WEEG NEWSLETTER February 2021

The newsletter is published monthly by the University of Southampton's Water and Environmental Engineering Group WEEG, and reports things of interest in this field worldwide, as well as ongoing undergraduate student and research work in WEEG itself.

We believe that water and energy are the most important topics worldwide for the next decades. Our work covers river and coastal engineering, water and wastewater and energy related to water.

Editorial: in the late 19th Century, the flow of electricity through cables was often compared with the flow of water. The pressure or head difference was the voltage, the current was - well, the current. This led to the situation where electrical engineers actually designed fluid mechanics applications. The most famous amongst them was of course Nikola Tesla, *inventeur extraordinaire* and slightly mad.

Hydraulic Engineering International: *Fluid Dynamics and Nikolai Tesla*

Nikola Tesla is today mostly known for the introduction of AC instead of DC as the grid electricity. Amongst many other things he also invented the remote control, designed a wireless radio, and developed a system to supply everybody with free electricity. The last invention, however, did not work and led to his ruin. Anyway, in between he invented some hydraulic machines as well:

The Tesla turbine: in 1913, Tesla patented a turbine which did not have blades and worked on a principle completely different from that used by conventional turbines: it employed the friction force between a moving fluid, and a rotating disk.

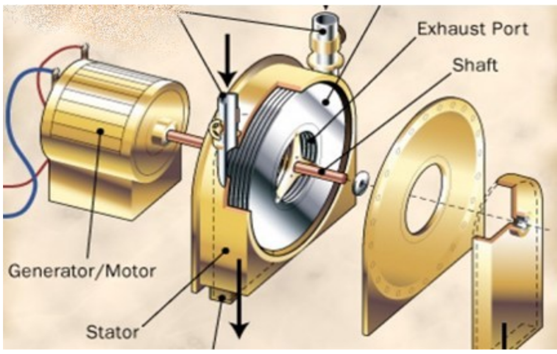


Fig. 1: The Tesla turbine

Fig. 1 shows a typical Testa turbine. It consists of a set of thin disks packed closely together, an inflow and an exit port. The fast moving fluid or gas enters the space between the disks, and the arising viscous friction drives the turbine. Although Tesla claimed efficiencies of 95%, recent tests showed typical efficiencies of 40 to 60%. The advantages of the Tesla turbine are the simple construction, and the fact that there are no components projecting into the direction of flow. The disadvantages, which prevent its use as a turbine, are the accuracy requirements for the disks at high speed. Today, modern materials allow us to overcome the disadvantages but the Tesla turbine has found its niche not as a turbine, but as a pump with a slightly modified involute shape (rather than circular as in the turbine) for the housing. This pump Is used for abrasive, viscous, shear sensitive, and other fluids where ordinary pumps have difficulties.

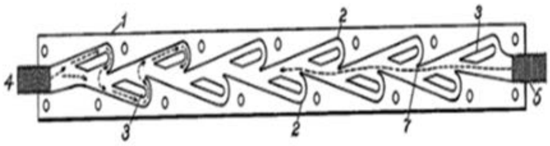


Fig. 2: The Tesla Valve, patented in 1920

The Tesla diode or Tesla valve is an arrangement of a conduit as shown in Fig. 2 where loops branch off the main conduit, and return back at an oblique angle, This leads to a low flow resistance in one direction, and a high flow resistance in the opposite direction without the need for any moving part. It is an interesting arrangement, but unfortunately it only works at higher Reynolds numbers. It is still used today, in microfluidics applications e.g. in ink jet printers.

The Tesla valve is really the origin of fluidics, and has led to the development of further components. One of them is actually employed quite a lot in hydraulic engineering, namely the ***Vortex valve:*** this is a fluidic element which consists of a circular body with a tangential inflow and an exit port in the centre, see Fig. 3.

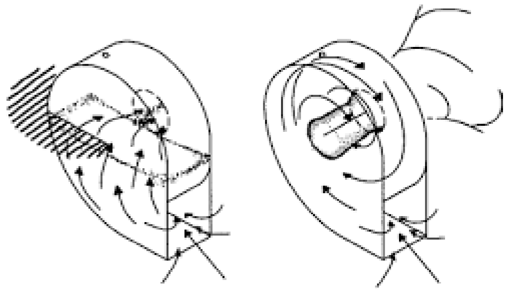


Fig. 3: The vortex valve

At low flows, as in Fig. 3 left picture, the water flows in and out without much energy loss. If the inflow pressure increases, the water will flow around the outer wall of the main body, interfering with the inflow. The higher the pressure becomes, the greater this effect. In other words: the vortex valve has a low flow resistance up to a certain pressure, from where on flow resistance increases dramatically. Fig. 4 shows the characteristic curve on the right.

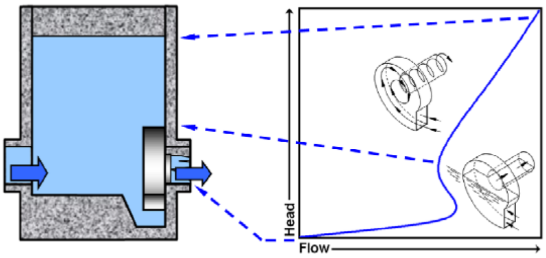


Fig. 4: Vertical vortex valve and curve

The vortex vale is used e.g. in rainwater retention, where we want a low flow resistance at low flows, a high resistance at high flows to retain the rainwater in the reservoir, and large openings so that debris does not block the control element. The vortex valve also has no moving parts, which is a big advantage. The largest vortex valve we know of is installed in the Kaunertal-Hydropower station in Austria. It has a diameter of 6.40 m, with an energy dissipation at full flow of 11 MW!

Lastly, the vortex valve effect of course does not occur when the flow is in the opposite direction, thus the link with the Tesla diode.

GDP: *Littlehampton Breakwater*

We are currently running a Group Design Project to look at the re-design of the breakwater in Littlehampton, West Sussex. The existing breakwater is interesting, since it is actually a permeable structure. It works through reflection of the waves at a sudden drop of the seabed. This is caused by the fact that the angle of the approaching wave crest is larger than the critical refraction angle, so that total reflection occurs.

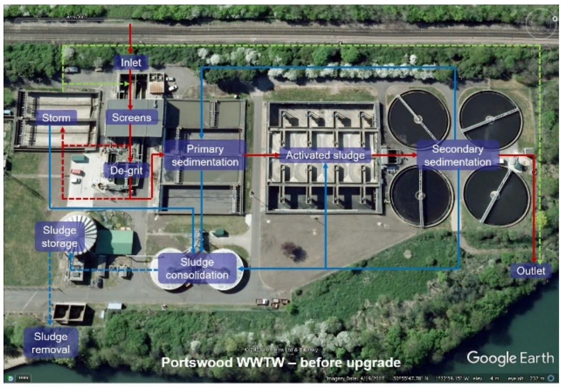
Fig. 5: Littlehampton breakwater

Unfortunately, the existing breakwater interacts with the longshore sediment drift in an undesirable manner. This causes a transverse bar (or shoal) to be formed at the entrance to the navigation channel, which significantly limits the type of vessels that can enter (and the times when they can do so), compromising the economic viability of the port. Also, the breakwater is reaching the end of its life, and a replacement is needed. Our GDP will provide the fundamental study, based on numerical simulations validated against field data, for the optimal design of the new breakwater, which should continue to shield the entrance channel from the waves, but without causing formation of a shoal.

Contact: Dr Sergio Maldonado,
email s.maldonado@soton.ac.uk

Wastewater: *Flowsheeting trials*

Not much space for wastewater topics, but we are currently using Google Earth as a teaching tool for flowsheeting, troubleshooting and upgrading of existing sewage treatment plants.



Jobs in water engineering:

This section gives you ideas of the type of work you can do when working in industry.

Civil and Environmental Engineering at Southampton University:

WEEG: our modules offer the chance to deepen your knowledge in water-related areas, and give better preparation for environmental engineering projects.

Contact: Dr Sonia Heaven,
s.heaven@soton.ac.uk, Bldg. 178, Room 5015

Further information:

We have two Facebook pages, which provide a logbook of our laboratory activities:

www.facebook.com/Hydraulicslaboratory/

www.facebook.com/environmental.lab.university.of.southampton/

Brought to you by:

UNIVERSITY OF Southampton