# WEEG NEWSLETTER May 2019

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:** Wave energy is a difficult topic. Waves could supply 1700 TWh per year, or 10% of the world's energy demand. Avid readers of the Newsletter will remember that research in wave energy started in California in the late $19^{th}$ century, and a lot of work has been done worldwide since the oil crisis in 1973 triggered renewable energy research. Today, however, there is only one commercial wave power plant operating worldwide. Let's have a closer look:

## Hydraulic Engineering International: *The Mutriku Wave Power Plant*

The wave power plant is located in Mutriku / Northern Spain. It forms part of the new breakwater which protects the harbour. The plant consists of 16 Oscillating Water Column (OWC) chambers each of 4 m width. Every chamber is fitted out with a 1.25 m diameter, 18.5 kW Wells turbine giving it a total capacity of 296 kW. Mutriku went online in 2011, and has been operating continuously since then, making it the $2^{nd}$ most successful commercial plant in the world. (Armstrong's Wave Motor of 1896 still holds the record, with 11 years of continuous operation).

**Fig. 1: Mutriku Wave Power Plant**

The planned power production was 600 MWh per year. So, where's the problem? Well, the actual power production so far was 1,600 MWh in seven years, giving an annual production of only 229 MWh per year or 38% of planned capacity. This sounds like not a lot. A recent publication went into the details of power production, however, giving reasons for at least part of the power reduction. The main reason lies in the fact that on average only 9.95 turbines were operating. Two OWC chambers have structural defects and do not hold any pressure; the rest is due to maintenance. Taking this into account, the plant produces 61% of the planned energy.

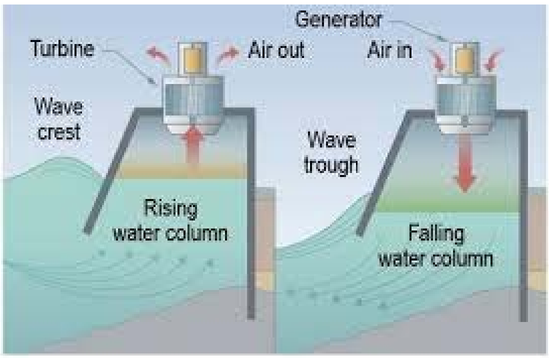


**Fig. 2: Oscillating Water Column - principle**

This leaves us with 39% of energy being unaccounted for. In order to find a reason, we need to look at the operating principle of an OWC, Fig. 2. The OWC consists of a chamber with a submerged inlet and an air space above the water level and a turbine attached to the top of the chamber. When the wave crest arrives, the air is pressed out driving the turbine. When the wave trough comes, the air is drawn in, also driving the turbine. The operating pressures range from 1.0 to around 18 kPa or 0.1 to 1.8 m of water. In the case of Mutriku, the air space has a height of 10 m and this, combined with the pressure, is probably part of the problem: the compressed volume of air is larger than the volume flow through the turbine, so that part of the energy in the air works to press out the water rather than generating mechanical energy in the turbine. The second and more important component is the pressure drop at the butterfly valve. This type of valve has a very low flow resistance when completely open ($K = 0.3$), but its loss factor then rapidly increases and reaches an astounding $K = 100$ for a 30 degree position. The valve serves to control the air flow, which is nice, but from the information it appears that at maximum power the valve has an angle of 30 degrees, and therefore dissipates 80% (!) or more of the available pneumatic energy.

The overall efficiency of the plant is difficult to determine. From our calculations, it appears that it converts 20.1% of the wave energy into electricity at 42% maximum capacity, and 6.9% of the available wave energy into electricity at 67% of maximum power. The capacity factor is

0.11, quite a bit less than that of wind energy installations (CF = 0.21 to 0.45 for offshore installations) or solar power plants (Spain: CF = 0.20 to 0.45). So, there's still a lot of work to do. The real problem appears to be the conversion of the pneumatic energy of the compressed air into mechanical energy in a controlled way, minimising compression effects and localised losses.

## Student 3rd Year Individual Projects: *the Fitz Waterwheel Company*

In this 3rd year Individual Project, the student investigated the Fitz waterwheel company and also conducted model tests to look at overshot waterwheels with very fast inflow velocities. Usually, tangential wheel speeds are in the 1.2 to 1.5 m/s range and inflow velocities about twice that value. This results in rotational wheel speeds of up to 10 rpm – quite slow, making expensive gearing necessary. By increasing the inflow speed we could increase the wheel speed and reduce the gearing costs; however, nobody ever tested such conditions before. One could expect a reduced efficiency.

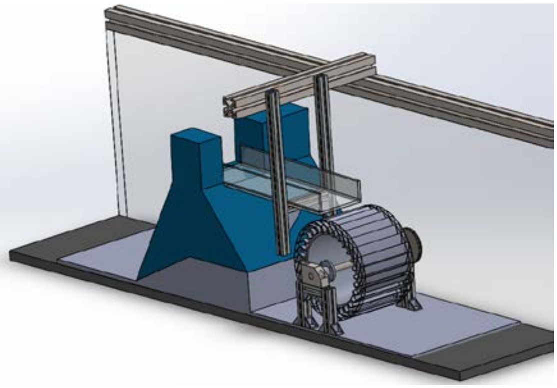

**Fig.3: Model wheel and weir**

So, the student designed and built a 1:15 scale, 210 mm diameter model wheel and tested it, Fig. 3. A steep ramp gives a fast inflow. Fig. 4 shows the test results, efficiency as function of normalised wheel speed.

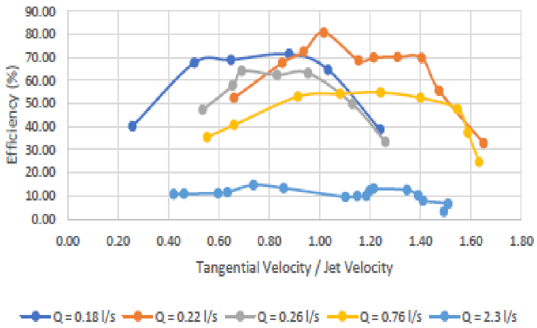


**Fig. 4: Overshot wheel efficiencies**

The efficiencies are quite independent of the wheel speed and range from 55% to 75% - about 10-15% less than a slow wheel. The wheel velocity was around twice that of an ordinary wheel, so that the reduced efficiency seems acceptable.

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## New website: *hydro.soton.ac.uk*

The Hydraulics group in WEEG has set up a new website www.hydro.soton.ac.uk where we will give an overview of the group's work, with special emphasis on recent developments in research, and a dedicated student page. The complete and utterly new WEEG site will also be available shortly.

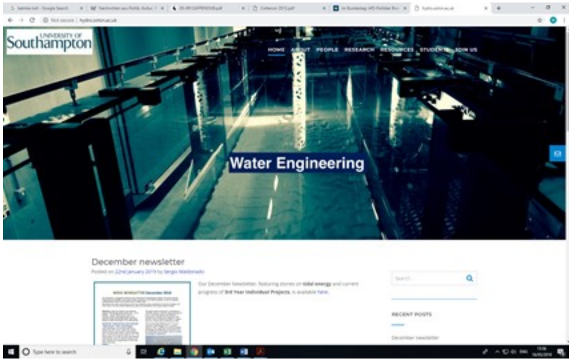


**Fig.5: Our new web page**

## Jobs in water engineering:

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



## Civil and Environmental Engineering at Southampton University:

**WEEG:** the Civil and Environmental Engineering pathway offers the chance to deepen your knowledge in water-related areas, and gives you better preparation for environmental engineering projects.

**Contact:** Dr Sonia Heaven, s.heaven@soton.ac.uk, Bldg. 178, Room 5009

Note our new addresses - WEEG staff have moved to the Boldrewood Innovation Campus

## 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/

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