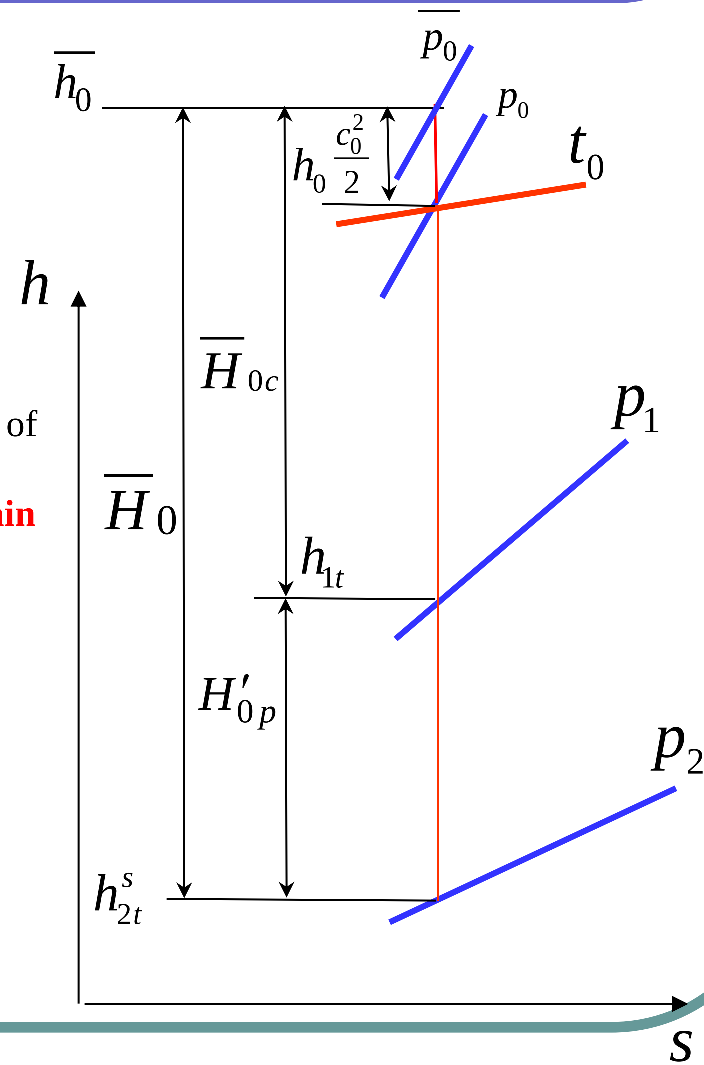
n – rotor speed

3.1. Degree of stage reaction



h_{2t}^{s} – enthalpy at the end of the stage theoretical expansion for the **main isentropic curve**

$\overline{H}_0$ – available energy



Degree of reaction (reactivity)

$$\rho = \frac{H'_{0p}}{\overline{H}_{0c} + H_{0p}} = \frac{H'_{0p}}{\overline{H}_0}$$

Depending on the stage reaction, the stage types are as follows (*conventional division*):

ρ= 0.1÷0.3 – impulse stages

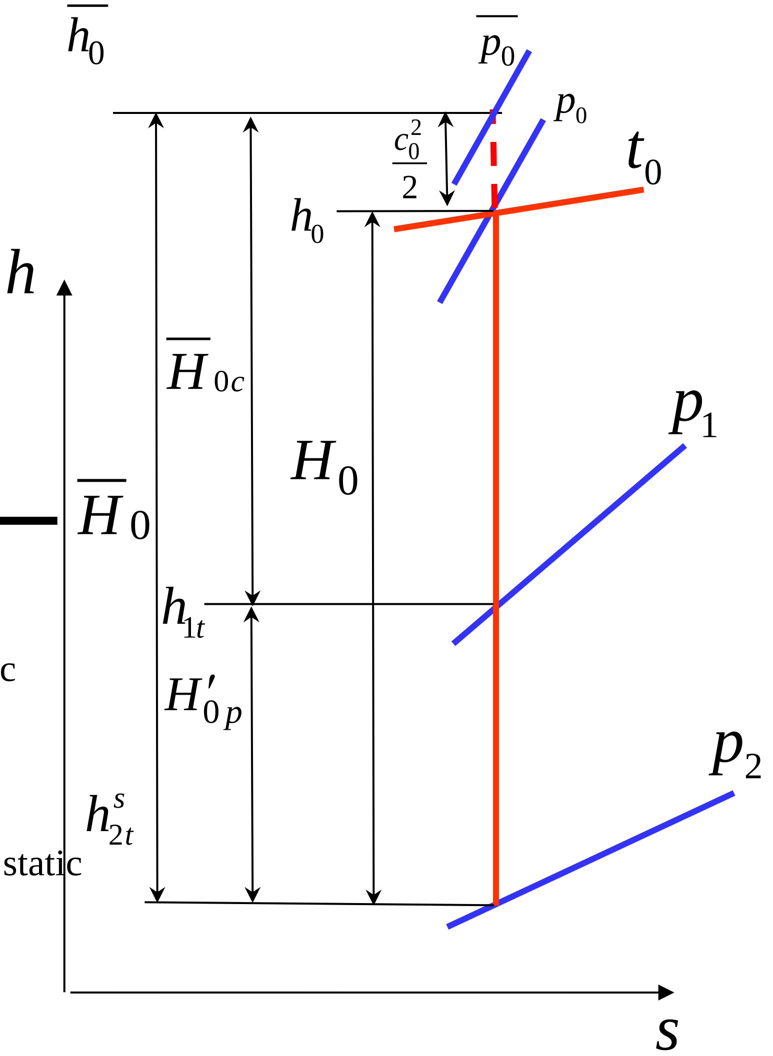
ρ= 0.4÷0.7 – reactive stages

For the theory of turbine stages, it is important to define the classification of stages:

1) ρ= 0 – purely impulse stage (*abstraction*)

2) ρ= 0.5 – reaction stage (*actual stages*)

3) ρ>0.



When calculating, the reactivity ρ is set.

Assume that p_0, t_0, c_0 and p_2 are set.

1) We determine the heat drop in the turbine stage based on the static parameters H_0.

2) We determine the static values.

3) We determine the stage available energy.

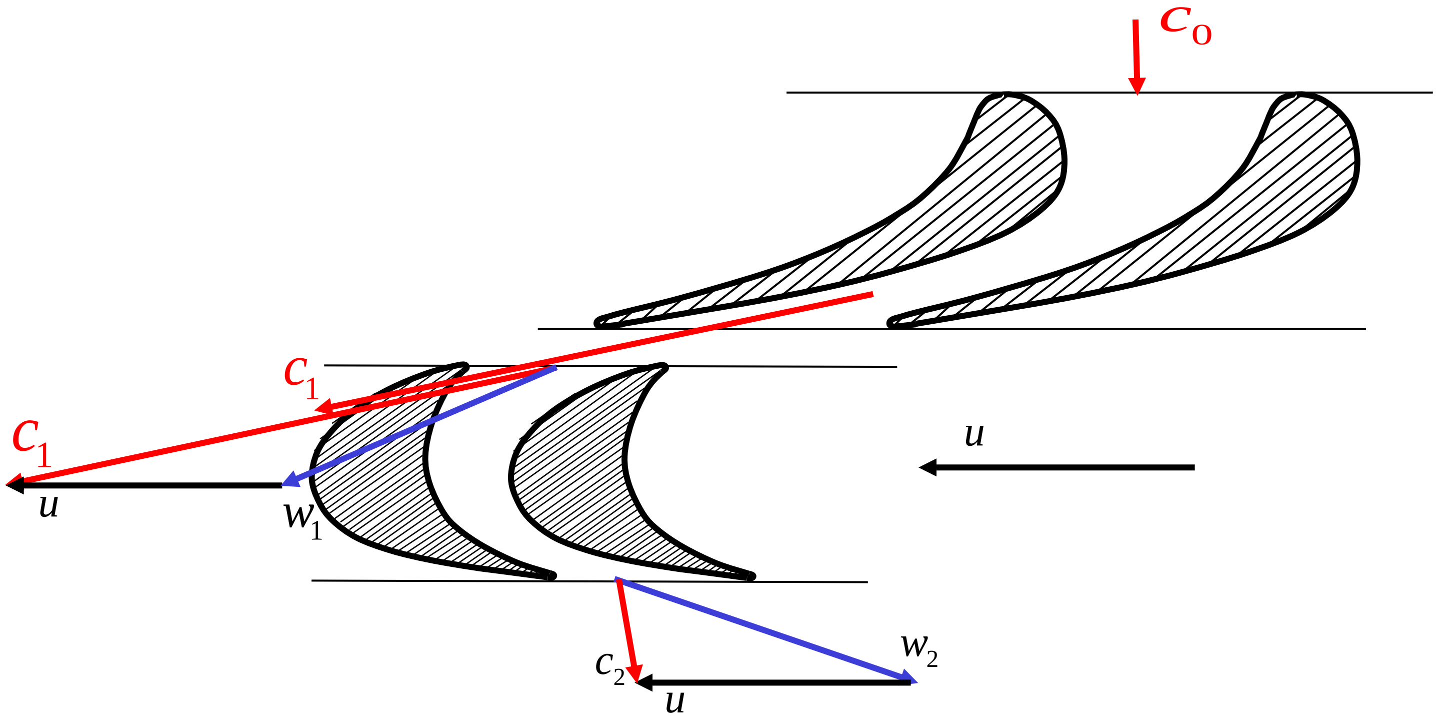
4) We determine the available heat drop in the nozzle ring based on static values:

$$\overline{H}_{0c} = (1-\rho)\overline{H}_0$$

4) We determine the pressure in the gap between the nozzle and rotor blades and the enthalpy at the end of theoretical expansion in nozzle blades.

4) We determine the available heat drop in the lattice in the static parameters and the main isentropic curve.

3.2. Stage velocity diagram

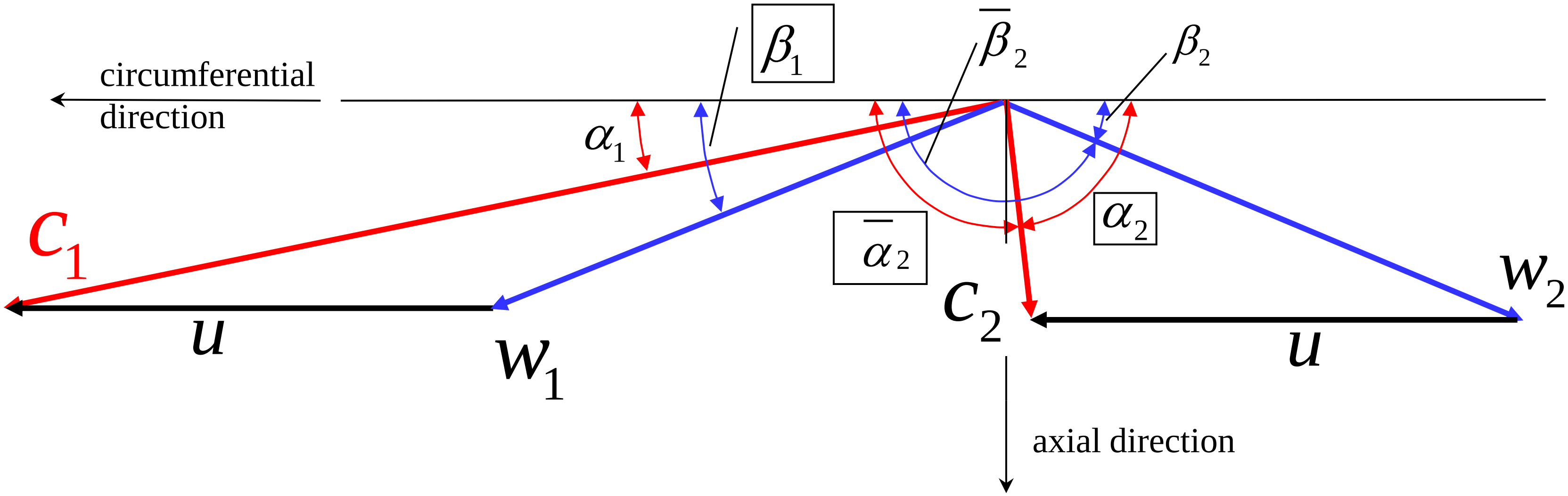


$c_1 = \varphi\sqrt{2\overline{H}_{0c}}$ - absolute velocity of gas flow at the inlet of rotor blades

w_1 - relative velocity of gas flow at the inlet of rotor blades

w_2 - relative velocity of gas flow at the outlet of rotor blades

c_2 - absolute velocity of gas flow at the outlet of rotor blades



$$\beta_2 = \pi - \bar{\beta}_2$$

$$\bar{\alpha}_2 = \pi - \alpha_2$$

<u>Questions to be answered later on</u>

1. How is angle $\boldsymbol{\alpha_1}$ chosen**?**

2. What determines angle $\boldsymbol{\beta_2}$**?**

3.3. Thrust affecting rotor blades

A. Thrust generation mechanism

- Real component (due to gas flow turn)

- Reactive component (due to flow acceleration)

Consequences:

$\rho = 0$ (pure reaction stage) → No acceleration (convergence is equal to 1).

$\beta_2 = \beta_1$

$\rho > 0$ → The flow across rotor blades is accelerated (convergence is greater than1).

$\beta_2 < \beta_1$

Conclusion: the angle chosen for the flow leaving rotor blades depends on stage reactivity