1.1 Water turbines

In the world thera are o lot of types of turbines named after theirs inventors. I mean in this chapter only three inventors with their very spread turbines around the world.

a) Pelton turbine

b) Francis turbine

c) Kaplan turbine

other turbines as Fourneyron, Bánki, … are not so spread around the world.

Pelton turbine is suitable for high head (different levels of water) applications, that predicted it for mountains rivers. Francis turbine has the head ranges from 10 to 80 m with wide ranges of flow. That´s very universal turbine. And Kaplan turbine is suitable for low-head with high-flow of water. It has also high efficiency instead of Francis turbine. Such turbine is suitable for lower reaches of rivers.

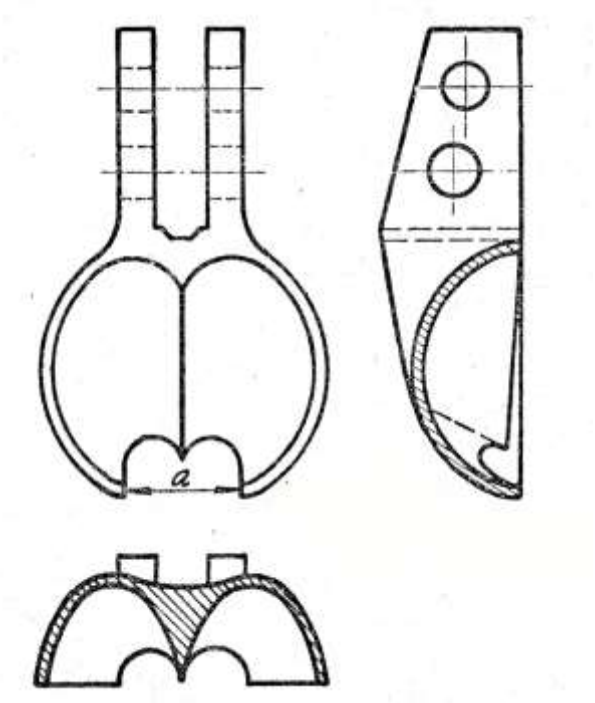
We could ask ourselves if it is posssible to have placed two types of turbines at one power plant. One kind for a high head and the second one for a low head. In that case there is a very importance the return of an investment.

There is a relation – the flow ranges in oppposite of head ranges – after that there is a relevant type of turbine. The head of water is depend on the weather, but the range of flow is possible to regulate.

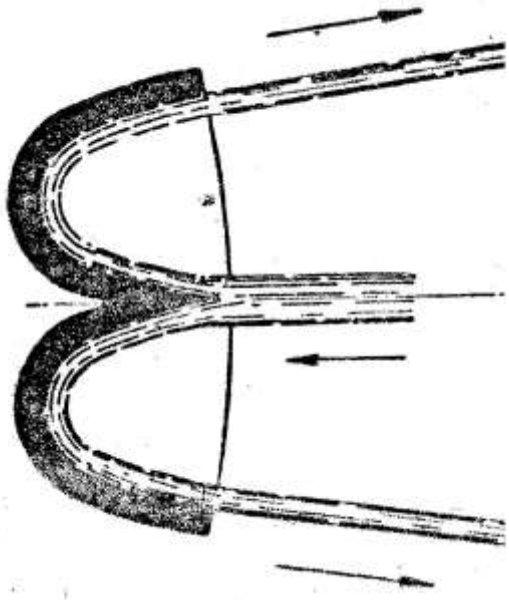
1.1.1 Pelton turbines

Lester Allan PELTON (1829 – 1908) an American engineer, the inventor of a water wheel with special buckets, the patent for his turbine from 1880.

We could see a very new shape of buckets.



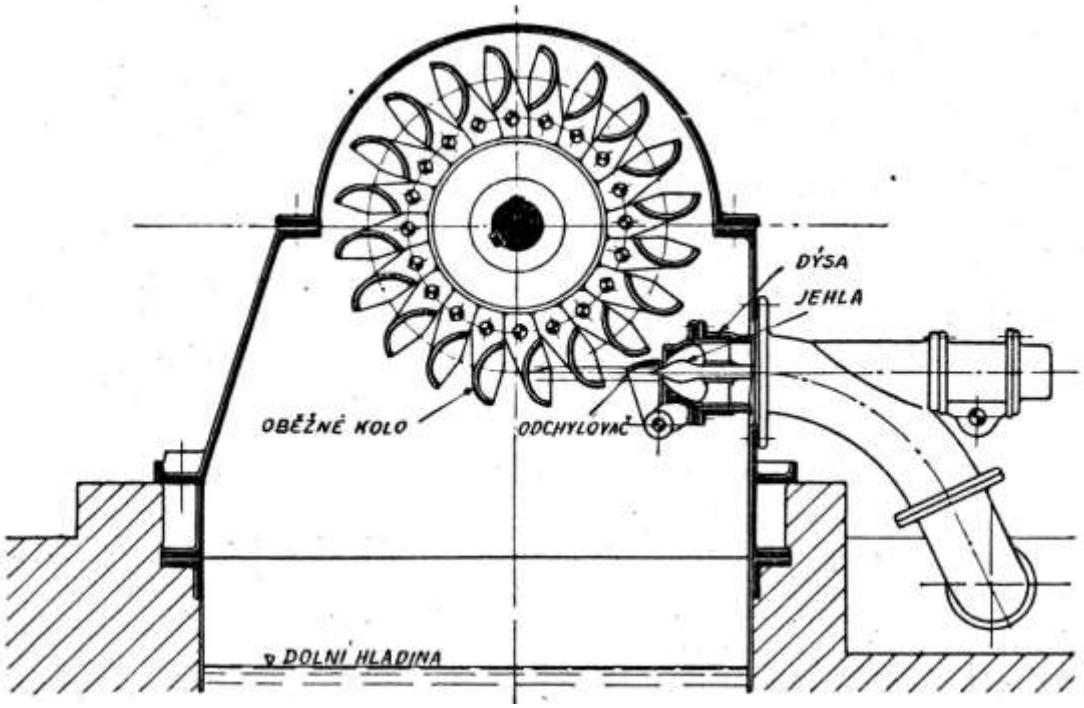
the princip of a function of such buckets is seen from the next image



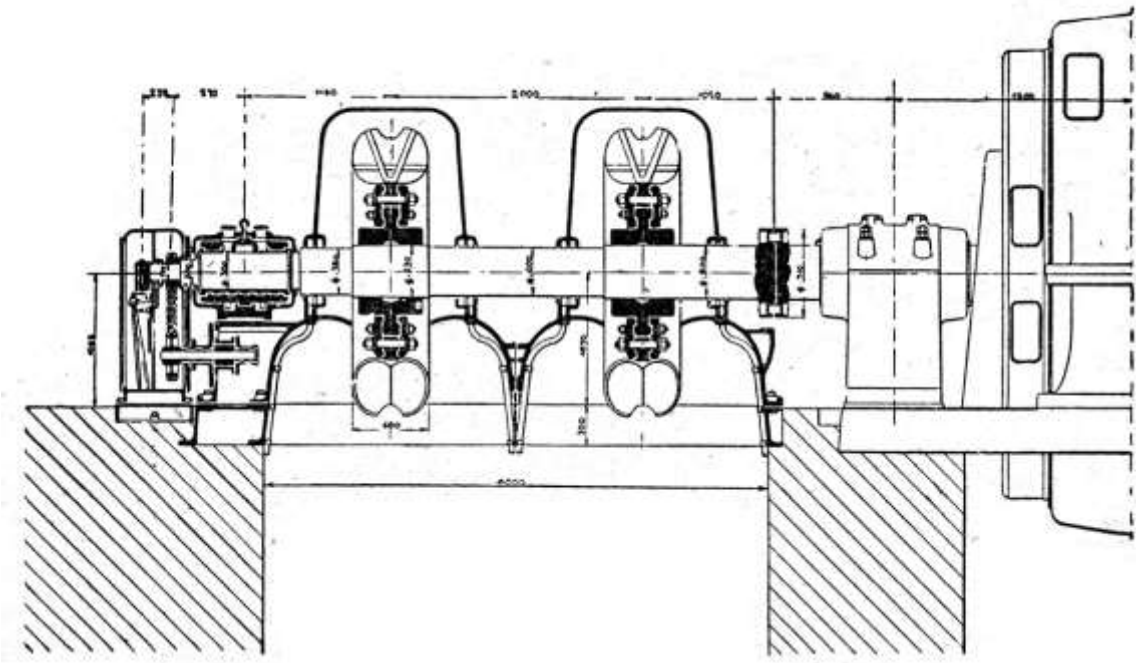
the flow of water from a jet hit on a edge of the bucket, the flow of water changes a direction and the result is a transfer of kinetic energy from water to the bucket

In the beginning the speed of the water is c. After leaving of the bucket the speed is nearly c/2 (reference point is the bucket). For reference point of the ground the speed is nearly 0. The water is falling straightly to outlet.

In the next image we see a layout of Pelton turbine – sometimes called the Pelton wheel.



The maximal flow is restricted by an amount of water through one bucket. Then we could connect two or more turbines at one shaft. See the next image.



the efficiency cca 90% (theoretically 100%)
the range of head cca 10 m - 1 000 m
round per minutes 50 - 2 000

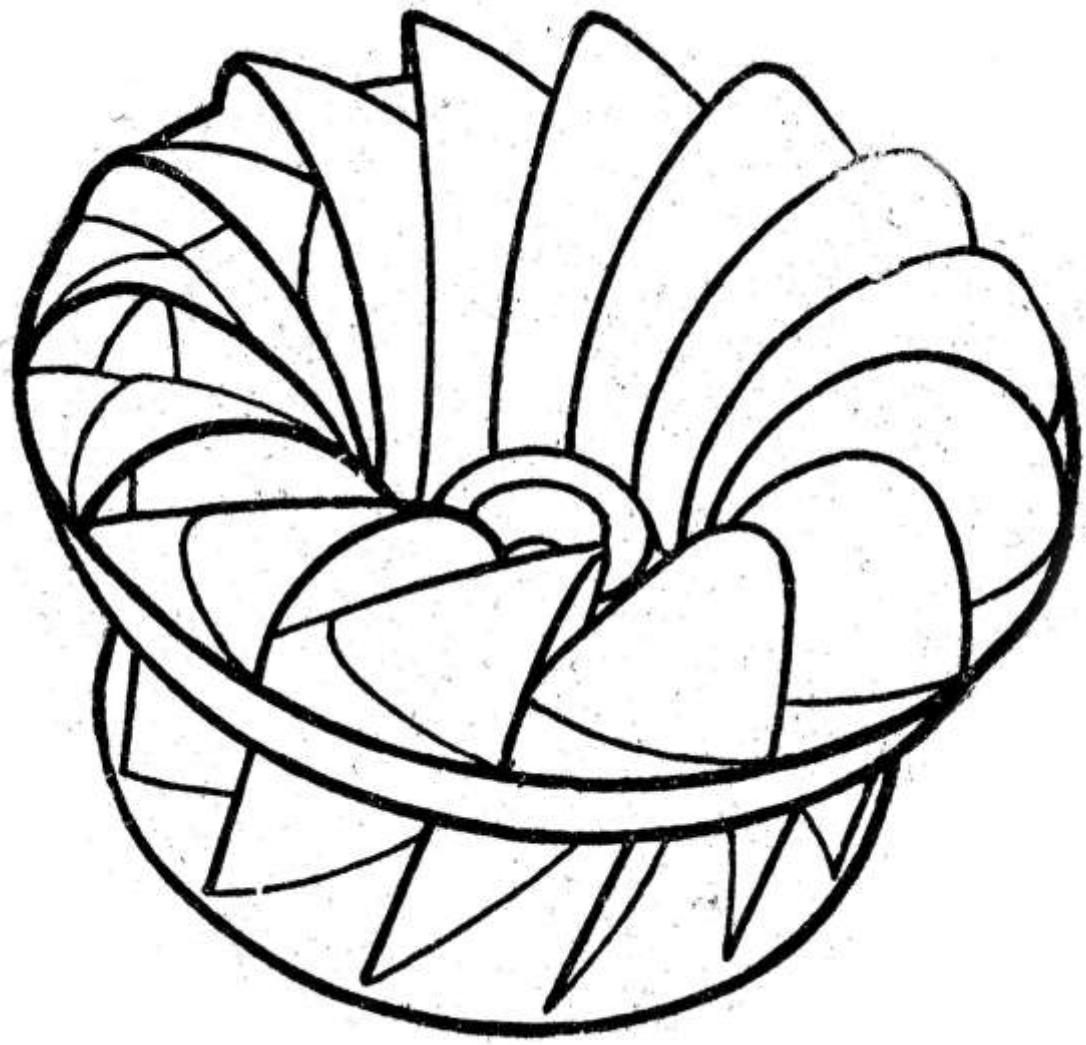
The turbine is suitable for the high head. There is a minimal regulation of rotation.

1.1.2 Francis turbine

James Bicheno FRANCIS (1815 – 1892) an British-American engineer, the inventor of his turbine around 1850.

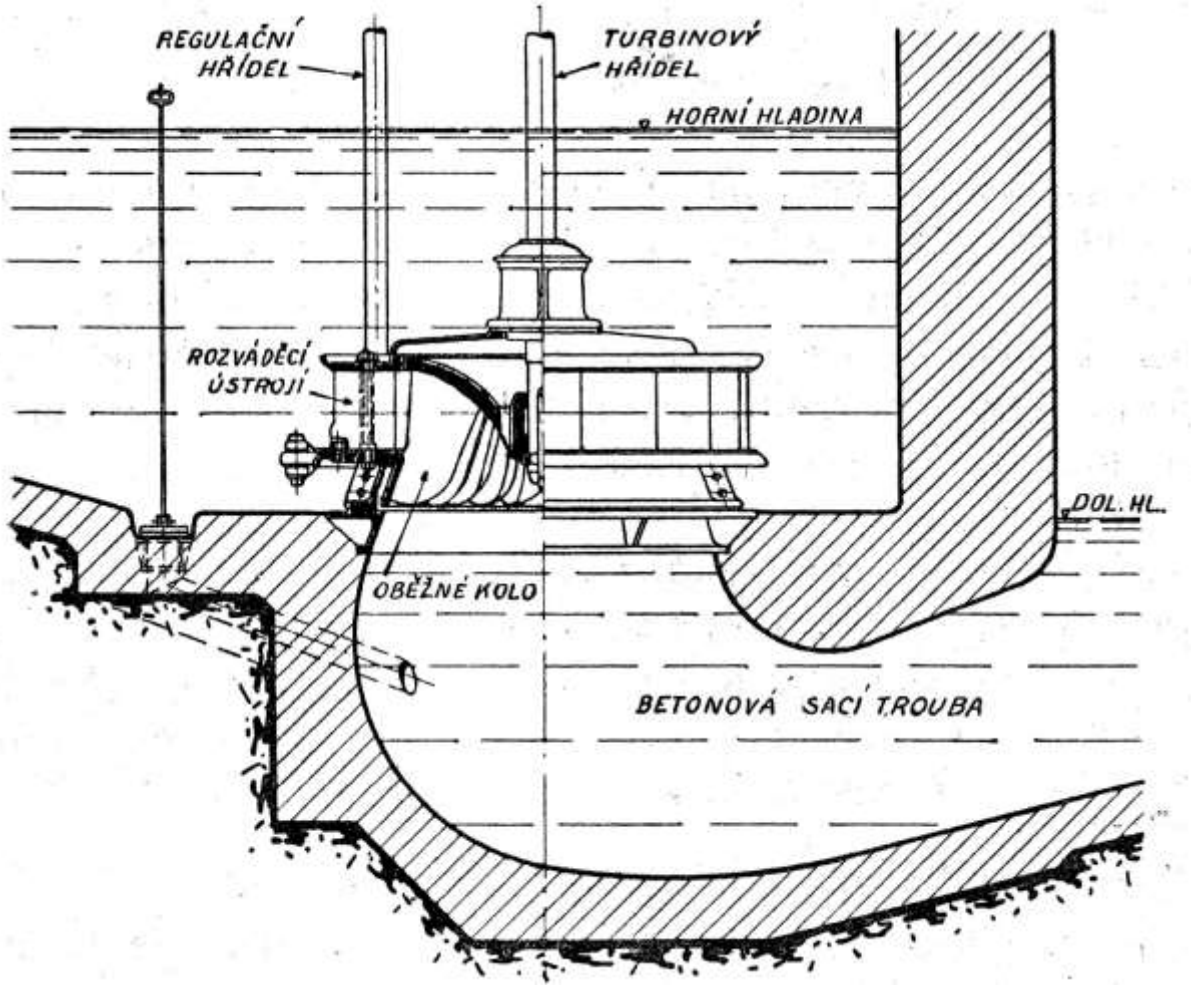
Francis turbine reached an improvement in a construction of water turbines. From Segner wheel through Poncelet and Fourneyron to an American engineer Boyden.

The basis of Francis turbine are special blades at a runner – see image



The inlet of water is marked by the pointer. The water gives nearly all its kinetic energy to the runner.

the next image pointed the situation of turbine at a dam There is the turbine with a vertical shaft.



The very useful gadget is a draft tube. This allows the turbine to use all available head (difference betwen up and down water level). The princip is a suction of water from the runner. The suction force depends on a height of the draft tube. The height of the tube must be less then the suction pressure. The reason is a cavitation.

the efficiency cca 85%
the range of head cca 20 m - 700 m
round peer minutes 60 - 1500 ot/min.

Very „popular“ turbine in the world

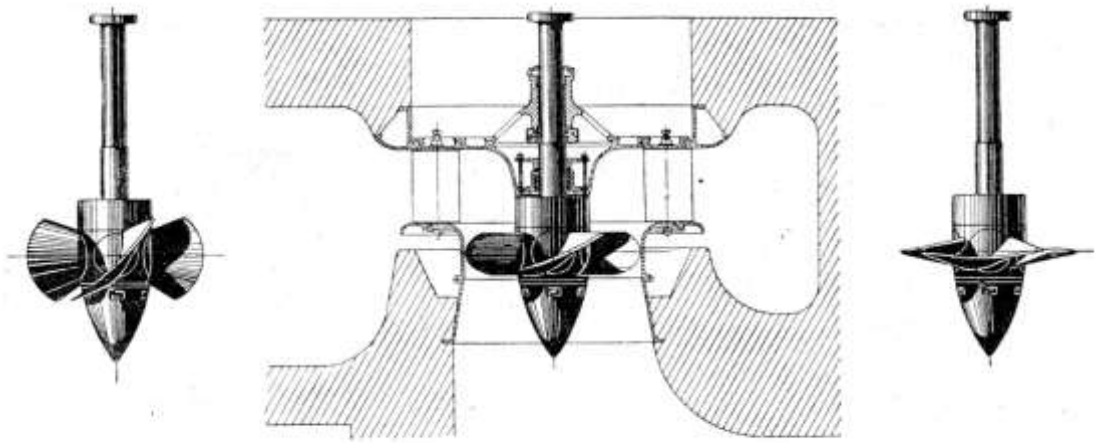
1.1.3 Kaplan turbine

Viktor Kaplan (1876 – 1934), an Austrian engineer and inventor of excess pressure axial turbine, the first prototyp was made at 1919 in former Czechoslovakia by the company Ignaz Storek from Brno

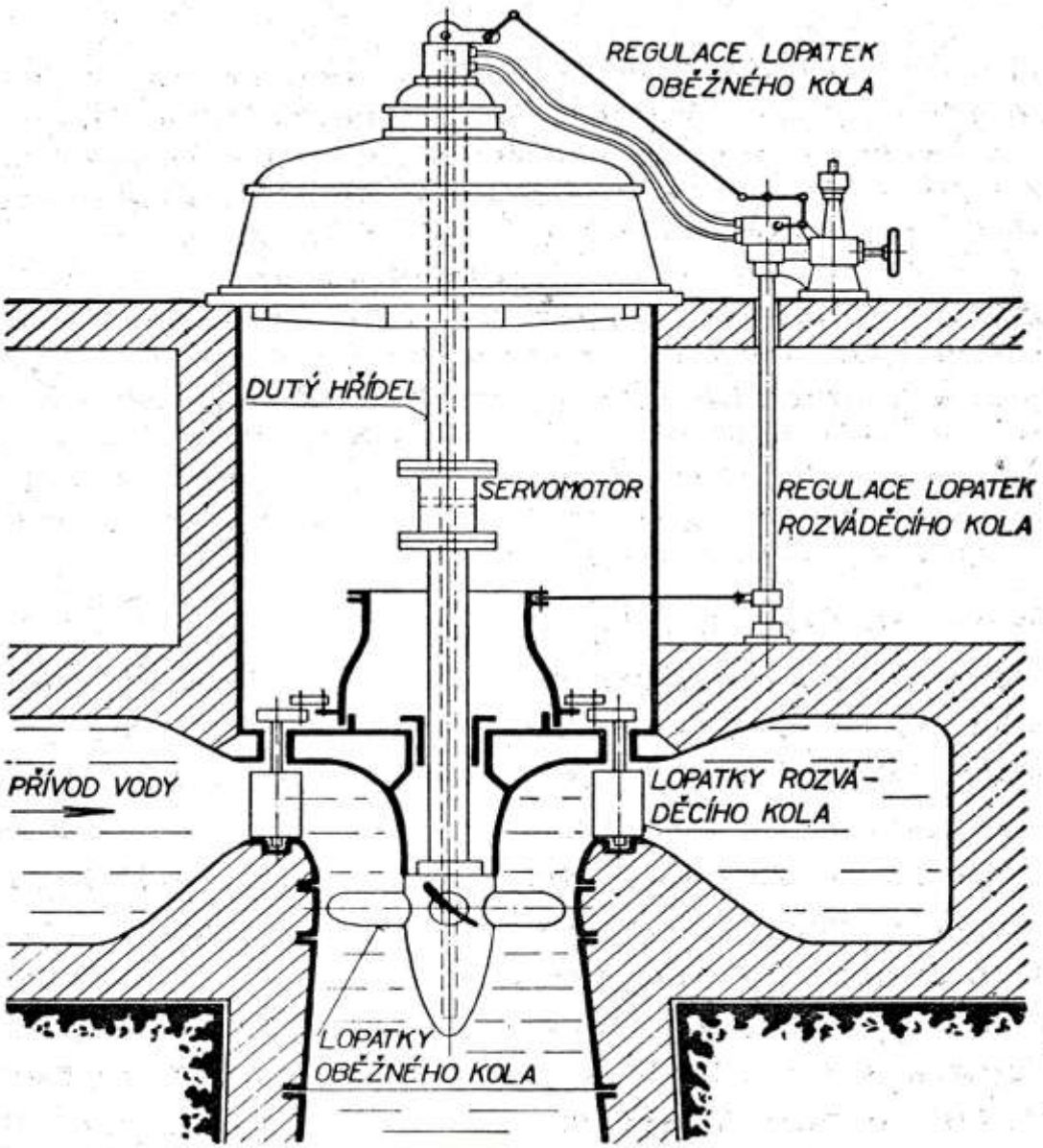
Kaplan turbine is very different from other turbines. Its outlook is very specific by using of automatic adjusted propeller blades. The reason for to adjust blades is to achieve efficiency over a wide range of flow and head. We are able to keep it at work for any flow of water with maximal efficiency.

The adjustable runner of Kaplan turbine in different adjusting positions

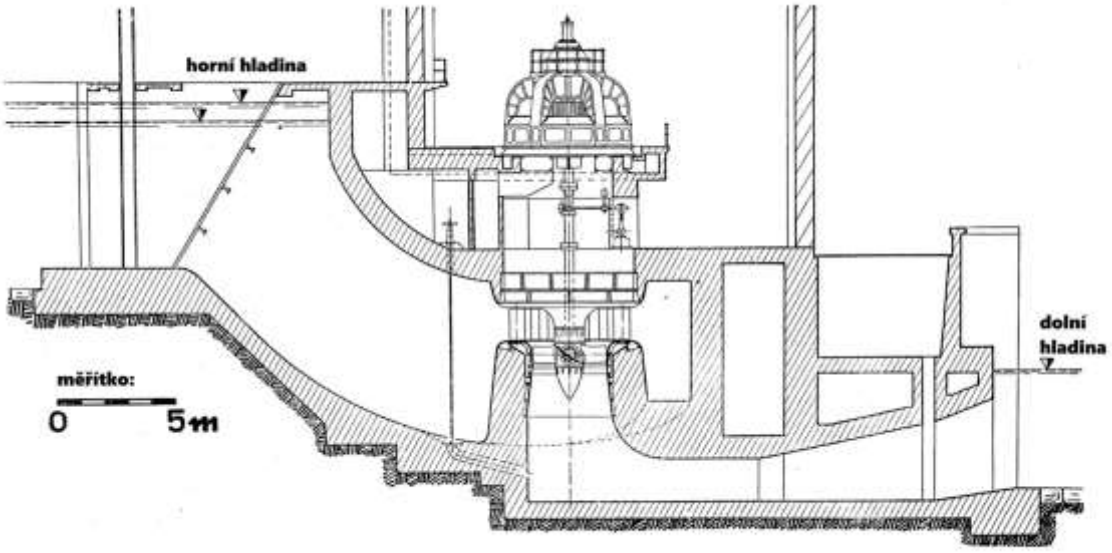
full open **half open** **closed**



The outline of regulation of Kaplan turbine



The assmebling of Kaplan turbine at the dam



Through the Kaplan turbine could run an extreme flow of water. What does it mean? Where must be placed three Francis turbines, here could be use only one Kaplan turbine.Thatś all.

the efficiency cca 95%
the range of head cca 0,5 m - 100 m
round per minutes 500 - 1000 ot/min.

turbine with high efficiency also with a smalll flow, very wide the range of regulation

1.2 Calculation of the output power

The formula for output P of water turbine:

$$P = M \cdot g \cdot h \cdot \eta \quad [W]$$

M mass flow of water [kg/s]
we could also use a liter per second

g gravitational acceleration [m/s^2]
g = 9,81

h head (difference of water levels) [m]

η the efficiency [-]
non-dimensional value, cca 90 %, then η = 0,9

The base of the formula is the difference of potentional energy E (J) between two levels for given amount m (kg) of water at given time t (s).

for imagination:
we have the Kaplan turbine for the head **10 m**, with flow of water for **1 000 litres/sec** (1 cubic meter water/sec.)
After use the formula we get the output P = **88 290 W**,
which means **88,3 kW**.

1.3 Conclusion

We could write down:

Kaplan turbine is suitable for the range of the head between 0,5 m to 100 m.

Francis turbine is suitable for the range of the head between 20 m to 700 m.

Pelton turbine is suitable for the range of the head between 10 m to 1000 m or more.

We see the Francis turbine is the most universal turbine and, without doubts, such turbine is widely used around the world. The best for low-head and extremely-flow there is the Kaplan turbine. For an extremely-head (mountains) there is the best Pelton turbine.