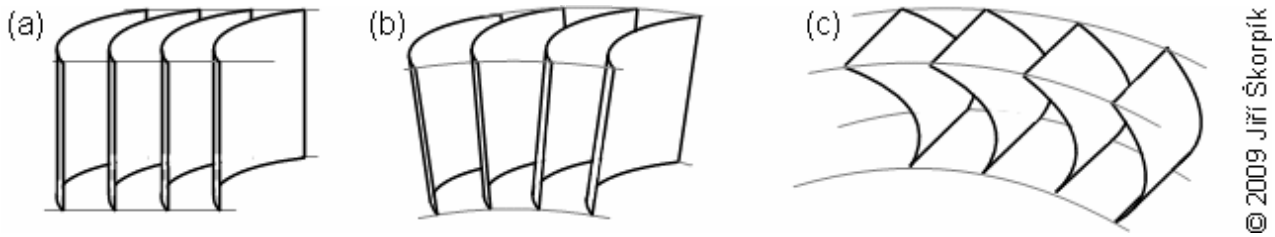
15. Shapes of parts and materials of turbomachines

Author: Jiří Škorpík, skorpik@fme.vutbr.cz

In previous articles of Turbomaschinery theme there are introduction any types of blades, blade rows and others passage (flanges, casings...), which are significant for a function of the turbomachine. A shape and a geometry of these parts are related with a type of the turbomachine, a kind of a working fluid and properties of flow (especially Reynolds number). Optimal shape of these parts and their placement inside the machine is influenced by their manufacturability, type of its fixation in the machine, their load (strength), their repairability etc. These factors influence the price of the turbomachine and its efficiency.

Fundamental terminology of blade rows

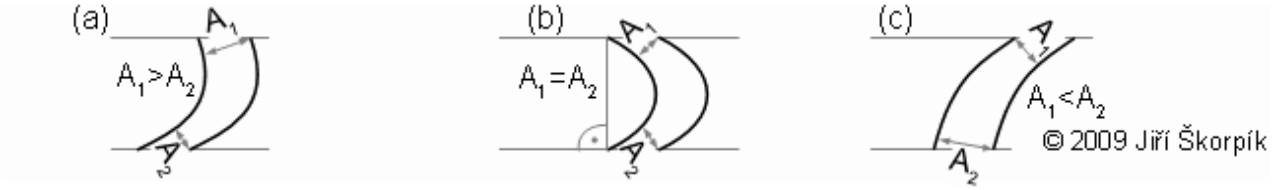
The blade rows can be classified through their shape and change of the working fluid velocity inside the blade row [1]:



1.291 *Main types of the blade rows.*
(a) line blade row (they are use in wind tunels for a measuring blade row, results with the measuring are applicated on other types of the blade rows.); **(b)** axial-ring blade row; **(c)** radial-ring blade row; (e.g. stator blade row of Kaplan turbine. The blades are drawn simplify such as if it were made of a thin sheet.

Besides these three main types of the blade rows there are diagonal blade rows which are used in a diagonal stages and axial-radial blade rows which are used in radial stages.

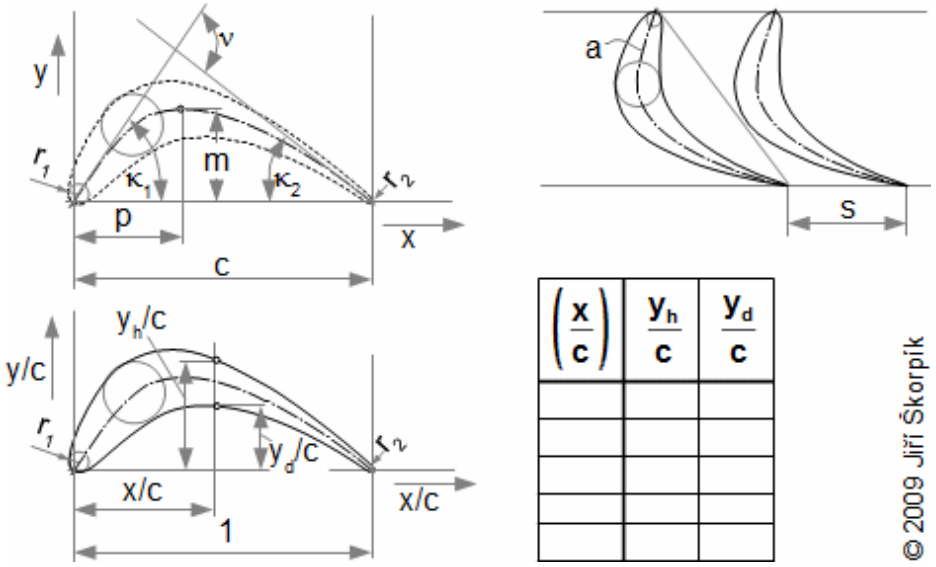
The blade inside the blade row can form three type flow passages:



2.312 *Schematic drawings of fundamental types of the blade passages.*
(a) convergent blade passage (turbine passage); **(b) impulse blade passage**; **(c) diffuser (divergent) blade passage** (compressor passage or for case on area A_1 is the critical flow area). **A** [m^2] a flow area in the section. The blades are drawn simplify such as if it were made of a thin sheet.

Shape of blade profile

The shape of a blade profile is function of a velocity triangle and an aerodynamic calculation which shows in article 16. Fundamentals of aerodynamic of blade profiles and blade rows. The shape of the blade profile must be defined through a suitable method on a manufacturing documentation. Currently is sufficient an electronic drawing (e.g. CAD systems through vector graphic), because machine-tools are able to work with these inputs directly. However there are others options as description of the shape of the blade profile. For example, coordinates of their shape be wrote in a table in the form *y; c* or through **the mean camber line** and the thickness of blade:



3.314 *The shape of blade profile and its description through its mean camber line.*
a mean camber line (plot center of circles between upper and lower surfaces of blade profile); $\mathbf{m=y_{max}}$ [m] maximum camber; **p** [m] position of maximum camber; $\boldsymbol{\kappa_1}$, $\boldsymbol{\kappa_2}$ [°] angles of mean camber line (on leading edge of profile and trailing edge of profile); $\boldsymbol{\nu}=\kappa_1+\kappa_2$ [°] camber; **c** [m] length of chord line; **s** [m] pitch; **r** [m] radius of profile edge. The shape of the mean camber line usually has a shape of the circle, parabolic or others geometric fundamentals curves (also it can be combination of two curves connected in the maximum camber point through together tangent [4, p. 123]). The terms and the signs of the blade profile geometry can be various. It depends on convention (by country, literature, by author etc.), therefore is necessary wrote this convention with the descriptions of the shape of the blade profile. Here are used the terms and the sings by [6, p. 572] that are usually used for the camber blade profiles or the camber airfoils.

The blade profile for a turbomachine is being chosen through aerodynamics requirements on their properties in a catalog of the airfoils. In cases thin blade profile and low camber be can came from a **base airfoils**[1] that are use in aerodynamic wing airfoils, in other cases shapes of the blade profiles be can came from experimentaly blade profiles that are tested inside the line blade row. If the airfoil catalog does not contain suitable airfoil must be developed and tested it.

[1] *Base airfoil*
It is a symmetrical airfoil. Some shapes of the base airfoils or their table coordinates are shown in [4], [6], [2]. There are many base airfoils, which differ from each other in a shape, aerodynamic properties and other properties. The requirement blade profile is made by camber of the base airfoil: