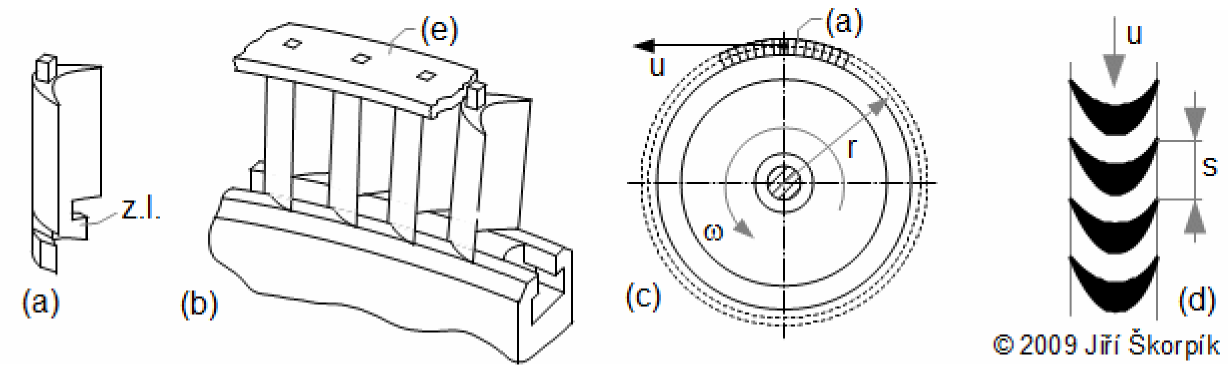
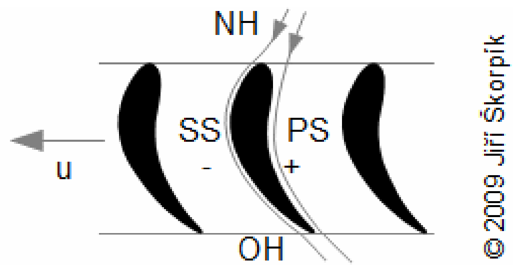


19.194 *The blade and the blade row (the Laval turbine).*
(a) blade; **(b)** blade passages are formed by blades; **(c)** turbine rotor with blades; **(d)** cylindrical sectional view through blade passages at radius *r* (**profile row**); **(e)** shroud (may not always be); **z.l.** root of blade. **u** [m·s^{-1}] circumference velocity at radius *r*; **s** [m] **pitch of blade row**; **r** [m] mean radius of blade length.



20.195 *The basic terminology of the blade.*
NH leading edge; **OH** trailing edge; **SS** suction side; **PS** pressure side.

Internal power output/input of turbomachine

The significant parameter of the turbomachine is its internal power output/input[2]. The internal power output is power of the working fluid flowing through the turbomachine:

$$P_i = a_i \cdot \dot{m}$$

21.289 *The power output/input of the turbomachine.*
$\mathbf{P_i}$ **[W]** power output/input is transfered power between working fluid and rotor inside turbomachine; $\mathbf{a_i}$ [J·kg^{-1}] specific **internal work** of turbomachine (transfered energy between working fluid and rotor); $\mathbf{m^\bullet}$ [kg·s^{-1}] mass flow rate through turbomachine. If working fluid consumes work (working machine), then a_i and P_i inside turbomachine be negative, but this sign "negative" is not usually used and is used term "power input".

[2]*Remark*
The internal power is not the indicated shaft power, it is also influenced by mechanical losses. The relation between the internal power and shaft power is descripted in the chapter 13. Power output/input of turboset.

The working fluid at flow through the turbomachine can produced/consumed to work, it can by heating or cooling (heat can be transmitted through walls of the turbomachine or heat produced inside the working fluid, for ex. a chemical reaction). It means that enthalpy, kinetic energy and potential energy of the working fluid can be change, beacause the equation of the First law of thermodynamics for open system is used for calculation a_i. This equation take into account all these forms of energy.

The equation for First law of thermodynamics for open system can be simplified with species of the working fluids and the type of the turbomachine. For example: for a case ideal liquid (hydraulic machine) can be derived this equation:

$$a_i = q + \frac{p_i}{\rho} + \frac{c_i^2}{2} - \frac{p_e}{\rho} - \frac{c_e^2}{2} + g\cdot(h_i - h_e) + (u_i - u_e) = \underbrace{\frac{p_i}{\rho} + \frac{c_i^2}{2} + g\cdot h_i}_{yi} - \underbrace{\left(\frac{p_e}{\rho} + \frac{c_e^2}{2} + g\cdot h_e\right)}_{ye} - z_{i-e}$$

$$y_i - y_e = \Delta y_{i-e}; \quad -z_{i-e} = q + (u_i - u_e)$$

22.543 *Specific work of the working fluid inside the hydraulic turbomachine.*
ρ [kg·m^{-3}] density of liquid; **g** [m·s^{-2}] gravitational acceleration; $\mathbf{y_{i,\,e}}$ **[J·kg^{-1}]** specific total energy of liquid at inlet and at exit[3]; $\mathbf{\Delta y_{i-e}}$ [J·kg^{-1}] change of specific total energy of working liquid between inlet and exit; $\mathbf{z_{i-e}}$ [J·kg^{-1}] specific internal losses of machine between inlet and exit; **u** [J·kg^{-1}] specific internal heat; **q** [J·kg^{-1}] specific heat of working fluid transmitted with surroundings; **h** [m] level of inlet / exit flange. The index **i** denotes the inlet, index **e** denotes the exit.

[3]*Remark*
Sum of specific pressure energy, specific kinetic energy and specific potential energy of the fluid is called specific **total energy of liquid** and it is usual marking of by letter *y*.

The equation First law of thermodynamics for open hydraulic system is called **Bernoulli equation** for incompressible flow.

The change of internal heat energy of the liquid is considered to be the loss for the hy. turbomachinery (reduced work of the liquid). The change of internal heat energy of the liquid arise during the flowing (the usable energy is transformed to the heat, which cannot use in the hy. turbomachine). External heat transfer inside the hy. turbomachine only increases the internal energy of liquid and does not affected to work machine.

In case of the heat machines can be simplify of the equation for First law of thermodynamics for open system to next form:

$$a_i = i_{c,i} - i_{c,e} + q$$

23.544 *The specific internal work of the heat turbomachine (the working fluid is the gas).*
Assumptions solving of this equation is: negligible influence of potential energy of working gas. More information about energy balance of heat turbomachines are shown in chapters 13. Energy balance of heat turbine and 13. Energy balance of turbocompressor.

The *Equations 22* and the *Equations 23* can be use for a simple calculation of basic parameters of the turbomachine:

20 t·h^{-1} of water is pumped from a lower tank to a higher tank through the rotodynamic pump. Pressure is *1 bar* in the lower tank, *40 bar* in the higher tank. The height difference of the levels *7 m*. What is approximate power input of the pump? The solution of this problem is shown in the Appendix 545.
Problem 1.545

Steam enters to the steam turbine at *36,6 bar* and *437 °C*. The exit pressure is *6,2 bar*. Find the specific internal work of this steam turbine. The solution of this problem is shown in the Appendix 546.
Problem 2.546