WEEG NEWSLETTER August / Sept 2017

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: Hydropower is a major part of hydraulic engineering. In the last issue, we had the Barbegal mill complex with a mere 32 kW. Today, let's look at the other end of the hydropower scale where things are not only a lot bigger, but also a lot more dangerous:

Hydraulic Engineering International: The *Sayano–Shushenskaya incident*

The Sayano–Shushenskaya dam is located in Siberia, at the River Yenisei. It has an overall height of 242 m, and a length of 1066m, Fig. 1. With an installed capacity of 6,400 MW, it is the world's 6th largest hydropower installation.

Fig. 1: Sayano–Shushenskaya dam

The hydropower plant has 10 turbines, which operate with a head difference of 191m. Fig. 2 shows the turbine hall.

Fig. 2: The generator hall

On 17 August 2009, turbine No 2 started to vibrate at four times the maximum limit. Then there was a sudden bang and turbine No 2's cover flew up, and the runner (all 920 tons of it) then shot 13 m vertically out of its position. Subsequently, two things happened:

(1) The load on the other turbines was cut off, so that the turbines span out of control. Turbines No 7 and 9 were also destroyed, and the others suffered damage.

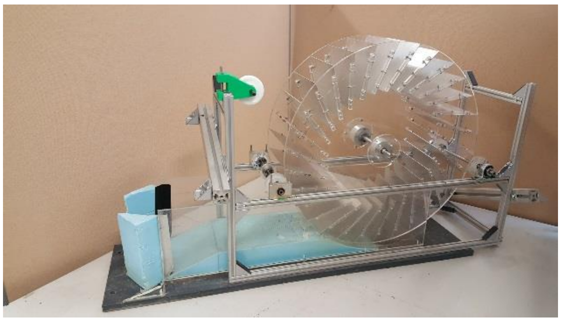
(2) The turbine house was flooded from the water out of turbine No 2's pit (300 m^3/s!). During the incident, 75 people working at the station were killed.

Fig. 3: The generator hall after the incident

There was of course a lot of speculation about the cause of the incident. One aspect was that the turbine was near the end of its working life (30 years), and that it was over loaded. The most probable cause for the incident itself was a pressure surge created by a sudden load change (look up "water hammer" in your hydraulics textbooks). The sudden deceleration of the moving water can generate an extremely high pressure surge or shock wave, which then blows out the weakest part of the system. The water hammer pressure in this instance can be up to 47 times higher than the hydrostatic pressure. This gives value of 87 MN/m^2 or 8,700 tons per square meter. These pressures only act for a fraction of a second, so their effect is explosive rather than static – as was illustrated by the fact that the 920 ton turbine runner was thrown 13 m upwards. Since we are engineers, we can try to have an educated guess at the forces acting. The travel time (or duration) of the pressure surge is t = 2*191/1450 = 0.26 seconds, and $v^2/2g$ = 13m gives us an initial velocity of v = 16.0 m/s. Since $F \times t = m \times v$, F_{max} = 560 MN or an astounding ***56,000 tons***. In the real structure, the forces would have been less, since e.g. the elasticity of the penstock pipes reduces the speed of sound. The incident shows that large scale hydropower systems are extremely challenging engineering problems, where risks have to be taken very seriously.

MSc projects completed:

Lorenzo Capecchi from the University of Turin / Italy just finished his MSc project on "Water wheels on rollers". The idea was to re-think the water wheel to reduce the costs for power take-off. The wheel itself no longe has anaxis, but sits on rollers which move 10-12 times faster than the wheel, Fig. 4. This reduces the enormous torque, and thereby the costs for a gearbox for power take-off.



Fig, 4: Water wheel on rollers

The tests were very interesting, we measured efficiency and the roller support reactions.

Ongoing MSc projects:

We have various projects running now: expect to hear more about these examples soon

- the reduction of the height of an incoming wave through energy dissipation half a wave length ***in front*** of the wave crest (yes, that's right, it is like a far-field effect),
- testing a wave wheel with a very special effect (more in the next issue), and
- developing three simple DIY hydraulic experiments with surprising effects.
- conceptual design of an energy self-sufficient municipal wastewater treatment plant
- energy and nutrient recovery potential of macroalgae produced from a sustainable multi-trophic aquaculture system in the UK

PhD position available: Hydropower for water saving irrigation

In classic irrigation systems, the water is distributed from main channels into smaller trenches, which then irrigate the fields or plants. This requires a lot of water, and today we want to utilise water saving drip or sprinkler irrigation systems. These however require pressurised flow. Now, as you can imagine, electric pumps are a possible solution but such systems need electricity lines (remember, the field are kilometers away from the next village), pumps and of course electricity. In this project, we want to investigate the use the ultra low-head hydropower converters (H = 0.10 to 0.30 m), Fig. 5, which we have developed in Southampton, combined with a very simple spiral pump. The aim is, to create a cost-effective system, which employs the available hydropower in irrigation canals to drive water saving irrigation systems. Within the project, we will build and test small scale and near-full scale systems and install a system in Spain (near Valencia), The project will run in cooperation with aQysta Ltd. (Delft / Netherlands) and is funded by the European Commission. Supervisor: Dr G Muller, g.muller@soton.ac.uk

Fig, 5: 1.8m diameter Hydrostatic Pressure Wheel

Jobs in water engineering:

This 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 a better preparation for environmental engineering projects.

Contact: Dr Sonia Heaven, s.heaven@soton.ac.uk, Bldg. 7, Room 5004

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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