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HISTORICAL AND TECHNICAL ASPECTS OF HYDRO ENERGY USE IN ROMANIA

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Abstract: Hydraulic energy is an inexhaustible, efficient, renewable source, it is one of the most important renewable energy resources, used, it seems, from ancient times, preserved a lot from the 18th century.
Since ancient times there have been concerns about the production of electricity from water power. In this paper, we want to present the evolution of hydraulic wheels starting from the oldest wheels that used the power of water in various fields of activity. The advantage of using water wheels is very important, especially from the point of view of environmental protection. It is a clean, inexhaustible energy that does not destroy the aquatic environment and fish fauna. It can be said, with certainty, that they are fish-friendly machines, causing a very small impact on the environment where they are placed. The impact on the environment is minimal, while the advantages are countless.
Keywords: hydraulic wheels, whirlpool, water mill, energy

1. INTRODUCTION

The hydraulic wheels are placed where there are water falls between 4 m and 6 m and where there is a maximum flow rate of 1 mc/s. most information about the use of water wheels dates from the 19th century. The hydraulic wheel is considered a relatively simple construction, but, in reality, for its design, the number and shape of the blades, the diameter and width, the speed of rotation, the type and shape of the channel downstream and upstream must be taken into account. All these are essential elements, which must have an adequate hydraulic design, to ensure efficient optimization and maximum yield.

Nowadays, the locations for the construction of hydropower plants have practically been exhausted. We must not forget that river flows have decreased substantially in recent years, and due to pollution, there are long periods of drought, followed by strong floods. That is why the construction of high-power hydropower plants is no longer required, especially due to the fact that the water flows are small and not least due to the fact that the construction of some hydropower plants leads to a major impact on the fauna and flora of the area. Thus, some researchers support the fact that we need to look back a little and learn from the past, to be aware that, by what we do, we destroy the environment, and all this turns like a boomerang against humanity. The effects of environmental pollution are more and more significant and if measures are not adopted to reduce pollution, the situation will worsen.

2. THE HISTORY OF HYDRAULIC WHEELS IN THE WORLD

The water wheel is an ancient device based on the use of water energy. Water is diverted from a river and led to the water wheel through a channel which, by its fall, creates energy with the help of paddles that are mounted around a wheel. It is the force of the water that moves the paddles, and through the subsequent rotation of the wheel it is this force of the water that is transmitted to the machines through the shaft of the wheel.

The water wheel was the precursor to the primary engine, the first uses of hydraulic wheels date back to antiquity, even if they were primitive, it seems that hydraulic wheels were initially used to grind grains.

The first references to a water wheel date back to around 4000 BC. Vitruvius. It seems that it was a vertical wheel with paddles. The vertical water wheel had a simple operating mechanism, the water flowed from an aqueduct, and due to gravity, its fall, it turned the wheel. They were used not only to irrigate cultivated land and grind grain, but also to supply drinking water to villages. During the time of the Romans, it seems that the wheel was discovered, the one who apparently discovered it was an engineer in the 14th century. This wheel was a vertical water wheel and dates from the Roman period.

The horizontal wheel followed, which since the first century was ineffective because it was difficult to transfer the power of the current to the transformation mechanism, being replaced in a very short time by vertical water wheels. A very big disadvantage, besides the fact that the transfer of current power to the transformation mechanism was very difficult, was that it was not possible to adjust the speed of rotation, which depended directly on the speed of the water and, therefore, on the flow of water at each moment.

To begin with, these wheels seem to have been built for grinding grain and for feeding different types of mills, so they were called water mills. In some countries like Syria, they got other names, it seems that the water mills were called "clouds" and had other uses as they were used to turn cotton into fabric. Other uses of water mills from the distant past:

- for the exploitation of sawmills;

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- for weaving looms;
- in metal processing;
- for the production of seed oil;
- for peeling rice;
- paper factory;
- for the production of electricity with the help of a generator.

Currently, there are still so-called primitive installations that use water energy, such as Marly's Machine, which pumps the water from the Seine necessary to feed the waterfalls, fountains and ponds in the gardens of the Palace of Versailles, the water machine in Porcheresse (Belgium), which is used for to supply water to the respective village.

In 1939 the spiral bucket waterwheel appears in Ohio. Olona river mills were not only used for grinding grain, but also for the production of seed oil, for husking rice.

The following figure shows some water mills that have been preserved over time and that contributed to the progress of science in that period (Figure 1 a, b), but also the reconstruction of a Roman pump found during the subway excavations from London (Figure 2) [1] .

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Figure 1a. Dell'Acqua cotton factory in Legnano

Figure 1b. Meraviglia Mill in San Vittore Olona

Figure 2. Reconstruction of a Roman pump

In the 18th century, the technique of building and placing water mills was developed. This was before the advent of the steam engine and the construction of hydraulic turbines. Thus, we can say that the water wheel is the precursor of the industrial revolution, it allowed the industrial revolution to start, followed by the discovery and use of higher power engines.

Initially, the hydraulic wheels had a rudimentary construction, they were made entirely of wood, with the technique existing at that time and were characterized by the presence of flat pallets. Due to the rudimentary construction and wooden execution, they had a low yield, of only 30%. These wooden wheels were later replaced by iron wheels, thanks to which the efficiency and durability of these constructions increased, being more resistant over time and contributing to the progress of science in this very important field.

3. THE EVOLUTION OF HYDRAULIC WHEELS IN ROMANIA

This period of history is notable for the discovery and exploitation of the kinetic energy of water courses, energy that was used to wash and process woolen fabrics. This washing system was a modest one called "steaza" (figure 3) [2].

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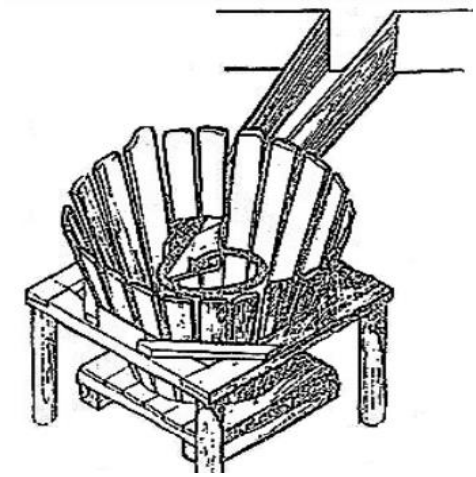


Figure 3. Sit mill (whirlpool)

The oldest hydraulic installation that has survived to this day is the staeza. It consists of a truncated basket (which was built of hard wood, and was placed in a massive oak pedestal, with wooden nails and joined, in the upper part, by a braid of reeds). At its base there was a trough that produced a stream of water. This jet of water imprints a circular movement on the fabrics placed in the basket.

The next so-called invention from the territory of Romania is a primary type of hydraulic mill that has different names depending on the geographical location. Thus it was called "mill with titirez" (in Vrancea), "mill with facaie" (in Oltenia) or "moara cu ciutura" (in Oltenia, Muntenia and Banat). This hydraulic mill would inspire the physicist Pelton to create the world's first power plant turbine.

In the following figure (Figure 4) several types of hydraulic mill wheels are presented

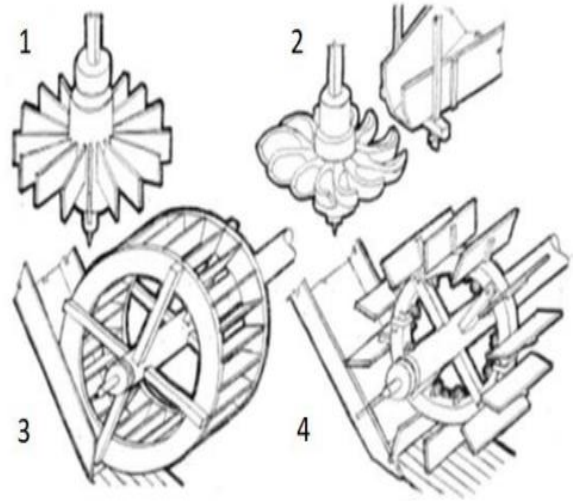
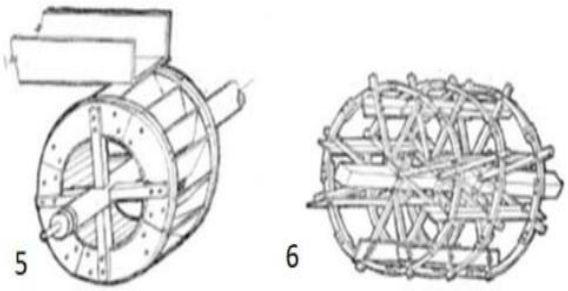


Figure 4 types of hydraulic mill wheels

1. Hydraulic mill with vertical axis and horizontal trough
2. The hydraulic mill with a wheel with a vertical axis and a vertical trough (the torch mill);
3.4 Hydraulic wheel mill with horizontal axis and bottom feed;



5. Hydraulic mill with wheel with horizontal axis and upper feed;
6. Hydraulic mill with wheel for floating mill [2].

Floating mills were one of the most frequently used techniques on the big rivers, being attested centuries ago here in Romania. Thanks to these mills, the peasants exploited the advantages of the rivers to the maximum.

The mill in Lucăceşti was provided with two component vessels - the large and the small culvert. It was built of oak wood and is provided with a covering made of beech sawdust. From the small abutment, access to the cabin was made through a bridge made of a former oak log. The Lucăceşti mill has two pairs of stones, one of large size, used for grinding corn, and the smaller one for grinding grains such as wheat and barley (Fig 5). When the water flow was high and the wheel turned fast enough, about 200 kg of flour/hour could be ground. [3]

Figure 5. The mill from Lucăcesti

Darsta with two fulling cylinders and two whirpools

Darsta is a rudimentary hydraulic installation operated by running water, in which dimia, postaval, etc. are processed. with the help of wooden hammers, with the help of darste, animal and vegetable skins and fibers were processed for clothing and utilitarian-household items.

The dredge with two waves and two eddies from Nistoresti (Figure 6) was reconstructed in the museum in 1970. It is a rectangular building with a single room with a bridge, built of river stone, glued with clay with a two-pitched roof with fir shingle cladding. The principle of operation consists in the fact that this installation the 2 work phases, namely: the thickening of the fabric and the drawing of the widths, work phases that were carried out with two distinct mechanisms, placed on two levels of the construction.

The wave to be thickened is a cylinder made of coils tied with horizontal rods on which the sticks are woven. It was set in motion by the force of water through a hydraulic wheel with buckets fixed on a horizontal axis. The hairing wave is a smaller cylinder that consists of coils tied with horizontal rods, manually operated with two cranks and under the wave is placed a leash with nails, which performs the hairing.

Figure 6. Darsta with two fulling cylinders and two whirpools from Lucarcesti

Water mill with **''alvan''** elevator

It was built in the 1950s and then rebuilt as a museum. The Alvan, a rudimentary local invention, but a big step towards the evolution of the mills of those times, is a fixed construction consisting of eight vertical pillars. They are placed on either side of the hydraulic wheel axis. On the axis of the hydraulic wheel there is a wheel with a chain, and the transmission is carried out by means of a chain of the Gall type, to a pinion located on the axis of the internal installation's meshed wheel. The pillars are joined to each other at the top, with two horizontal crossbars in the console, over which the cables that support the hydraulic wheel stretch, on one side. One end of it has the spindle mounted on a metal frame that moves on two vertical guides. All these are arranged on the previous pillars of the Alvan. The other end moves vertically by means of a cable that is part of the alvan (Figure 7).

Figure 7. Water mill with **''alvan''** elevator

Plum brandy Distillery with water Wheel Sarbesti, Gorj County

Povarna with hydraulic wheel from Sarbesti jud Gorj dates from the second half of the 19th century. The construction is rectangular in shape and is provided with a porch in front, it has a load-bearing skeleton made of oak beams. The high walls are lined with two rows of alder boards, the upper row completely covers the joints of the lower one. It has a high, four-pitched roof that is covered with slate. The interior houses the distilling installations composed of two boilers, a cooling unit and stills for brandy.

These hydraulic wheels were called ciuturi, the removal of water from the river was done with large wheels with buckets. This mill has 6 mills and highlights the creative spirit of the Romanian peasant from those times. The mill was built far above the water, it was placed on massive pillars, about 4 m above the water because there were frequent floods in that area (Figure 8).

Figure 8. Plum brandy Distillery with water Wheel Sarbesti, Gorj County

The water mills of Banat

Written historical sources tell us about the road of water mills in Banat. It seems that the first water mill is recorded from the middle of the 13th century, when, it seems, there were 2 water mills in Banat, namely on the Timiș and Bârzava rivers. In the 14th and 15th centuries, the appearance of water mills is increasingly frequent in the Banat area due to the fact that certain rules of the Hungarian kingdom of the Banat province began to be imposed.

The mill with horizontal axis and vertical wheel and the floating mill, hydraulic machines that can be included in the class of hydraulic wheels. The system of a horizontal axis mill consists of a large fixed wheel that is on a horizontal axis that takes the kinetic energy in the form of a hydraulic shock. Hydraulic wheels are classified into flow wheels and intake wheels. The current wheel was found in floating mills and works with the kinetic energy of the water through its impulse on the paddles of the large wheel.

The wheel was made of two large discs. These were linked together with wooden blades and the horizontal axis on which the wheel was fixed transformed the hydraulic energy into mechanical work. This transformation of hydraulic energy into mechanical work took place by means of a gear wheel fixed on the shaft and which was coupled to the grinding installation.

The vertical wheel mills from Timisoara appear in engravings from the 17th century. The floating mill in Banat is known thanks to the few photographic images preserved from the beginning of the 20th century. About the mill with a vertical wheel, not much data has been preserved despite the larger number of copies still in operation in 1957, there were no preserved documents or buildings, only the graphic documentation for a single mill in the Begăi basin and another for a mill from Kovin. The horizontal wheel mill in the mountainous Banat has been studied by ethnologists in the last three decades. In 1957, 509 horizontal and vertical wheel mills were in operation. Figure 9 shows the Mill from Vîrtop, Răcăjdia [4,5].

Figure 9. The mill from Vartop, Răcășdia.

The principle used in the classification of modern hydraulic machines, turbines or wheels is the position of the axis, which can be vertical or horizontal. The vertical wheel mill has a horizontal axis position. Statistics from 1957 show that Romania had 3450 mills with a vertical wheel. Banat, unlike other historical provinces, had at that time 74 mills with vertical wheels.

Another significant example is the Mill from Grop, Ilidia, which is a mill with a vertical wheel and the horizontal axis has the same hydrotechnical arrangements found in mills with a horizontal wheel.

There are of course also some differences, these differences between the two classes of mills are in the field of water intake and water transmission (Figure 10).

Figure 10. The mill from Grop, Ilidia

The figure below (Figure 11) shows the stone mill from Şopotu Vechi.

Figure 11. The Stone Mill from Şopotu Vechi.

Another representative example is the Gypsy Mill from Şopotu Vechi (Figure 12), which has a hearth for making fire, without a chimney. Here the commoners from the neighboring villages made the fire warm, while they waited for the flour to be ground. Even if it has been abandoned for a long time, the installation is still functional.

Figure 12. Gypsy Mill from Şopotu Vechi

Figure 13. Andrei's Mill from Dolina

Floating mills appeared on the waters of Mureș and Tisa, which delimit the northern and western borders of the province to a small extent from those of the Danube. Even if in 1957 there were no floating mills registered in Banat, a few were still in operation, due to the fact that the area in the west of the country has a remarkable hydrographic network. This extensive and rich hydrographic network of the Banat province favored the operation of floating mills only on the high waters, on Mures, Tisa, Timiș and Bega in the northern area of the Banat plain[4].

In 1944, the mills in Banat gradually disappeared. At first, the mills in Periam disappeared, in 1946 and 1947 those in the Mures Valley from Chelmac, Căprioara and Igriș disappeared. The mill in Ususău was maintained until 1954, and in 1963 the last floating mill in Banat, the Belotin mill[5], was destroyed.

The figures below show some mills preserved in Banat, namely: Vâlculeştilor Mill from Topla (Figure 14), Cunicel's Mill from Topleţ (Figure 15), Branilor Mill from Gârlişte (Figure 16), Mill Firiz from Eftimie Murgu (Figure 17).

Figure 14. Vâlculesti’s mill from Topla

Figure 15. Cunicel's mill from Topleţ

Figure 16. Brani’s mill from Gârlişte

Figure 17. Firiz Mill from Eftimie Murgu

4. CONCLUSIONS

This work tries, in short, to highlight the evolution of water mills from ancient times. However, the subject is very vast and cannot be contained in a single work. From here, from these primitive mills, we reached the huge hydroelectric power plants today. This paper tries to summarize a retrospective of the beginnings of the use of mills in various activities, which led to their evolution until today. It is interesting that some mills are in functional condition and it should be studied that they could work even today in some inaccessible places.

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