TEXT MARTIN NEANDER PHOTO MAGNUS TORLE

THE WINNING WAY OF VIRTUAL WATER

IT TAKES 140 LITRES of water – virtual water, that is – to make a single cup of coffee. "The concept of virtual water helps us realise how much water is needed to produce different goods and services," says **Tony Allan**, the 2008 winner of the Stockholm Water Prize.

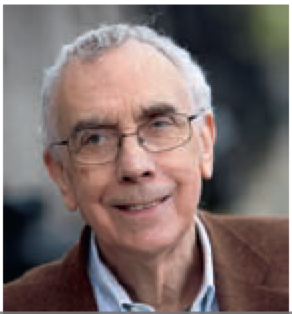
THE WINNER OF THIS year's Stockholm Water Prize, John Anthony Allan, seems to have a natural affinity for water. He doesn't hesitate to step into the impressive fountain of London's Somerset House – close neighbour to King's College London where Allan is professor emeritus – to allow that perfect picture the photographer wants.

Date of birth
29 January 1937.
Career
Started in the geography department at Durham University. After a period in the British National Service and five years in industrial management, returned to science at the School of Oriental and African Studies (SOAS) in London. After 35 years at SOAS, moved to King's College London where he is now professor emeritus.
Latest book read
Arabs, by Mark Allen.
Most influential person
Kader Asmal, former South Africa Minister of Water Affairs and Forestry and Stockholm Water Prize winner in 2000. Kader Asmal is the only other non-engineer/water scientist who has been awarded the Stockholm Water Prize.
Favourite quote
Water flows uphill toward money and power.
The best tap water ever had
In 1987 in Damascus, Syria.

"Prizes such as this usually come late in the life of laureates," says Tony Allan, 71. "However, I feel very honoured to have been recognised, and it gives me further energy to think that I have a few more years of creativity left. I also very much appreciate that the prize jury has acknowledged my interdisciplinary activity."

Allan's work has focused in part on helping people understand the hidden water use in products and services. He uses the example of a cup of coffee, which, he calculates, has 140 litres of water "embedded" in it. This amount of water is roughly the same as what is used daily by the average person in the UK for drinking and household needs.

"The concept of virtual water helps us realize how much water is needed to produce different goods and services," he says. "In semi-arid and arid areas, knowing the virtual water value of goods or services can be useful in determining the best use of the scarce water available."



For more than 40 years, Tony Allan has been interested in the technical, environmental and socio-economic problems of managing water in water-scarce regions, mainly in the Middle East. As an environmental scientist his early preoccupations were with using water resources more efficiently.

While studying water issues in the Middle East, he developed the theory of using virtual water imports via food as an alternative water source to reduce pressure on the scarcely available domestic water resources there and in other regions short of water. Over the years, it became increasingly clear to him that the trade of virtual water is closely linked to aspects such as politics, economics, agriculture and climate change.

"Virtual water trade refers to the idea that when goods and services are exchanged, so is virtual water," Allan says. "When a country imports a tonne of wheat instead of producing it domestically, it saves about 1,300 cubic metres of real domestic water. If this country is short of water, the water that is saved can be used for other purposes." He explains that, by the same terms, the exporting country has exported 1,300 cubic metres of virtual water, "because the real water used to grow the wheat will no longer be available."

Although all the water ministers in the world are aware of the issue of virtual water, the notion is still very disturbing to political leaders and senior water professionals, says Allan.

"Neglecting the implications of virtual water 'trade' enables political leaders and many millions of water consumers to be in denial for decades

> "Neglecting the implications of virtual water 'trade' enables millions of water consumers to be in denial."

about their immediate water crisis," he says. Allan cites the insight of American business guru Peter Drucker, who says it is better to do the right thing badly than the wrong thing extremely well. One of the greatest challenges that we are facing today is shifting from doing the wrong things extremely well with our scarce water and energy resources to accelerating the adoption of clean technologies.

"To this end, individual families, global corporations and public sector organisations can all be provided with estimates of the impact of their consumption of water and of goods and services on water resources," he says. "Yet there are some good signs. Coca-Cola has been among the first [multinational companies] to recognise the role of water footprints and virtual water estimates. They want to identify how they can improve their performance in water management, because they do not want to jeopardise their reputation and brand." One personal challenge Allan is facing is to become a full-fledged vegetarian.

"Vegetarian food consumers in the most advanced economies consume only half the water of a non-vegetarian," he says. "This is crucial because 80 to 90 percent of the water spent in these economies is used in producing food."

The Stockholm Water Prize

THE STOCKHOLM WATER PRIZE is a global award founded in 1990 and presented annually by the Stockholm Water Foundation to an individual, organisation or institution for outstanding water-related activities. ITT Water & Wastewater are proud to be one of the founders of the prize.

Stockholm Water Prize winners receive 150,000 US dollars along with a glass sculpture. The award this year was presented 21 August in the Stockholm City Hall. King Carl XVI Gustaf of Sweden is the patron of the Stockholm Water Prize.

Tony Allan was awarded this year's prize, "for his unique, pioneering and long-lasting work in education and raising the awareness internationally of interdisciplinary relationships between agricultural production, water use, economies and political processes."

VIRTUAL WATER
IN DIFFERENT PRODUCTS (L)

1 glass beer (250ml) 75
1 glass milk (200ml) 200
1 glass wine (125ml) 120
1 cup coffee (125ml) 140
1 cup tea (125ml) 35
1 piece bread (30g) 40
1 potato (100g) 25
1 egg (40g) 135
1 hamburger (150g) 2400
1 cotton T-shirt (medium, 500g) 4100
1 page A4 paper (80g/m²) 10
1 pair of shoes (bovine leather) 8000
1 microchip (2g) 32

Source: SIWI, UNESCO-IHE Institute for Water Education

TEXT MARTIN NEANDER
ILLUSTRATIONS LADISLAV KOSA, ITT WATER & WASTEWATER

"Once you have done the simulation with CFD, there is a huge amount of information available." GUILLAUME MERCIER

Stimulating SIMULATION

More and more industries are using simulation to design new products and to find new application benefits. No matter if it is to test how aeroplanes fly or the function of water pumps – simulation is an indispensable tool.

SIMULATION IS THE SAME as an imitation of real things, state of affairs, or processes. Simulating something means that certain key characteristics or behaviours of selected physical or abstract systems are represented.

Simulation is used in many contexts, including the modelling of natural or human systems in order to gain insight into their functioning. Other contexts include simulation of technology for performance optimization, safety engineering, testing, training and education.

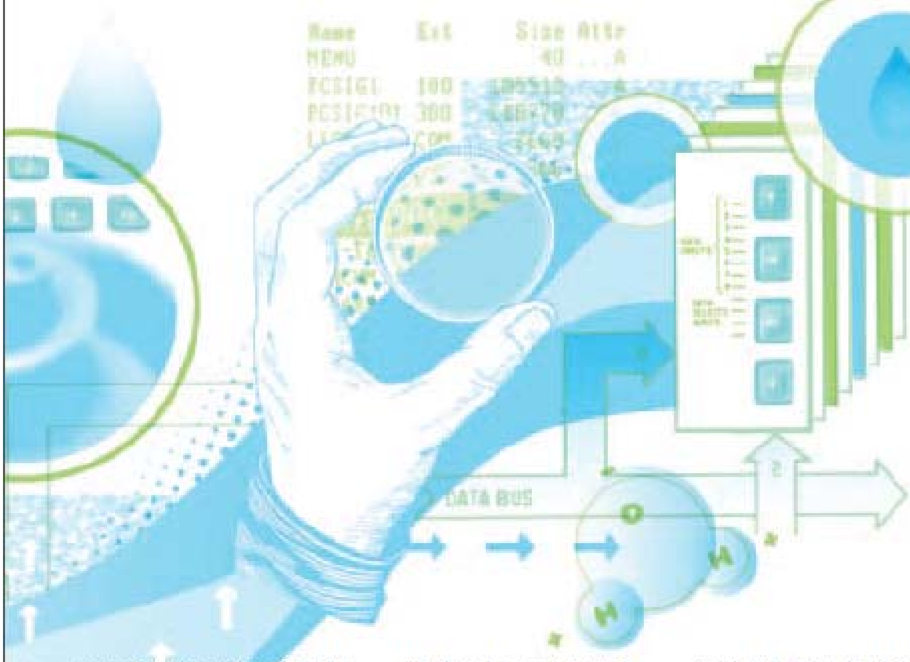
Already during the First World War, wooden mechanical horses were used to simulate the movement of real ones. Many years later, the first landing on the moon had not been able to take place without simulation techniques.

During the recent decades, physical models have been increasingly complemented by the use of computational fluid dynamics (CFD) simulations.

Understanding fluid dynamics problems often requires both virtual simulation and physical testing.

Industries are increasingly using CFD to develop products and applications. The aerospace and aircraft industries, for example, started to use CFD to simulate the flow of air around wings in order to measure the most efficient way to lift aeroplanes.

The automotive industry was also quick to pick up the new simulation tool. All auto makers now have CFD capabilities to be able to put their cars on the market as quickly as possible. CFD helps shorten the time spent designing and engineering new cars, and it is vital because there is so little time to build these cars to stay competitive. Computational simulation helps designers in the automotive industry address aspects such as the optimal shape of the car in



terms of superior aerodynamics and reduced fuel consumption.

Today, in all industries where various aspects of flow are involved, such as the ship and electronics industries as well as in the chemical process and water businesses, CFD is used to get adequate answers to design and application issues.

"Pump design analysis has come a long way from the days of slide rules and drafting tables," says Guillaume Mercier, CFD team leader at ITT Water & Wastewater's marketing department. "Over the past years, CFD has made its mark on the pump industry, reducing the need for expensive physical tests and cutting new pump development costs. In the past, engineers conducted experiments to see what happened inside pump stations by using models made of plexiglass, for instance."

Pumps represent a challenging simulation problem, because they involve rotating internal components whose motion – particularly when combined with stationary components – needs to be included somehow in the model. For pumps, components such as impellers rotate, and their rotation drastically affects the fluid flow through the device. The CFD methods have greatly increased the ease and accuracy of simulating pumps.

Thanks to the contemporary advanced calculations and computer simulations, ITT Water & Wastewater engineers have gained a better understanding of what goes on inside a pump.

SIMULATION IMPROVES
WEAR RESISTANCE

THE PUMPS OF ITT Water & Wastewater's new Flygt 2600 line are more than three times more wear-resistant, compared with traditional dewatering pumps. They have been developed to offer superior anti-wear capabilities, thanks to the patented hydraulic system Dura-Spin.

"We wanted to prevent large particles from increasing the pump wear," Fredrik Söderlund, head of hydraulic design at ITT Water & Wastewater, explains. "It was done by designing a spiral that was put to the suction cover and that works as a particle obstacle. The Dura-Spin spiral design forces the particles to the boundary layer flow on the shroud disk, which pushes them out of the pump. CFD has made it possible to understand the physics of particles in water and how to influence their track in this pump environment."

This knowledge has already led to an improved design and shorter development periods.

"A CFD analysis yields values for pressure, velocity, temperature and other flow variables throughout the solution domain," Mercier says. "A key advantage is that CFD provides the flexibility to readily change design parameters and determine the impact of those changes on performance."

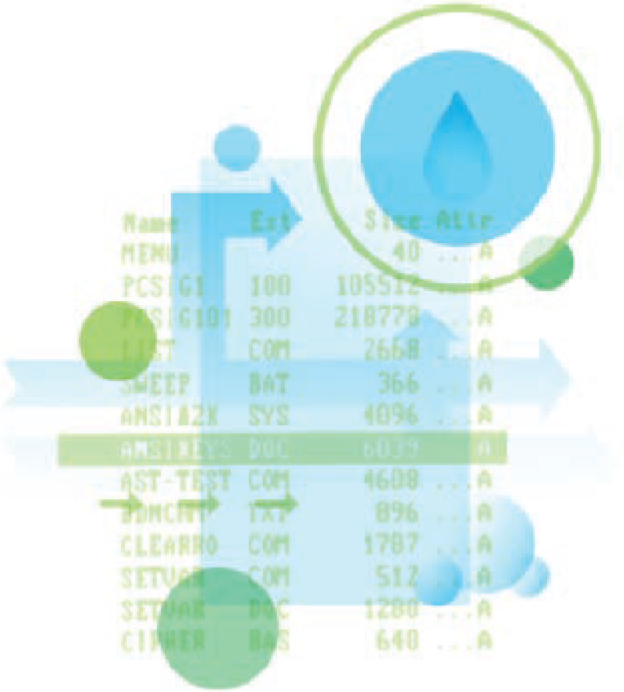
According to Slavica Žikić, application engineer and an expert in pump station design at ITT Water & Wastewater, system engineering simulation can typically be used at ITT for complex applications.

For Water & Wastewater it is important to prove that a product installed in a specific environment will preserve the promised performance.

"We assist the customers to design and dimension facilities where our products are installed," she says. "It is necessary to ensure that products will work well in the requested application."

Slavica Žikić adds that although CFD simulation is being used more and more in engineering, different phenomena are detected by CFD and physical model testing, so both are necessary.

> We assist the customers to design and dimension facilities where our products are installed. It is necessary to ensure that products will work well in the requested application." SLAVICA ŽIKIĆ



Prototype testing has some drawbacks, compared with CFD, Mercier says.

"You really need to prepare the measures of the model and carry out careful calibration," he says. "You cannot easily switch to measure several parameters, which you can do through CFD. Once you have done the simulation with CFD, there is a huge amount of information available, such as pressure and flow dynamic quantities. It is also easier and quicker to analyse all this data, thanks to CFD, than designing an accurate prototype."

A direct benefit of CFD is that velocity and flow direction are simulated. From the data created by the CFD tool, it can be understood how the water flows and will behave in the real environment. The flow can be visualised in various scales from water drops to the large motion of a bulk flow. The velocity magnitude, which is the distance the flow travels in the application during a certain time, can be simulated at virtually any point. CFD also helps in establishing where the flow is slowing down or where it is doing unwanted recirculation.

"The benefit of simulation for customers is that it helps to show that pumps are not over-dimensioned for a certain application, but correctly selected," Mercier says. "CFD can confirm that you do not over-engineer your application."

Dimensioning the right pressurised sewage systems

THE PRESSURISED SEWAGE systems of ITT Water & Wastewater are superior to the gravitational sewer system in some installations.

"The beauty of it is that we use a small pump, situated in each household, to transport the wastewater to the pipe exit," says Torbjörn Norrhäll, research engineer at ITT Water & Wastewater. "The small pumps force the water forward in these pipes to a wastewater treatment plant or a gravity sewer. This is more cost-efficient."

In simulating an estimated network of 100 pump stations, for example, it is not feasible to assume that all the pumps are running at the same time.

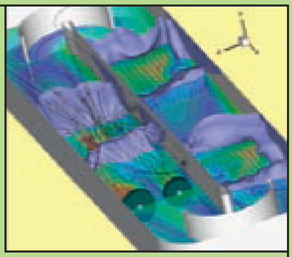
"For this calculation, we have to use statistics and estimate how many of these pumps will run simultaneously, at a probability of between 5 and 10 percent," Norrhäll says.

STAYING AHEAD IN THE RACETRACK SIMULATION

ITT WATER & WASTEWATER'S Flygt mixers play an important role in the racetrack systems of many wastewater plants. Racetracks – large, oval-shaped oxidation ditches – are part of the wastewater treatment that uses long solids retention times to remove biodegradable organics from wastewater.

The propellers of the mixers rotate in a circular motion, providing the necessary thrust for the water and oxygen mixing needed in treatment process. Simulation methods are used to design mixers to produce a thrust that will generate the most advantageous bulk flow velocity.

"We have used CFD to capture the hydraulic losses, including losses due to air bubbles, which break the bulk flow, and also losses due to bends," says Thomas Börjesson, research engineer at ITT Water & Wastewater. "Determining these losses is essential for the proper mixer choice. We also use CFD to learn more about the flow field. We can simulate how the oxygen is transferred, what zones are lifeless, and what zones are getting fresh oxygen in order to draw on the full capacity of the entire racetrack tank.



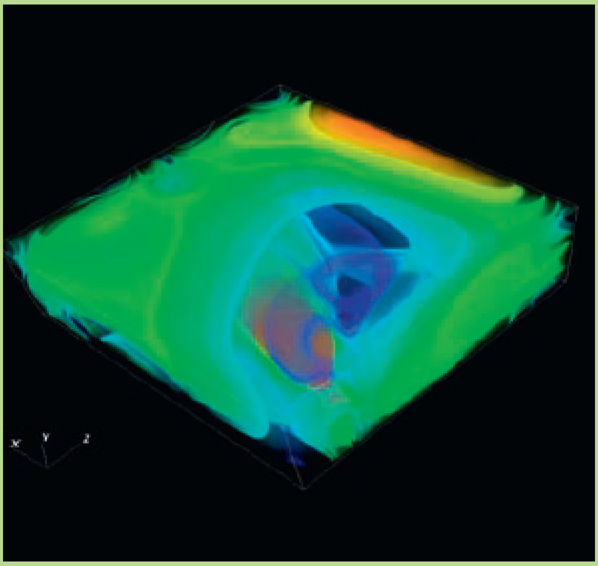
Racetrack systems are designed and tested using CFD simulation methods.

Computational Fluid Dynamics

COMPUTATIONAL FLUID dynamics (CFD) simulations improve pump performance by allowing engineers to evaluate a far greater number of alternative designs on the computer without building costly prototypes. CFD involves the solution of the governing equations for fluid flow, heat transfer and chemistry in tens or hundreds of thousands of computational cells in the defined flow domain. Engineers can obtain solutions for problems with complex geometry and boundary conditions.

CFD covers everything from simple solutions, which do not take into account the movements inside the pump, to complex computations that calculate all the turbulence that occurs. These complex operations, which require tremendously powerful computers, are carried out by scientists at universities but are not possible in an industrial context.

ITT Water & Wastewater uses Reynolds-averaged Navier-Stokes, or RANS. This is an advanced tool that uses turbulence models but calculates everything else – pressure, speed, load and so on. A Linux cluster with a large number of computers is used to carry out all the computations that this simulation requires.



CFD involves the solution of tens or hundreds of thousands of computational cells in the defined flow domain.