

FlowMixer™ , The Vortex process Technology (VPT) for Aeration, Aquaculture and Waste Water Treatment



Background;

During heavy rain enormous masses of rain water fills up rivers and water courses and moving a lot of BOD (Biological Oxygen Demand) and COD (Chemical Oxygen Demand) from the acres to the rivers. The result is that the oxygen levels in the rivers decreases endangering the aquatic life and releasing chemical substances, a very bad smell is related to this as well. Later on, untreated waste water over floods waste water plant releasing untreated water into the sea.

A new kind of aerator, the FlowMixer™, that instantly can be set to operate and that can introduce sufficient amount of oxygen in a short time, is needed. This new aerator must have a rugged design making it possible to survive the hard conditions in our rivers but yet agile so it can be used in other applications as aquaculture and waste water treatment. The actual design was made in the form of a vandal proof “protective box”, with 10, Watreco FlowMixer™ 10 units connected in parallel, see picture above.

Demonstration;

In this project a large scale test of the FlowMixer™ was partly financed by EC (European Commission) and done in collaboration with the Municipality of Eindhoven, Waterschap de Dommel and the Technical University of Eindhoven. The purpose of the test is to check the feasibility of this new type of aerators in small rivers. These small rivers can suffer of oxygen after heavy rainfall or when large amounts of deoxygenated water are added to the rivers by means of sewage water treatment plants.

Sewage Treatment Plant (STP) Eindhoven is the largest in the field of sewage treatment of the river De Dommel and contributes significantly to the water quality of the river Dommel. Thus the effluent yields under dry weather flow in the summer about 50% of the flow in the Dommel, which rises to around 90% during long showers with rainwater supply.

The secondary purpose was to get a better view on the energy consumption of this specific aeration technology. Furthermore, the ecological impact of this technique on the local river environment will be investigated. The test was done at the waste water treatment plant in Eindhoven, Holland.

In addition, all municipalities’ sewers along the Dommel overflow about 10 times per year into the river Dommel. As a result the oxygen concentration in de Dommel gets extremely low, which is bad for the

ecological life around the river. These oxygen depressions are harmful to plants and animals in the Dommel. De Dommel Water Board and the city of Eindhoven take measures against those depressions in various ways. It requires that the oxygen depressions are completely eliminated in order to meet the environmental goals. From a previous project called Kallisto it is concluded that surface aeration is the most cost effective and the only real viable measure.

De Dommel Water Board and City of Eindhoven wanted to gain more knowledge about the new technology through a pilot project. This as preparation for the construction of a 10 times larger full scale plant that will have the capacity to introduce 250 kg of O₂ per hour into the water. This full scale plant will be financed by EC and it will also be the object for attention from environmental authorities and politicians from EC.



The aerator in action in the river Dommel Litter in the river during “normal” conditions

The results of the test was that the average amount of oxygen that was introduced into the river varies between 9,5 kg/O₂/h (dry weather conditions) to 17 kg/O₂/h wet weather conditions. The expected values were between 3 to 5 kg/O₂/h.

As the VPT is a vacuum technology the efficiency is depending on the outer pressure, i.e. the depth of the water. This means that if there is a higher water level the back pressure from the outside equalize the sub pressure inside. This was compensated with the aid of an auxiliary fan, and after introducing this fan, the process was very robust.

The pilot plant had not observable effects on the aquatic fauna and flora.

The pilot plant was not affected but the very high water flow and level. Sometimes there was a difference of 3 m compared to normal levels.

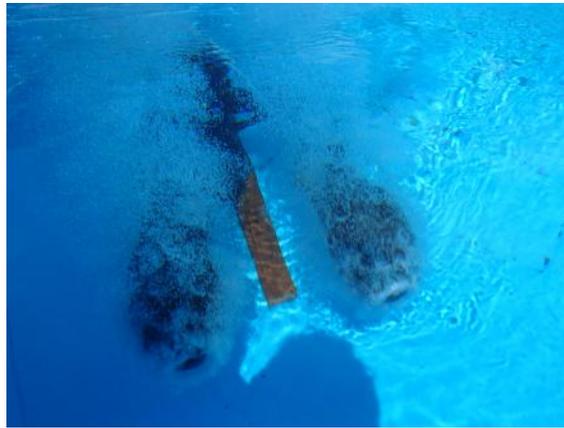
The design of the pilot plant was very sturdy and was not affected from contaminations as bicycles, tree branches plastic debris and similar.

Technology Description

VPT for Aeration - Watreco FlowMixer™ system

The solution is based on a low energy use VPT, developed in Sweden by Watreco and distributed worldwide by H2O Vortex. Watreco A.B. holds the world-wide patents on the VPT. The technology as applied to aeration has been installed in more than 10 customer sites in the EU such as municipal ponds, fish farming and river restoration.

The FlowMixer™ system was planned and developed after we discovered that there was a need to control algae growth in municipal ponds. It was already known for us that introducing oxygen into the water could control algae growth. Realizing the step from removal of air bubble with the aid of vacuum to injecting air by utilizing the effect was not very big. The first test with an improved version of another product from Watreco, the IVG went very well. The further development was focused to find a way to make the bubbles much smaller and also the start a circulation as the efficiency is increased when the oxygen level is low. Bringing de oxygenated water to the unit, increases the transfer of oxygen. A theoretical estimation lead to the insight that certain geometries is very benevolent for the two main criteria. By utilizing both the inside and the outside of the FlowMixer™ unit it was possible to create very fine bubbles and a circulation at the same time. The first tests verified our design.



When this technology, for aerating is utilized, much higher efficiency is achieved as the bubbles are very fine and the back directed flow on the outside gives an effective circulation. When this is combined with ongoing monitoring of performance as in the pilot plant, significant benefits can be realized compared to the traditional treatment methods.

The technology tested at the location is a big scale treatment process that uses a combination of these physical treatment disciplines:

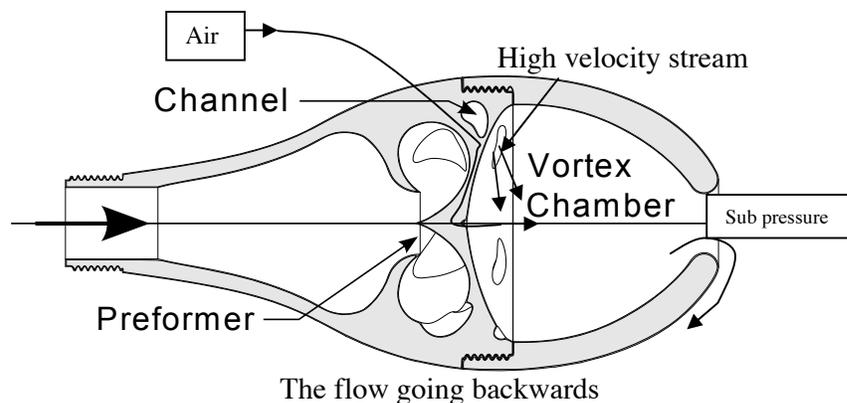
- Hydrodynamic cavitation, causing the sub pressure inside the FlowMixer™
- Introduces air from the outside into the water
- Makes it possible to mix gasses or other liquids and even a powder into the flowing media.
- Gives a high efficiency and a high oxygen transfer as it creates very fine bubbles
- Integrated Monitoring and Control System

One of the ideas behind VPT is to allow a fluid to self-organize into an ordered vortex movement utilizing the complex design of the vortex chamber and the pressure of the water or other media. The unique biomimetic design of Watreco's vortex generators enables a consistent and low energy method to achieve

water treatment in a variety of end-use applications design and it is possible to generate a well-defined and controlled vortex at a considerably lower pressure and flow than what can be achieved through other techniques. The VPT is based on no moving parts, continuously processing of fluids and requires a minimum of maintenance. It is manufactured in Sweden using a 3D printing technology.

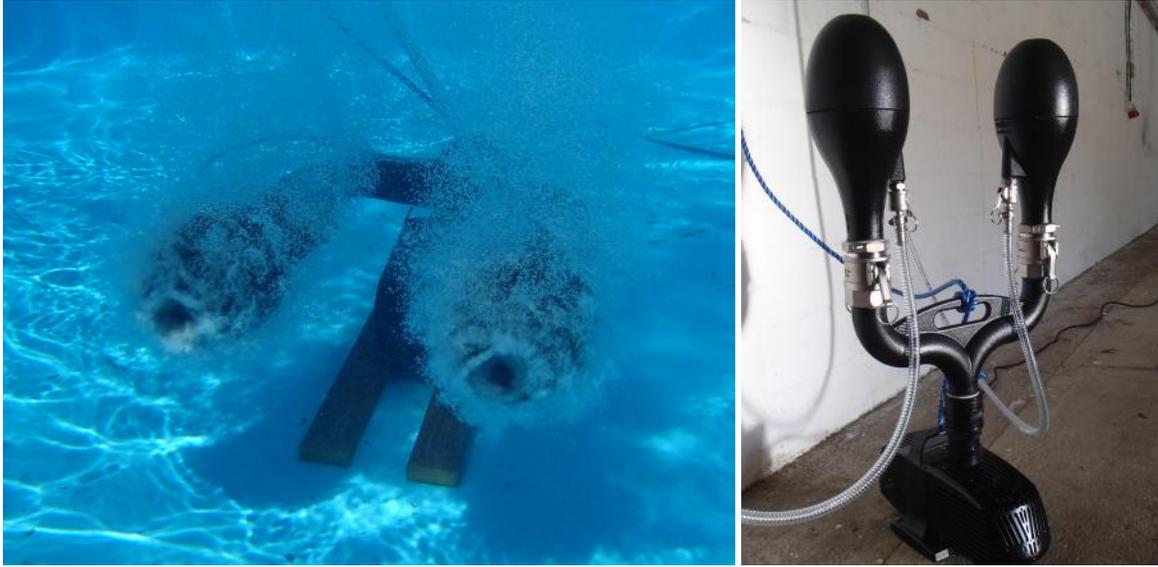
The vortex generator shapes the fluid flow in three stages:

- Pre-former: The inlet of the vortex generator provides a smooth outward direction of the flow through toroidal motion toward a set of well-defined channels.
- Channels: After the pre-former, the fluid is directed through the channels, each with vortex-forming geometry. Each channel delivers a very high velocity stream of vortex flow tangentially into a vortex chamber.
- Vortex chamber: In the vortex chamber, the vortices from the channels are wound together. A strong and stable vortex flow is formed inside the vortex chamber, causing reduced pressure along the vortex axis. There is very high pressure at the periphery and almost vacuum in the center.



The FlowMixer™ unit is sub merged and the sub pressure in the center of the vortex is connected to the air via a hose. The air and water is strongly mixed inside the FlowMixer™ and ejected through the opening. Here the “fat lip” bends the out coming vortex and the outside of the FlowMixer™ acts as an airfoil so the flow is directed backwards. During this process the pressure is lowered and the air is “ripped” into very fine bubbles. The lowered pressure is applied at the front of the FlowMixer™ which also acts on the water being on the front of the unit. As the flow then is directed backwards there will be a flow of the surrounding water as well. All in all, the FlowMixer™ unit will introduce air into the water and move the oxygenated water as well.

VPT Applications



The free standing version of the FlowMixer™, in this case in twin mode. This version is perfect for small municipal ponds or aquaculture applications.

Some examples of possible applications:

Aeration

By pumping water through the FlowMixer™ it is possible to achieve a very high oxygen transfer. This will give a high efficiency so low energy consumption can be achieved or a high capacity for the same size. Usage in big systems has high energy consumption. The FlowMixer™ can be run on solar or wind generated power something that is important in remote systems.

Aquaculture

The FlowMixer™ solution is very beneficial is used for aquaculture applications. Adding sufficient amount of oxygen in both fish and shrimp ponds increases the productivity. If the oxygen level is always kept above 90% of the saturation, the growth of shrimps is increased by a factor of 5. The FlowMixer™ represent a lift in the technology compared with the oxygenating method used today. The mainstream today is to let the seawater overflow into the ponds during high tide. However, this infects the ponds with various diseases that must be treated. By effectively introduce oxygen with the FlowMixer™ it is possible to use very little chemicals as antibiotic in order to let shrimps / fishes stay healthy. In the end, a healthier and less chemical treated product is produced in a more efficient production.

Waste water

Treating waste water utilizing the FlowMixer™ unit is excellent. Especially in cases where flocculation is used. The FlowMixer™ is here used as a DAF (Dissolved Air Flocculation) unit that increases the flocculation of very small particles.

In the example with waste water from the food industry is received into a waste water plant. The water is digested in a bio digester and biogas is the end result. The problem is the vegetable fat comes with the waste water and it needs to be removed before the bio digester. Normally it is just skimmed from the surface leaving the smallest fat drops in the water. When the FlowMixer™ is introducing the fine bubbles the fat

adheres to the surface of the bubbles and they float to the surface and can be skimmed off. The result is better “polished” water that is more suitable for bio gas production.



Test in a waste water treatment plant where residuals from agricultural industry (Red beats...) are treated. Please note the fine “foam” from the very fine bubbles in combination with the vegetable fat.

As a matter of fact even free ions in water can be removed in this way. If the FlowMixer™ unit is run in an optimal way the air is more or less dissolved in the water resulting in a “milk like” liquid with extremely fine bubbles. These bubbles even lift out ion as iron and other metals from the water.

After the bio step inside a waste water plant, sedimentation is utilized to separate the particles from the water. Sometimes filament bacteria is growing during the nitrification process. The problem here is that sometimes the bacteria capsules nitrogen gas and they float on the surface instead. In some cases the bacteria start to grow and the mass of bacteria can over flood the pond. By treating the water with the FlowMixer™ there is a lesser tendency to float and the growth can be controlled.

Anti Algae

As mentioned earlier the growth of algae in various ponds is a huge problem. This because the pond is over fertilized and the oxygen level goes too low. This means that the algae takes over and suffocates the other aquatic life. This is also connected to a very high pH-level, sometimes up to 9,5



A typical pond on a golf course where the FlowMixer™ treats “thread alga blooms”. The situation was controlled after 3- 4 weeks. By introducing oxygen via the FlowMixer™ both oxygenation and circulation is achieved. The pH-level goes slowly towards neutral and the oxygen starts to act on the algae. After some

weeks the algae falls to the bottom where the now “oxygen boosted” micro biological life deteriorate the bio material from the algae and the oxygen levels are maintained. After some time, the pond or small lake is brought back to life. The system works more efficient and is less harm full compared to UV-light systems.

Ongoing monitoring of performance

Monitoring and Control system integrated with delivered technology Consistent with Best Practices

Web access, alarming, trending and reports

Technical Summary

- A comparison between the pilot FlowMixer™ plant with other types of agitators in a similar cases as in the waste water pond show that the pilot FlowMixer™ plant can do the same work or better, i.e. circulating and aerating around 2000 m3 per hour but just using 50% of the energy used by other types of agitators. An average type of agitator uses 28 plus 2 kW (agitating and air pumping), a total usage of 30 kW. The pilot FlowMixer™ plant is powered by 2 Pedrollo pumps on 7,5 kW each, 15 kW in total.
- The pilot FlowMixer™ plant can operate in shallow water from 0,5 m and deeper, compared with the agitator technology that need at least 1,8 m but probably more than that in order to operate properly.
- The average type of agitator need a special stand to rest when the water is to shallow, this gives a more expensive and complex solution.
- The pilot FlowMixer™ plant offers in general a less complex solution and therefore has a lower maintenance level. The pilot FlowMixer™ plant has a dual operation where the pulling in of air is built into the solution for circulation of water. The agitator uses two solitaire systems for the same solution something that is even more expensive and complex.
- The pilot FlowMixer™ plant has a more sturdy design and is vandal proof. It can better stand fouling from silt and bio material as tree branches and plastic litter or similar, compared to agitators or membrane bubbler technology.
- The pilot FlowMixer™ plant has a better oxygen transfer as the bubbles coming from the FlowMixer™ are much finer.
- The general freedom of usage is greater with the pilot FlowMixer™ plant. They can be used in ponds against algae growth without any tangling of long algae threads. The pilot FlowMixer™ plant can have different attitude so that surface water can be pulled down but with the same functioning as earlier. The pilot FlowMixer™ plant opens for an alternative powering as with wind power, both directly and via electricity.
- The pilot FlowMixer™ plant is safer for humans and animals! An agitator has a sharp, fast rotating propeller that easily can chew anything that comes into it. This also limits the agitator for use in aquaculture as it chew fishes and shrimps. Also, if an accident happens and a person falls into the water they can be drawn into the propeller of the agitator as well. The intake of water to the pilot FlowMixer™ plant is well hidden and equipped with a grid that prevents such accidents.