WEEG NEWSLETTER June-July 2022

The newsletter is published 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: The deceleration of water causes an increase of pressure. Sudden deceleration can create extremely high pressures, the so-called water hammer effect. This has been known for centuries, but damage does still occur quite frequently both at large and at small scale..

Hydraulic Engineering International: *Water hammer*

Causes: Usually, we assume water to be incompressible. This works very well for nearly all aspects of hydraulic engineering, except for the sudden deceleration of a fluid mass in a pipe. If the deceleration or stoppage occurs near-instantaneously, then the kinetic energy of the flow is transferred into an elastic compression wave which travels upstream and can generate extremely high pressures. The pressure p is a function of the water density ρ, the flow velocity v_0 and the speed of sound c.

$$p = \rho c v_0$$

Now, when you look at the equation and remember that the speed of sound in water is 1450 m/s, you can immediately see that even a pipe flow velocity of only 1 m/s can, when stopped suddenly, cause a pressure of 145 m! In the previous edition of the Newsletter, we had a brief look at the inertia pump – a pump which employs not-quite-so-sudden deceleration. Here, the pressure was a function of the negative acceleration and the length of the fluid column. In water hammer, the length does not play a role in the pressure magnitude.

Fig. 1 shows the effect of an accidental stoppage and the ensuing water hammer on a turbine in a hydropower station.

Fig. 1: Wrecked turbine at Sayano-Shushenskaya hydropower plant in Siberia

The water hammer effect is of course well known: it has been used for pumping since the early 18th Century in the so-called hydraulic ram pump. Still, damage occurs very frequently e.g. in high-head hydropower stations in the case of sudden valve closures.

Penstocks are long pipelines which connect reservoirs high in the mountains with a hydropower station in the valley. They are particularly vulnerable to water hammer damage because of the head differences of up to 1500 m and the arising high flow velocities.

In Fig, 2 a damaged reinforced concrete penstock is shown, which illustrates the pressure magnitude.

Fig. 2: Penstock burst at Sorang Hydropower Project in Himachal Pradesh, India

And, another case:

Fig. 3: Bhote Koshi hydropower plant in Sindhulpalchok, Nepal

Earlier we said that the water hammer pressure is a compression wave. Now, a wave has a trough and a crest, so the compression in water hammer is followed by an expansion, Fig. 4. This can become important when you think of thin-walled steel pipes whose buckling strength (caused by internal negative pressure) is significantly lower than their resistance to internal positive pressures.

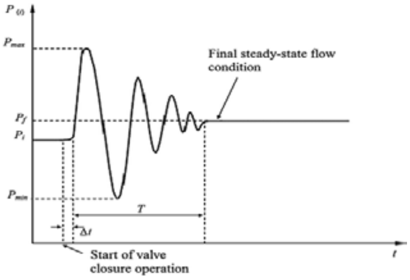

Fig. 4: Water hammer pressure oscillation

Sometimes it is the expansion that causes the damage. Fig. 5 shows steel penstock pipes which buckled inwards, indicating that the damage was caused by the expansion phase of the water hammer pressure.

Fig. 5: Pipe buckling at Mississippi River Power Corp and Bear Creek Hydroelectric project

Note that these examples of damage occurred quite recently (2009 and 2011), showing that our understanding of the need to protect against water hammer is still incomplete.

What can we do? There are several ways to reduce water hammer-induced pressures. The obvious one is to prescribe a minimum closure time of control elements, or to take care with manually closed valves, since water hammer can occur even in domestic pipe systems.

Fig. 6: Water hammer damage to domestic pipe

A second option is to provide a water hammer arrestor, which is a pressure vessel that absorbs the shock wave and reduces the pressure. A third possibility would be to aerate the water, thus drastically reducing the speed of sound: 1% of air bubbles in the water reduce the speed of sound from 1450 m/s to 100 m/s! In hydropower plants, pressure relief valves and surge tanks are used to either blow off the excess pressure, or to absorb it.

PhD Research: *Decision support for tertiary wastewater treatment*

Mohammad Zamzami is exploring the use of Choosing-by-Advantages (CBA) and Analytical Hierarchy Process (AHP) methods for selecting optimal tertiary treatments to promote wastewater re-use in Saudi Arabia - including novel dynamic membrane systems. His research involves a survey of industry professionals: now he has completed the University's ethical approval process he will fly to Saudi Arabia for site visits and interviews.

Technical dimension parameters	Your score (9 = most important, 1 = least)		
Aspects	RSF	MF/UF	DM
↑PTE1 Minor maintenance cleaning interval			
↓PTE2 Minor maintenance cleaning time			
↑PTE3 Recovery cleaning interval (major maintenance)			
↓PTE4 Recovery cleaning time (major maintenance)			

Fig. 6: Example of an AHP survey form

MSc Project: *Sludge dewaterability*

A lab-based project aims to look at some fundamental aspects of dewaterability using a range of equipment and techniques: an issue with a major impact on costs both in the water industry worldwide and for biorefinery-based systems in the emerging biotech sector. *Contact*: Dr Yue Zhang, Y.Zhang@soton.ac.uk

Event: *Environmental biotech ECR*

The Environmental Biotechnology Network's Early Career Researcher Conference is back live this year from 12-14 Sept in Nottingham: and it's free! We look forward to a host of exciting ideas on engineered systems for environmental protection, bioremediation and resource recovery. Details on https://ebnet.ac.uk/ecr22

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: Em Prof Sonia Heaven, s.heaven@soton.ac.uk, Bldg. 178, Room 5021

Further information:

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

www.facebook.com/Hydraulicslaboratory/

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