WEEG NEWSLETTER Feb-March 2022

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: Learning from history has many different facets. It can mean re-discovering forgotten but useful principles, or combining old and new and creating something better. Here are some further examples:

Hydraulic Engineering International: *Can we learn from history? Part 2*

In the first part of this mini-series, we looked at waterwheels as effective hydropower converters with efficiencies as high as 85%, a largely forgotten technology that could today contribute to hydropower generation again. We also looked at beaver dams, where the strange situation has developed that the current consensus as expressed e.g. in the EU Water Framework Directive is at odds with scientific and historical facts. In both of these cases, we can learn something from the past. In others, like the old controversy over the real nature of the 'living force' of water (or the kinetic energy, as we would call it today), mathematical expressions have been established and the discussion has reached a final conclusion.

Today we will look briefly at one of the oldest hydraulic machines known to humanity, for which – after a mere 2300 years – we still do not have a generally accepted theory; at the combination of old and new to create a more efficient energy conversion process; and at a type of artificial dam which is related to beaver dams but seems to have gone out of fashion.

The Archimedes Screw (AS) is a well-known machine, which was already in use to pump water in the 3rd Century BC. Fig. 1 shows the concept: the rotating screw runs in a trough, which is less than half filled, and the rotation lifts the water upwards.

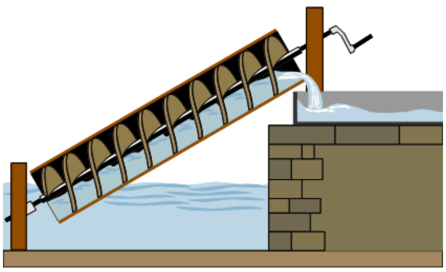

Fig. 1: The Archimedes Screw

In the 1990s it was realised that it can also be used in the reverse direction as a hydropower converter. Apparently Navier had originally suggested this application in the early 19th Century, although I have not been able to verify this as yet. Still, its performance was believed to be a function of the losses due to e.g. leakage only: meaning that its ideal theoretical efficiency would be 100% and the actual efficiency is 100% minus losses.

The new application sparked off a series of theoretical investigations, where on the one hand simple models were developed, which indicate that the performance or efficiency is actually a function of the geometry, i.e. slope and distance between blades, with efficiency reducing with increasing slope and / or reducing number of turns. On the other hand, complex numerical models were employed to analyse the performance. These models indicate that it is the slope of the turns which affects the efficiency.

It seems that after about 2300 years of its existence, these were the first serious attempts to develop a theory. I am not sure what the moral of this story is, since the application of the AS is limited to very specific areas and its design is governed by empirical rules. In other words, the value of a theory would lie more in the scientific rather than the applied area of hydraulics. In any case, the jury is still out on which approach is correct.

Renewable energy is of course today's hot topic and will remain so. Here, the work, inventiveness and originality of historic hydraulic engineers could also benefit today's work. The kinetic energy of water is abundant, especially in tidal currents. Using it cost-effectively, however, is a different matter.

Floating waterwheels were used from the 6th Century onwards. Scientific work in France at the beginning of the 19th century developed a theory for power conversion, and empirical values for e.g. the effect of blade numbers – which were found to increase the efficiency. Still, the values did not go above 34% and the technology disappeared.

Combined with modern hydraulics, however, and using what is called flow augmentation, which employs the local acceleration of the flow using flow separation, the efficiency can be increased quite dramatically. And suddenly a forgotten technology, which was considered to be very ineffective, can become interesting because - well, the technology itself is so simple, and therefore cheap and robust.

Soil retention dams: In the first part of this mini-series, we looked at beaver dams and their effect on groundwater recharge and on sediment accumulation and prevention of erosion. Roman engineers built similar, very shallow dams, especially in the Provinces of Tripolitania and Nabataea. Their purpose was twofold. First, they collected the water from the infrequent rainfall events and recharged the groundwater. The wadis or dry valleys where the dams were built often had just a rock surface, making agriculture impossible. The dams created large areas of very slow flowing water, where fine sediment would deposit. The combination of both effects led to the formation of land that could be used for agriculture. Fig. 2 shows such a dam.

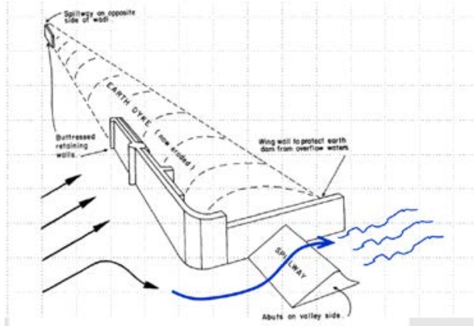

Fig. 2: Soil retention dam with spillway overflow

There are several remains of Roman soil retention dams still in existence: Fig. 3 shows a masonry dam with buttresses in Tripolitania (Libya). Note the low height of the dam.

Fig. 3: Soil retention dam with buttresses (Taregat basin, Tripolitania)

Today, the concept of building shallow dams for soil retention in rocky arid areas seems to have fallen out of fashion. This is somewhat disappointing, considering the importance of a sustainable agriculture where natural water resources are harvested rather than e.g. the use of groundwater resources up to exhaustion, which is clearly not sustainable.

Student Group Design Projects: *2nd generation floating water wheel*

Tidal and fast river currents can be a valuable source of renewable energy: even today, however, the problem is to develop a technology which can utilise this resource in a cost-effective way.

A US company, Big Moon Power (BMP) of Salt Lake City, Utah has developed a novel floating waterwheel with augmented flow, the first of which is currently under construction.

In the GDP, the students – in cooperation and with funding from BMP - are developing a 2nd generation geometry with significantly improved conversion efficiency.

Fig. 4: Testing of models in a hydraulic flume

The work includes the development and application of novel theoretical models as well as testing of a variety of configurations in our hydraulic flume facility, Fig. 4.

EBNet event: *Algal gas scrubbing*

A joint webinar on 17 May with Algae-UK and some excellent international speakers, will look at algae-based gas clean-up. A system using wastewater from algal ponds was developed and patented by Aqualia SA as part of the FP7 All-Gas project. See https://ebnet.ac.uk/events

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.

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Further information:

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

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