Introduction

Europe has centuries-old traditions in both inland navigation and hydroengineering. These traditions have also been present in Polish history. In spite of the diminishing importance of inland waterways as crucial transportation arteries, there are in Europe (as well as in Poland) numerous canals and navigable rivers whose hydrotechnical infrastructure is an example of craftsmanship. With the development of rail and roads, waterways were pushed to the back as a means of commercial goods and passenger transport. However, today’s generation’s interest moves towards the slow motorboat tourism, therefore once industrial water trails now are turning into tourist trails. This article presents selected, the most interesting European hydrotechnical objects. They include:

I. inclined plane in Arzviller
II. inclined plane in Ronquières
III. round lock in Agde
IV. staircase locks (France, Sweden, Great Britain)
V. rotating boat lift in Falkirk
VI. tunnels (e.g. in Malpas)
VII. aqueduct in Beziers
VIII. aqueduct in Pontcysyllte
IX. boat lifts (Belgium, Germany, Great Britain).

The most interesting Polish hydrotechnical objects presented here are:

1. inclined planes on the Elbląg Canal
2. inclined planes in Pakość
3. staircase lock in Paniewo
4. ground lock in Kroskowo
5. tunnel in Stare Jabłonki
6. aqueduct in Fojutowo
7. aqueduct on the Ilawa Canal
8. siphon – junction of the Klodnica River and the Gliwice Canal
9. drawbridge in the Żuławy Region (in Drewnica)
10. pontoon drawbridge in Gdańsk Sobieszewo
11. rotating drawbridge in Giżycko

Poland can proud itself on numerous hydro engineers who had built navigational canals and equipped them with necessary infrastructure both in Poland and abroad. The most known is Gabriel Narutowicz who was also a president of Poland in 1922. Although there has been some regress in recent decades in Poland, some canals and navigational rivers still live and fill tourists with admiration for the infrastructure. Since motorboat tourism (especially barge tourism) has been gaining on popularity in recent years in Poland, it is reasonable to present the most interesting objects of waterways in Poland and in Europe. International boat charter companies offering barges are operating dynamically in Poland providing cruises that meet needs and appeal to tastes of every tourist. Hydrotechnical objects are attractions that make a cruise an exciting and interesting experience.

Invention of chamber lock

A lock is a device for raising and lowering vessels (ships, barges, yachts) between stretches of water of different levels on river, lake or canal waterways. It is a fixed chamber in which the water level can be varied.

A chamber lock was invented in China in 984 by Qiao Weiyue who had been appointed a deputy transport minister a year earlier in the province of Huaiian. Until then Chinese had used inclined planes on which flat-bottom boats by the means of rope (that was wound on the winches set in motion by oxen) were hauled. During this operation boats had very often been damaged or crushed and transported goods (e.g. emperor’s grain) stolen. Qiao Weiyue solved this problem by building the first in the world chamber lock.
on the Western River. It was 50 steps (250 feet) long and enabled to cover the level difference of 4-5 feet. This invention became commonly used in China and triggered the development of water transport as well as the construction of the Grand Canal and the Magic Canal. The first chamber lock in Europe was built in 1373.

**Types of locks**

In Poland the most common are one-chamber locks, e.g. Przegalina (on Martwa Wisła), Gdańska Głową (on the Szkarpa River), Gawrony (on the Ślesin Canal), Przewięź (on the Augustów Canal), Miłomłyn (intersection of the Ilawa Canal and the Ostróda-Elblag Canal).

There are twin parallel chamber locks, e.g. Karwik (on the Jeglin Canal in the Masurian Lake District). Even though the locks were wooden, today some of them are still working, e.g. on the White Sea-Baltic Canal. In Poland in Krostków there is probably the only in Europe a ground lock having only the ends strengthened.

The most modern locks are rectangular with concrete or bricked walls. There are some exceptions, however. The cross section of Guzianka lock is trapezoid (the wider part being water level). In such locks when the water level is high there is more place for vessels than when the level of water is low. The lock keepers have to be careful when letting the vessels in at high water level. If there are too many boats, they may get crushed while water is lowering. On the Canal du Midi (France) locks are ovoid. They are modelled on the arched vault. This solution was applied to prevent the chamber from collapsing. On the same canal there is an interesting round lock in Agde. It is at the junction of water routes and there are three entrances. The plans to build Canal du Midi appeared under the reign of Francis I. He brought Leonardo da Vinci to France in 1516 and commissioned a survey of a route from the Garonne at Toulouse to the Aude at Carcassonne. The construction of the canal itself took place from 1666 to 1681 under the supervision of Pierre-Paul Riquet a high rank official. It was formally opened on 15 May 1681 as Canal royal en Languedoc (Royal Canal in Languedoc). It was also called Canal des Deux Mers (meaning canal of the two seas). Its main task was to transport the newly built war ships from the Mediterranean Sea to the Atlantic Ocean. Due to the canal it was possible to omit Gibraltar ruled then by the hostile Spain. Du Midi Canal is one of the oldest in Europe. It has fascinating monuments, e.g. 170m long tunnel in Malpas, built within 6 days in 1679, therefore it is also the oldest tunnel in Europe.

**Multi-chamber locks and the Augustów Canal in Poland**

If it is necessary to overcome a substantial difference of levels within a short section of waterway, multi-chamber staircase locks are built, e.g. two-chamber lock in Paniewo (Augustów Canal) or four-chamber lock in Niemnowo (the Augustów Canal). At the end of XVIII century, Prussian economic sanctions disturbed the transport of Polish goods on the Vistula to Gdańsk which as a port also imposed duties on goods (in 1823 these restrictions led to a trade war between Prussia and Polish and Russian representatives). In such a situation an idea to build a waterway connecting the Vistula river and Neman river was born. This waterway would connect the Vistula with the Windawa River at the Baltic Sea and would omit Prussian territory. The authors of this project were a group of Polish military officials supervised by lieutenant colonel Ignacy Prądzyński (later a general of the Polish Army). The project was approved by the government of Kingdom of Poland on 27th July 1824.

Tsar Alexander II was persuaded into construction of this canal and he commenced it in 1825. The first eastern section from the Neman river to Augustów city was ready in 1830. By the end of 1839 the canal was completed. It had never really played a strategic role as a waterway connecting the Vistula river and the Baltic Sea, that omitted the city of Gdańsk. Fares paid by vessels going up and down the route didn't cover the actual expenses on the canal since their number was low. However, the economic situation of Kingdom of Poland changed. Prussia resigned from the heavy duties imposed on goods transported on the Vistula. Obviously, the Augustów Canal played a spectacular political role.

**Multi-chamber locks in Western Europe**

Multi-chamber staircase locks are found on European waterways. They consist of eight to twenty chambers. The waterways with cascades of locks include: Du Midi Canal (Fonserannes, near Beziers, France) eight-chamber staircase lock the first in Europe, the Göta Canal (Sweden), the Kennet-Avon Canal (in Devize, England) with 29 or 28 (depending
Impressive constructions of European waterways

Currently, other alternative devices are used to let a boat cover a high difference of level in a short distance. The most interesting include:

1. Inclined plane with a dry carriage

Such solutions can be seen on the Elbląg Canal. The inclined planes consist of two parallel rail tracks, boats are carried on the carriages which run on these rails. The first project of Elbląg Canal was drawn in 1837, yet the construction itself began in 1844. The first four dry inclined planes – Buczyniec, Kąty, Oleśnica and Jelenie – were then opened. The designer and supervisor Georg Jacob Steenke was commissioned by Frederick II to connect the Eastern Prussia and the Baltic Sea with a navigable route. The last inclined plane i.e. Caluny (by Lake Drużno) was built between 1874 and 1881. Each of these inclined planes enables to overcome the difference in water level of 20m.

2. Inclined plane of longitudinal type with a caisson filled with water

In contrast to dry inclined planes, here a vessel is being transported in water. The example of such a construction is, opened in 1968, an inclined plane in Ronquieres in Belgium. Its length is 1432m and it lifts boats through 68m. Each caisson measures 91metres by 12metres. It takes 50 minutes in total to pass through the entire structure. It can carry one boat of 1350 tonnes or a few smaller within the same limits.

3. Inclined plane of transverse type with a caissons filled with water

The system works by lifting or lowering a caisson containing a boat on a carriage along a slope using a balancing counterweight. The only difference comparing to the previous longitudinal type is the position of the caisson. An example of this structure is the inclined plane in Arzviller, France. The difference of water level is 44,5m.

4. Boat lifts

Boat lifts are hydrotechnical structures transporting up or down vertically vessels in a container – a bath filled with water. It works in the same way as lifts for people. The oldest boat lift in Europe was built in Anderton in 1875. It is still serving on duty and is a monument. The highest lift in Europe is a new structure in Strepy Thieu in Belgium built in 2002. The difference of water level is 73,15m. Another important lift just within 12km from the Polish border is the construction in Niederfinow on the Odra-Havel Canal. This object was built between 1927 and 1934. The difference in water level is 36m.

5. Rotating (lock) lift

Today the most fascinating hydrotechnical structure on European waterways is the rotating lock in Falkirk in Scotland. It was built in 2002, the difference of water level is 24m. It replaced 11 locks and made sailing between Edinburgh and Glasgow easier. It works in the same way as a big wheel in an amusement park. The whole operation takes 15 minutes. Each of the gondolas is 25m long and its weight (vessel and water) is 300 tonnes.

Apart from the above mentioned, other interesting hydrotechnical objects include tunnels, aqueducts and drawbridges. Europe has many of such objects. One of the more interesting and distinctive European aqueducts is navigable Pontcysyllte Aqueduct designed by Thomas Telford. It carries the Llangollen Canal (in use since 1846) over the valley of the River Dee 39m above the river.

Polish hydrotechnical appliances

Poland has as well numerous interesting hydrotechnical appliances, some of them are presented below.

Tunnels

In Poland there is one navigable tunnel for small boats or yachts in the village of Stare Jabłonki. It was built in 1872 between Lake Szeląg Maly and Lake Szeląg Wielki.

Aqueducts

Poland has no stunning navigable aqueducts, nonetheless worth mentioning are the following objects:

- Siphon of Kłodnica – an intersection of Kłodnica River and the Gliwice Canal going above Kłodnica River
- Aqueduct in Fojutowo (10km to the south of the Czersk town) which proves an attraction on the canoe trail. It forms a crossing of two watercourses, the Czerska Struga below and the Great Brda Channel above. This aqueduct was built between 1845 and 1849.
1. Ilawa Canal – it crosses Lake Karnickie. It runs on the dike that divided the lake into two smaller ones called Lake Karnickie and Lake Jezierzno. Since the water level of this lake is 2-3m lower than that of Lake Jeziorka (the largest in the area) constructors decided to create a 6m high, 484m long and 50 wide embankment on the bottom of the lake. Its upper part above the water level holds a watertight channel which is 10m wide and 1,5m deep. It was opened in 1860. There is an emergency gate (in Zagadka, Ligowo – its width is 4,4m which limits the width of yachts that can enter the canal). The gate looks like a lock.

Drawbridges

- The most famous for drawbridges in Poland is the Szkarpawa River. There are one span bridges. The largest and most modern is in Drewnica.
- An interesting example is a pontoon drawbridge on Martwa Wisła in Gdańsk.
- Finally a rotating drawbridge (built in 1848) in Giżycko on Giżycko Canal – one of the busiest sailing routes in Poland.

Conclusions

Hydrotechnical objects have been indispensable from the dawn of history to make a waterway suitable for navigating. The difference of water levels is for a vessel impassable barrier unless objects like locks, inclined planes, lifts or aqueducts are introduced. Tunnels are, in a way, a forced solution which has to be applied when construction of system of locks or other complex objects to cross a hill or a mountain is uneconomic. A water tunnel connects two sections of a trail by eliminating the level difference. Eventually, drawbridges, they let the waterways and roads co-exist. Apart from the practical and economic benefits (goods and passengers transport) hydrotechnical objects are great tourist attractions. They become the superior attractions during a cruise, sometimes even the cruise destination. Such objects attract not only boaters but also car tourists who come just to watch, e.g. Falkirk Wheel in Scotland.

Abstract

This article presents selected European and Polish hydrotechnical structures of waterways, their history, present state and the latest construction trends. Waterways were pushed to the back as a means of transport for industry when the rail and roads developed. Nowadays there are new possibilities arising for waterways as water tourism has become a very popular way of leisure. The key attraction for tourists on water is navigating through hydrotechnical structures, for example locks. Europe can proud itself on considerable achievement in this field. Numerous, unique and brilliant lock constructions still working are the “living” proof of the European technical thought.

References