

# ACTIVE FISH PASSAGE – THE WAY TO ECONOMICALLY CLEARING WATERCOURSES

**Technology developed in Polish conditions reveals a new approach to clearing watercourses. For the first time in history, a fish ladder becomes a device that ensures the profitability of such an investment. The surplus electricity can become a source of generating positive cash flows. The article presents the principle of operation of the fish pass and the possibilities of its application.**

The purpose of the fish passage is to allow the migration of aquatic fauna species along the river bed, both upstream and downstream. The fish passages are supposed to replace natural river rapids in places where water damming structures were built. In general, traditional fish ladders, regardless of the technology in use, “divide” the difference in water level before and after the damming structure into ten or so, or several dozen parts (depending on the size of the difference). This is achieved by building a sufficient number of interconnected pools with a different water level, elevated by appropriate height. The difference and flow rate between consecutive pools are selected in such a way that certain fish species are able to overcome them by swimming against the current. The idea of an active fish passage is to force the water in the pools to move up and down the river.

## PRINCIPLE OF OPERATION

One could imagine a few technical solutions for forcing an adequate volume of pool water to move, but the most easily feasible and, at the same time, allowing for the use of energy of the descending path of the fish passage, is the use of Archimedes' screw as a working element. The screw allows water to be transported in both directions (originally, Archimedes' invention was a pump), pumping takes place without changing the water pressure in open high-capacity chambers with low linear velocity. All these parameters make it possible to safely “transport” fish in both directions of the river. In terms of technical design, the fish passage consists of two paths - the ascending path, pumping water up, and the descending path, bringing water down. The principle of operation of each path is based on the principle of operation of Archimedes' screw, but the elements differ in terms of their design. The ascending path consists of a large diameter



Source: Flying Fox Michał Lis for Instytut OZE Sp. z o.o.

pipe with an internally welded single blade of Archimedes' screw. The whole system has bearing connections in two places and is driven by a gear motor. Its end, from the tailwater side, is completely submerged in water, making it possible to take the water from the bottom position and transport it to the top position together with migratory organisms. The descending path consists of a shaft with externally wound Archimedes' screws blades, usually four, arranged

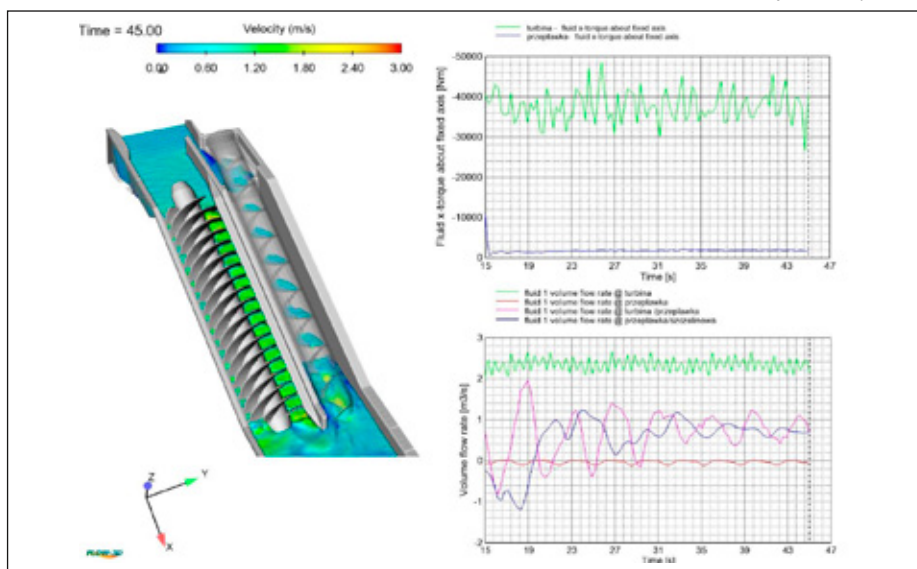
in 90-degree increments. The whole system also has adequate bearings and cooperates with a trough with a size slightly larger than the outer diameter of the blades. In the case of a descending path, the rotor with blades is driven by water pressure.

## ENERGY-POSITIVE FISH PASSAGE

The individual blades, in cooperation with the trough, form chambers in which the fish can be floated safely down the river. Speed

Simulation of flow through the fish passage

Source: Instytut OZE Sp. z o.o.



(that must not be too high) is fundamental for safety. The hydraulic system of the device does not ensure proper deceleration of the floating water speed, and it is necessary to slow down the rotor speed. Braking means converting the energy of the rotating shaft into another type of energy, e.g. thermal energy, by using a friction brake. Of course, a friction brake could be used, but then only the immediate surroundings could be heated, and yet the energy could be used in a more useful way. First of all, there is a descending path right next to this system, which requires energy to raise water from the bottom position. In theory, we are able to select devices in such a way that, when mechanically connected with each other, they could drive and brake each other, but it would be necessary to complete energy balances of both devices, taking into account the efficiency of mechanical systems that connect them. However, it could be very difficult to create such a mechanism in practice, due to the changing conditions in the river.

Thus, it seems much more practical to convert mechanical energy into another kind of energy and use it for propelling the ascending path. In this case, electricity is the optimal choice. The rotor in the descending path can be braked very effectively by means of an electric generator that produces electricity, which can supply power to the gear motor for the ascending path. It should be remembered that practically the entire amount of water flowing downstream in the river could be used for supplying power to the descending path of the fish passage, instead of passing through the damming structure unproductively. If you were to do an energy analysis of both paths at that time, it would turn out that the descending path produces several times more energy than the ascending path needs to work. This makes such a fish passage not only an active but also an energy positive system (it produces energy). The power grid is, first of all, an appropriate buffer

Active fish passage – the implementation in Starogard Gdański



Source: Instytut OZE Sp. z o. o.

that reduces problems with the variability of flow in the river (which would be the case if a mechanical connection was used) and allows you to manage the surplus energy produced.

#### ADVANTAGES OF THE ACTIVE FISH PASSAGE

The main advantage of an active fish passage in relation to a traditional fish ladder is a much smaller amount of space required for its installation. Due to the small differences in height between consecutive pools and a large volume of individual pools, traditional fish ladders are structures that require a lot of land. An active fish passage, which uses Archimedes' screw, would occupy several times or even more than ten times less land, depending on the difference in water levels. This is directly related to the magnitude of interference in the natural environment and the costs of the investment.

An additional advantage of the active fish passage over the traditional one is the difference in the way a fish crosses the ascending path. In the case of a traditional fish ladder, the fish have to overcome the cur-

rent of water in the cracks on their own, which makes them exhausted. In the case of an active fish passage, the fish are lifted together with the water and they can overcome the level differences without any loss of strength.

#### APPLICABILITY

The basic limitation of using the described active fish passage is the amount of level difference. Due to the size and limitations related to the angle of inclination of the fish passage of this type that can be applied, the upper limit of applicability is about 5m of level difference. Of course, in specific cases, if the terrain conditions allow it, it is possible to use a cascade of fish ladders, which solves this problem. The range of applications is:

- use of eco-flow turbine at existing hydro-power plants,
- in the construction of a new SHP, ensuring two-way fish migration,
- clearing the watercourse at other weirs.

#### TECHNICAL PARAMETERS

As to the size of the ascending path device, it is usually a pipe with a diameter from 1 to 1.5m and a length depending on the level difference, from a few meters to even more than 20m in length. In the case of the descending path, the diameter of the rotor is between 2 and 3.5m, depending on the amount of water to be brought down the river. Devices of this size have a quite considerable weight, ranging from a few to a dozen or so tons. As it comes to the ascending passage, the power of the devices may vary from a few to a dozen or so kilowatts; as far as the descending path is concerned, the power is from 20 to even about 200kW in the case of the largest devices.

Thanks to many years of experience, knowledge and involvement in research and development projects, we deliver a new product to the market in the form of an active fish passage. We are convinced that it will become an excellent alternative to traditional fish ladders and will increase the ecological capacity of river sections.

Instytut OZE sp. z o.o. implements a project co-financed by European Funds "Research and development to design an innovative active fish and aquatic fauna passage". The aim of the project is to increase the innovativeness of Instytut OZE by carrying out complex R&D work allowing for adding a new product to the Company's offer in the form of an active fish and aquatic fauna passage. The EU co-funding of the project: PLN3,002,157.50



Republic of Poland

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Łukasz Kalina  
Business Development Manager  
e-mail: lukasz.kalina@ioze.pl  
+ 48 512 008 805  
Instytut OZE Sp. z o.o.

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