



INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Water Turbines

1 Celkový obraz

O modulu

Pomůcky a nástroje

Pravidla a konvence

2 Obsah

1. Celkový obraz	2
2. Obsah	3
3. Pelton Turbine	4
3.2 Pelton Turbine	4
4. Francis Turbine	8
4.2 Francis Turbine	8
5. Kaplan Turbine	12
5.2 Kaplan Turbine	12
6. Banki Turbine	16
6.2 Banki Turbine	16
7. Deriaz Turbine	19
7.2 Deriaz Turbine	19
8. Rejstřík	22

3 Pelton Turbine

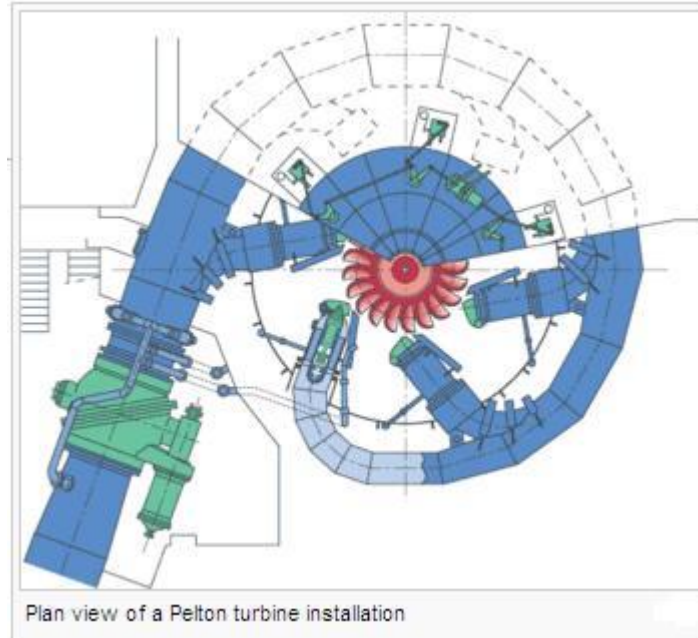
3.1 Pelton Turbine

Pelton turbine, also called **Pelton wheel**, is a water turbine, invented by American engineer Lester Allan Pelton in the 1870's. It is a modified version of a turbine developed by Samuel Knight some time earlier. It is considered to be one of the most efficient types of water turbines.



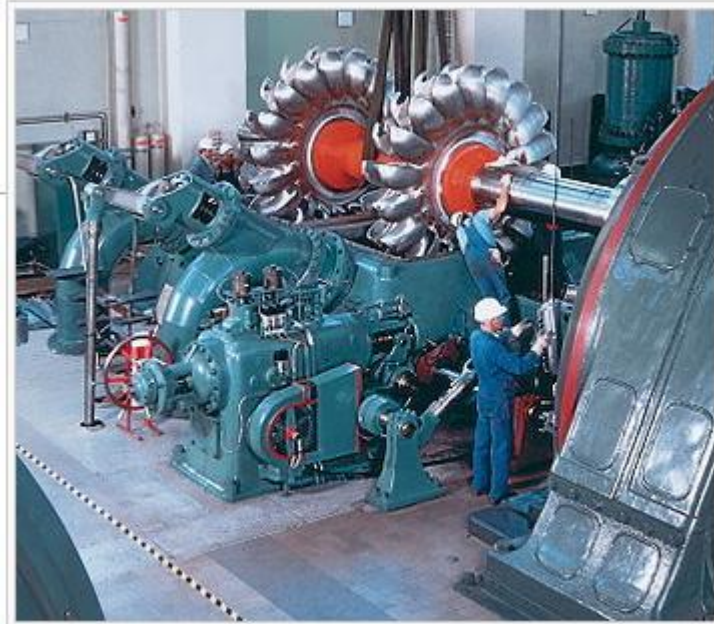
Description

The Pelton turbine is an impulse machine, which means that it acquires energy from a jet of water. The water goes through nozzles (up to 6), which direct it onto spoon-shaped buckets on the periphery of a runner. Thanks to this the runner rotates and produces mechanical energy, which is transmitted by the shaft to a generator. Because the momentum of the water has been transferred to the turbine, the water is decelerated and slowly flows out the other side of the buckets.



Application

Pelton turbines are most efficient at high heads (usually up to 1,800 meters, but higher are also possible), which allow them to get a lot of power from a water source with high pressure and low flows. They are produced in various sizes – some of them, used in hydroelectric plants, weigh many tons and their output is up to 200 megawatts. The smallest of them have a diameter of several centimetres and are used to extract power from mountain streams with flows about a dozen of litres per minute.



Assembly of a Pelton wheel at Walchensee Power Plant.

Vocabulary

Pelton turbine, Pelton wheel – Peltonova turbína

invented – vynalezený

efficient – výkonný

jet – prudký proud

nozzle – tryska

spoon-shaped bucket – lopatka ve tvaru lžice

runner – lopatkové kolo

transmit, transfer – přenést

shaft – hřídel

momentum – pohybová energie

decelerate – zpomalit

application – využití

head – hydraulický spád

flow – proud

hydroelectric plant – vodní elektrárna

weigh – vážit

output – výkon

diameter – průměr

dozen – tucet

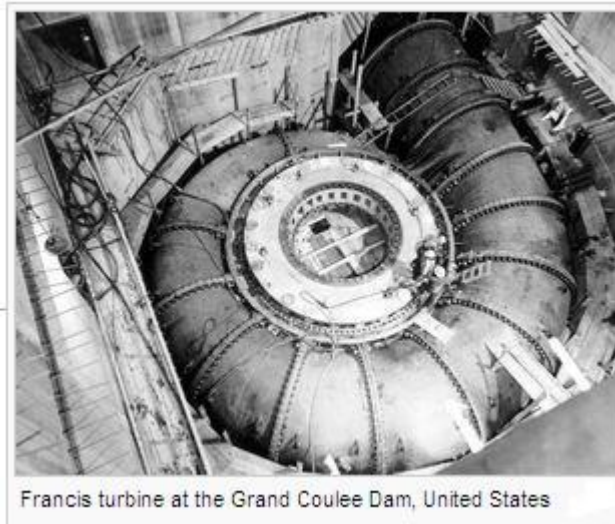
litre per minute – litr za minutu

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4 Francis Turbine

4.1 Francis Turbine

The **Francis turbine** is a form of a water turbine. It was invented by an American engineer James Francis. Nowadays they are the most common turbines.

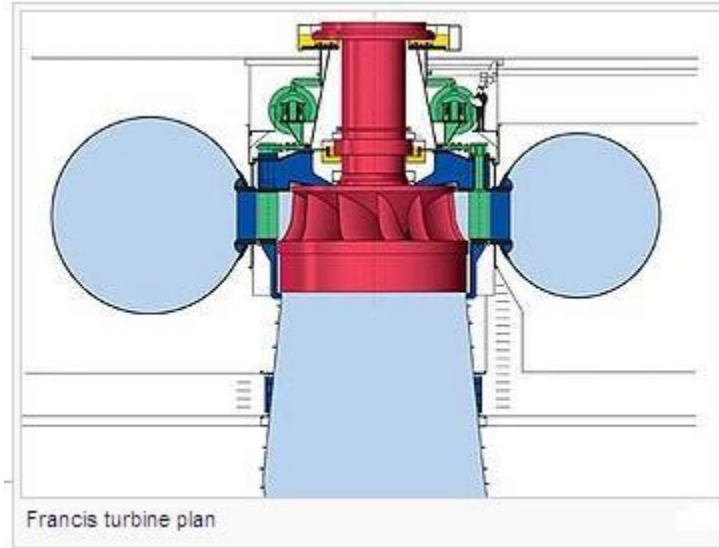


History

In the past people used water wheels to get the power from water, but they were not very efficient. First inventions of water turbines came in the first half of the 19th century. In 1826 French engineer Benoit Fourneyron invented an outward flow turbine with the efficiency of 80 per cent. Another French engineer Jean-Victor Poncelet proposed an inward-flow turbine in that time, but it was not build until 1838. James Francis used his mathematical abilities to improve these designs and in 1848 build a turbine with the efficiency of 90 per cent.

Description

The Francis turbine is a radial reaction turbine. When the water goes through the turbine, it changes pressure and thus its energy is transmitted. That is why these turbines are usually located at the base of a dam, with the high pressure water source and the low pressure water exit.



The inlet is a spiral. The water comes to the runner tangentially through guide vanes, which makes the runner to spin. Efficiency of operation can be influenced by adjusting the guide vanes, depending on different water flow conditions. During the movement of the water through the runner, the water spins faster, which is caused by the law of angular momentum conservation. Thus, together with the pressure of the water, the efficiency of the turbine is significantly increased. At the outlet the water is decelerated and its pressure is recovered. Special runner features shaped as a cup cause that the water stops swirling and leaves with very little kinetic energy.



Application

Francis turbines can be used for a very wide head range between 20 and 700 metres, and their power differs from several kilowatts up to one gigawatt. They are both used for direct electrical production or for pumped storage. In the second case they function as a pump and fill a reservoir, when the power demand is low, to be able to generate power during peak hours.

Vocabulary

invent – vynalézt

invention – vynález

water wheel – vodní kolo

efficient – výkonný

outward – vnější

inward – vnitřní

per cent – procent

propose – navrhnout

radial – radiální

pressure – tlak

transmit – přenést

base – základna

dam – přehrada

inlet – vstup

outlet – výstup

runner – lopatkové kolo

tangentially – tangenciálně

guide vanes – vodící lopatky

spin – otáčet se

adjust – nastavit

water flow – vodní průtok

law of angular momentum conservation – zákon zachování hybnosti

decelerate – zpomalit

recover – obnovit

swirl – vířit

head – vodní spád

power – výkon

pumped storage – akumulace energie přečerpáním vody do vyšší nádrže

pump – čerpadlo

power demand – poptávka po elektrické energii

generate – vyrábět

peak hours – doba špičky

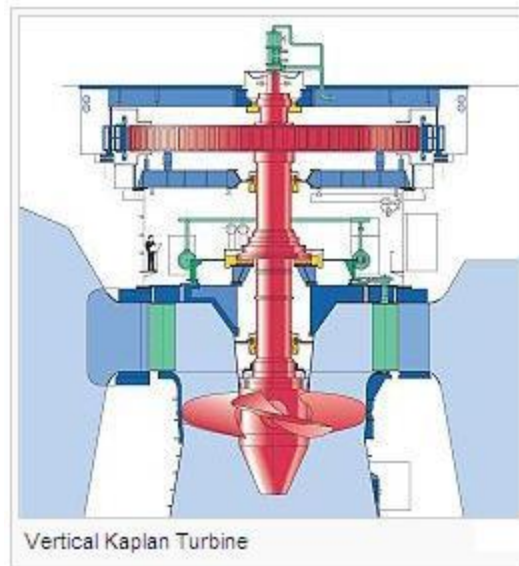
cut-away – znázorněný na příčném řezu

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5 Kaplan Turbine

5.1 Kaplan Turbine

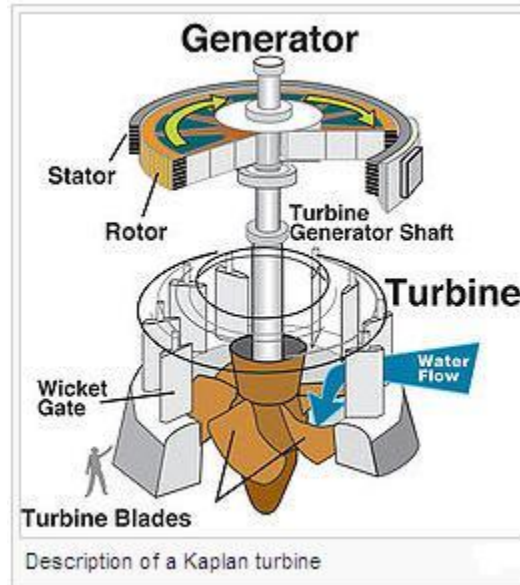
The **Kaplan turbine** is a type of a water turbine with adjustable blades, invented by an Austrian engineer Viktor Kaplan in 1913. These turbines are used in low-head power production, which is not possible with Francis turbines.



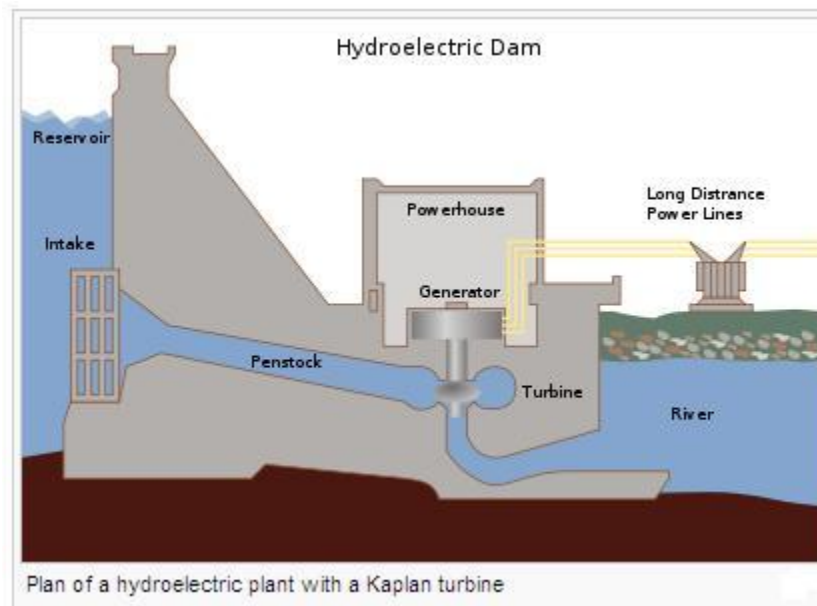
Operation

When the fluid flows through the Kaplan turbine, it changes its pressure and gives up its energy. The inlet of the turbine looks like a scroll and wraps around the wicket gate. The water goes through the gate in a spiral and falls onto a propeller, which is forced to spin. The outlet is a draft tube. Here the water decelerates and thus the kinetic energy is recovered.

The draft tube has to be full of water, but it does not have to be at the bottom of the water flow. However, lower location helps to keep the suction on the turbine blades smaller. The suction causes pressure drop which results in cavitation.



Application



Kaplan turbines have very high efficiency, usually over 90 per cent, although it can be lower in very low-head applications. Production and installation of large turbines of this type is very expensive, but they work reliably for a long time. Usually they are used to produce electric power in the lowest head hydro sites. Micro turbines for private usage are also produced and they can be used for power production with 60 centimeters of head.



Vocabulary

turbine – turbína

adjustable blades – nastavitelné lopatky

head – hydraulický spád

power production – výroba energie

electric power – elektrická energie

fluid – tekutina

pressure – tlak

inlet – vstupní otvor

outlet – výstupní otvor

wicket gate – rozváděcí lopatky, rozvaděč

propeller – vrtule

draft tube – sací potrubí

suction – podtlak

cavitation – kavitace

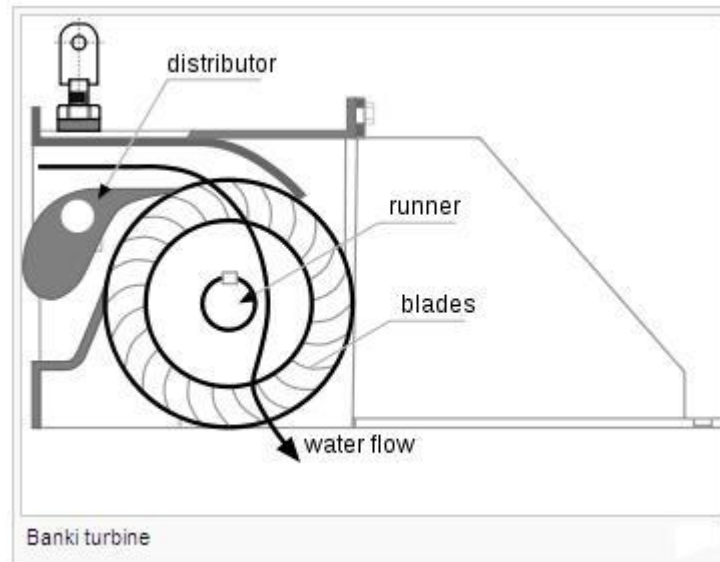
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6 Banki Turbine

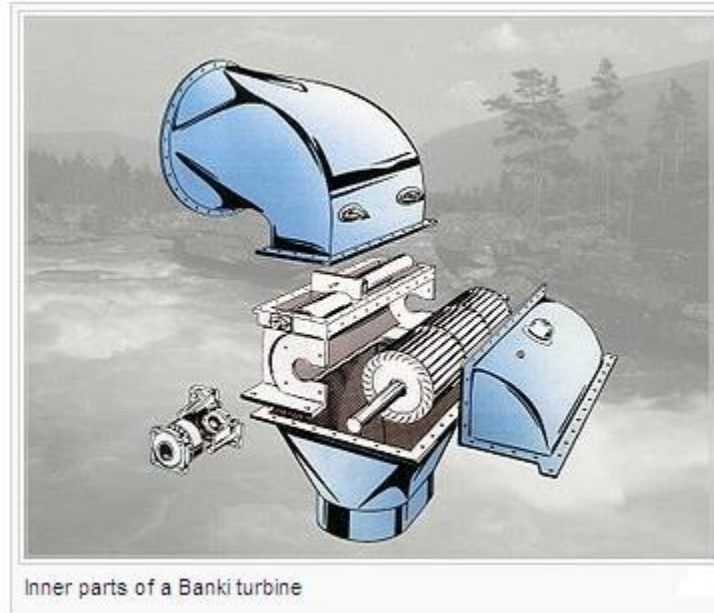
6.1 Banki Turbine

Banki turbine, also known as a **Banki-Michell turbine**, **Ossberger turbine** or **crossflow turbine**, is a type of a water turbine developed by Hungarian engineer Donát Bánki in 1917.



Description

The Banki turbine has a cylindrical runner with a horizontal shaft, which can possess up to 37 blades. The blades are arranged radially and tangentially. They are very sharp, which reduces the water resistance. The turbine has trough-shaped blades, their cross-section is an incomplete circle.



Operation

While most water turbines have axial or radial water flows, in Banki turbine the water goes through transversely, that means across the turbine blades. After it flows into the top of the turbine, it makes the wheel rotating by its weight. When it flows past the blades into the middle of the turbine, its direction is changed, thanks to which more power is gained.



Application

Because the Banki turbine is a combination of the impulse and reaction turbines, it can be used in a wide range of heads. Although their efficiency is lower than the efficiency of other turbines, they are quite popular because of their low price and easy installations. That is why they are used especially in very small hydropower units with the output of less than 2,000 kilowatts and with heads smaller than 200 meters.

Vocabulary

Banki turbine, crossflow turbine – Bánkiho turbína

developed – vyvinutý

cylindrical – válcový

runner – lopatkové kolo

shaft – hřídel

blade – lopatka

radially – radiálně, paprskovitě

radial – radiální

reduce – snížit

resistance – odpor

trough-shaped – ve tvaru žlabu

cross-section – průřez

axial – axiální

transversely – příčně

weight – hmotnost

direction – směr

power – energie

application – využití

head – hydraulický spád

efficiency – účinnost

hydropower unit – blok vodní elektrárny

output – výkon

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7 Deriaz Turbine

7.1 Deriaz Turbine

Deriaz turbine is a form of a water turbine. It was named in honour of Paul Deriaz, a hydraulic designer and its inventor. It was the first diagonal turbine, invented in 1956.

Description

Deriaz turbine is a mixed-flow turbine, which means that water enters the unit radially and leaves it axially. It is similar to Kaplan turbine but its runner blades are more inclined, and thus it is more suitable especially for medium heads, ranging between 20 and 100 metres. The blades are adjustable and can be rotated around their axis, which is at right angles to the main shaft.

Advantages

Thanks to its construction, the Deriaz turbine has many other advantages:

- The blades can be completely closed so that the runner turns into a smooth cone. This permits to start-up with minimum load while the unit is immersed in water.
- The blades can be adjusted to work efficiently as a pump as well and thus it is suitable for pumped storage plants
- It works efficiently over a wide range of head and load. Unlike with Francis runner blades, this type allows varied pumping loads
- It distributes the pressure and load across the blade from the casing to the hub equally
- It does not have problems with the development of cavitation, no matter of the height of the head
- It has a lower runaway speed when a sudden loss of load occurs in comparison with Kaplan turbine, which results in significant savings in generator costs.

Application

Turbine selection is often based on its specific speed, which can be found from the formula

$$N = \frac{nP^{1/2}}{H^{5/4}}$$

where n is rotational speed in revolutions per minute, P is the power in horsepower, and H is the head of water in feet. Deriaz turbines are most suitable for N ranging up to 110.

Vocabulary

inventor – vynálezce

mixed-flow – smíšené proudění

radially – radiálně

axially – axiálně

axis – osa

runner – lopatkové kolo

blades – lopatky

inclined – nakloněný

head – hydraulický spád

adjustable – nastavitelný

adjust – nastavit

right angle – pravý úhel

shaft – hřídel

cone – kužel

immersed – ponořený

load – zatížení

efficiently – účinně

pump – čerpadlo

pumped storage plant – přečerpávací elektrárna

cavitation – kavitace

runaway – ve vysokých otáčkách

savings – úspory

specific speed – měrné otáčky

formula – vzorec

rotational speed – rotační rychlost

revolutions per minute – otáčky za minutu

power – výkon

horsepower – koňská síla

range – rozsah

8 Rejstřík