DHI SOLUTION

UV REACTORS FOR WATER TREATMENT

Modelling meets industry demands

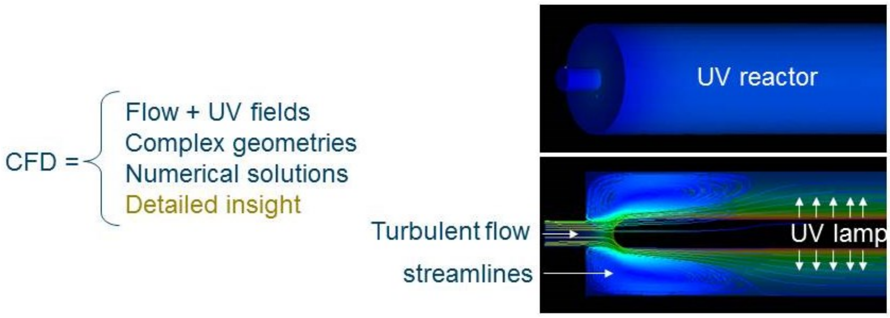
BATTLING PATHOGENS WITH UV LIGHT

The abundance of water as well as its unique physico-chemical properties make water an indispensable industrial asset. However, the overuse of water and the inevitable contamination resulting from it require the development of methods of thorough cleaning before water can be recycled or returned to environment. Particularly important are treatments against microbial growth – exponentially growing microbial pathogens and other organisms can severely poison sources of drinkable water, or disrupt environments. For example, ballast water is often taken up on ships at certain locations and then discharged at destinations far away from the original locations. In such cases, the alien, non-indigenous organisms can prove to be a great threat to the environments.

An efficient and proven method to decontaminate water from the microbial contaminants is to use ultraviolet (UV) light to destroy their DNA.

NEED TO OPTIMISE UV REACTORS IN INDUSTRY

UV reactors are systems that expose flowing water to light from UV lamps. They're widely used in treating (for instance) drinking water, wastewater, industrial process water and ballast water. However, different water processes involve a variety of operating conditions (pressures, temperatures, velocities) and they therefore sustain a diversity of organisms as well. In order to ensure that UV reactors provide sufficient decontamination rates, their design and operating regimes must be properly calibrated and optimised. A particularly useful method for this is to model combined flow and UV fields in complex geometries by means of Computational Fluid Dynamics (CFD).



Extended CFD includes electromagnetic (EM) and concentration fields, offering detailed insight

SUMMARY

CLIENT

- Water utility companies
- Shipping industry (ballast water)
- Ultraviolet (UV) reactor producers

CHALLENGE

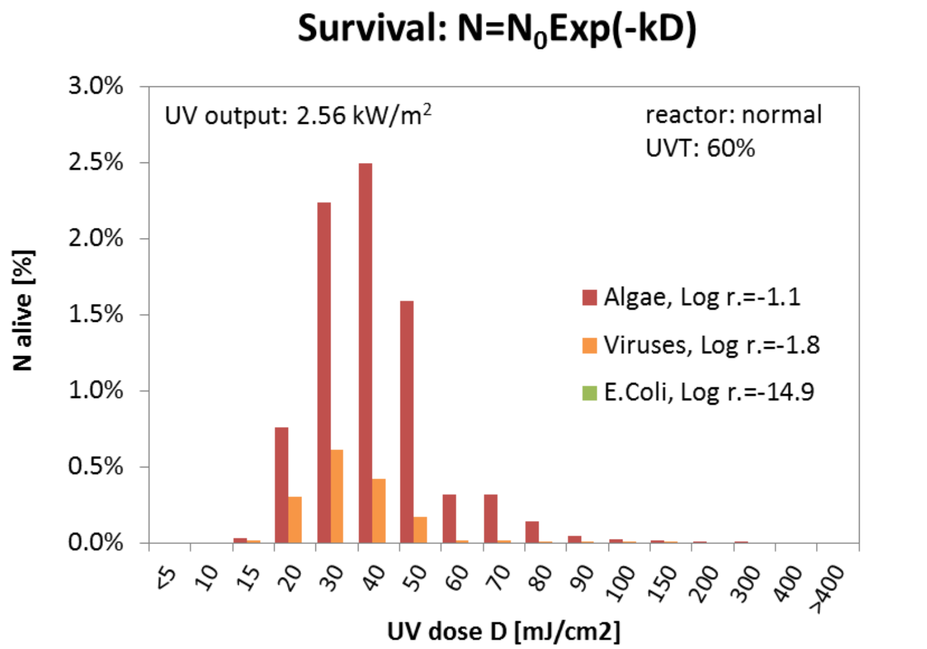
- Overuse of water and consequent contamination
- Need for:
  - thorough cleaning of water before recycling or returning to the environment
  - treatment of water against bio agents
  - ensuring that UV reactors provide sufficient decontamination rates and thereby provide appropriate water treatment

SOLUTION

Computational Fluid Dynamics (CFD) to model combined flow and UV fields in complex geometries

VALUE

- Accurate calibration of design and operating regimes of UV reactors
- Ensured sufficient water decontamination rates of UV reactors
- Proper treatment of water before recycling or returning to the environment



Survival of selected organisms as function of UV dose distribution in a UV reactor. Log reduction of the species is obtained by summing up all the survived organisms

The developmental work required for these changes is conducted at the DHI-NTU Water & Environment Research Centre and Education Hub, we conduct CFD modelling of UV reactors for water disinfection. We model and verify designs of reactors provided by our clients. Moreover, we also develop completely new designs of reactors that fulfil prescribed criteria.

Fundamentally, we test whether the amount of survived pathogens in a given UV reactor exceeds a critical value. We thereby help verify that the reactors meet the highest international standards (for instance, the protocols of ballast water treatment) for water quality.

UV OPTIMISATION – THE VARIABLES AND PROCEDURE

CFD modelling of UV reactors requires accurate calculations of both turbulent flow and UV fields in complex geometries. It also needs an in-depth knowledge of radiation killing rates of various (pathogenic) biological organisms such as plankton, bacteria and viruses.

The key variable that characterises each reactor is its UV dose. This implies the total amount of UV radiation an organism acquires while travelling across the reactor. Since the paths traversed by organisms as well as UV fields differ within a reactor, there's a distribution of different UV doses characterising a system (hence numerical modelling is a must in complex flows and geometries). The larger the dose acquired by an organism, the larger is the likelihood of it being destroyed.

The minimal doses delivered are the most important as they affect the survival rate of pathogens. In properly designed and calibrated UV reactors, the minimal doses do not fall below a standardised critical value.

The typical modelling procedure of a UV reactor is as follows:

1. Making the computational domain (UV reactor's geometry)
2. Making properly refined computational mesh
3. Choosing turbulent models and calculating velocity fields
4. Choosing of radiation models and calculating UV fields
5. Calculating accumulated UV dose
6. Finding/measuring organism's inactivation rate constants
7. Calculating inactivation of organisms as function of UV dose distribution

In 2007, DHI Singapore collaborated with Nanyang Technological University (NTU), forming the DHI-NTU Water & Environment Research Centre and Education Hub. Year 2012 marked the end of Phase I – the first five years of the collaboration. With the venture renewed for another three and a half years (2012-2016), we look forward to many more successes in Phase II of the centre in the near future.

Contact: Goran Goranovic - ggo@dhigroup.com
For more information visit: www.dhigroup.com