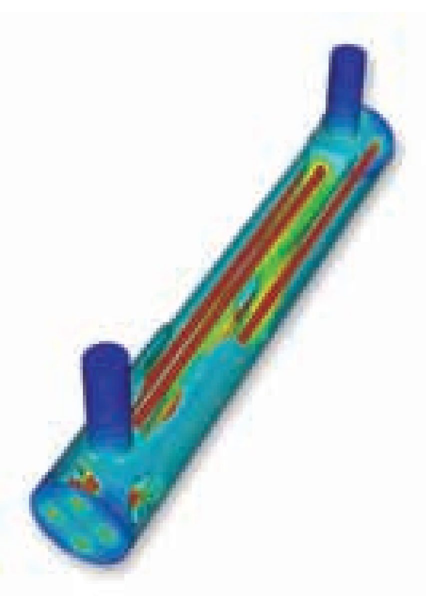
OPTIMIZING UV SYSTEMS

Optimizing UV reactor design prior to the prototype stage

By Derrek Cooper & James Bolton

The use of ultraviolet (UV) reactors for drinking water systems has increased in recent years because of its ability to deactivate harmful waterborne organisms that chlorination usually has no effect upon. The UV reactor design, however, is complicated by the fact that the dose provided to waterborne particles is a function of the time that the particles spend in the reactor and the path through which the particles take.



With CFdesign and the UVCalc Module, both the velocity magnitude and computed fluence rate in the UV reactor can be visualized.

These in turn depend on fluid flow through the reactor, which is complex and nearly impossible to predict with conventional calculations. Traditional computational fluid dynamics (CFD) software has been integrated with software that predicts the fluence rate or irradiation distribution in various areas of the reactor, but these tools are designed for use by fluid dynamics specialists, not those who are typically responsible for the UV reactor design.

Simulation Tools

Upfront CFD tools have been enhanced through integration with tools that compute fluence rate. Upfront CFD software, such as CFdesign, enables engineers to easily perform fluid-flow analysis by utilizing native associative computer-aided design (CAD) integration so that geometric changes can be made in the CAD system and are automatically recognized in the CFD tool without loss of data.

This eliminates the need for translating and importing geometry and keeps the assembly connected to the BOM, assembly constraints, toolpaths and drawings. It provides quick tools to create caps for the inlets and outlets by selecting the edge chain, and the internal void is then created automatically.

The UV lamp is modeled in the CFdesign UVCalc module as a linear array of cylindrical elements, each emitting UV light from the edge of the segment. The reflectance and refractance of the UV light as it passes through the air as well as the quartz and water interface of the UV lamp are considered.

The fluence rate distributions predicted by this method have been tested using small spherical quartz spheres filled with actinometer solution, and studies have been carried out to test predictions of this method versus biodosimetry tests where a microorganism is injected upstream of the UV reactor and samples are taken of the influent and effluent. From the drop in the viable microorganisms in the effluent versus influent, the reduction equivalent dose can be calculated and correlated to the predictions of the UV calculation module.

The ability to explore designs using UV calculation capabilities with upfront CFD software makes it possible to evaluate a larger number of iterations and obtain more detailed information on the performance of each UV reactor than with traditional methods. The design can be optimized to a higher level than in the past by adjusting the geometry of the reactor to ensure that particles pass near the UV lamps and spend a minimum amount of time in the reactor.

This makes it possible to reduce the cost of the reactor by reducing the number and size of UV lamps that are needed to deliver the specified dose. This optimization process makes it possible to substantially reduce the initial capital and operating costs of the reactor, while ensuring the prototype will meet regulatory requirements.

The design process using this method typically begins by building an initial concept design of the reactor in an MCAD program. The design is opened within the upfront CFD program and controls it in the MCAD interface, and the flow volume is automatically generated. The CFD software assigns volumetric boundary conditions and material properties and assigns optimal mesh sizes on the model and flow volume. The CFD software generates the optimal mesh and provides interactive access to first-pass flow simulation results within minutes.

The engineer accesses the integrated UV calculation module to map out the fluence rate or irradiation distribution in the UV reactor and then enters the UV design parameters such as the number, locations and power levels of lamps along with the items such as water transmittance in the UV calculation module. The module then computes and returns the fluence rate values so users can visualize a complete map of the fluence rate throughout the reactor model just as they would view analysis results for flow distributions or pressures.

The distribution of the UV dose can be determined along various flow paths in the reactor as well as the impact of other factors such as flow rate, flow distribution and axial mixing, all of which can affect the UV dose and performance of the reactor.

Scenarios can be run such as simulating the effect of inlet flow distribution changes, different transmittance of the fluids and changes in the flow rate or obstructions. Design comparisons and data results of multiple reactor concepts through contour plots, cut planes, iso-surface, particle traces and vectors are also made available. After examination, the design changes can be implemented through MCAD software.

The ability to explore designs using UV calculation capabilities available makes it possible to evaluate a large number of iterations and obtain detailed information on the performance of each UV reactor. As a result, the design of the UV system can be optimized to a higher level than was possible in the past by reducing head loss, preventing short circuiting and channeling flow as close as possible to the reactors, substantially reducing initial operating costs. *wqp*

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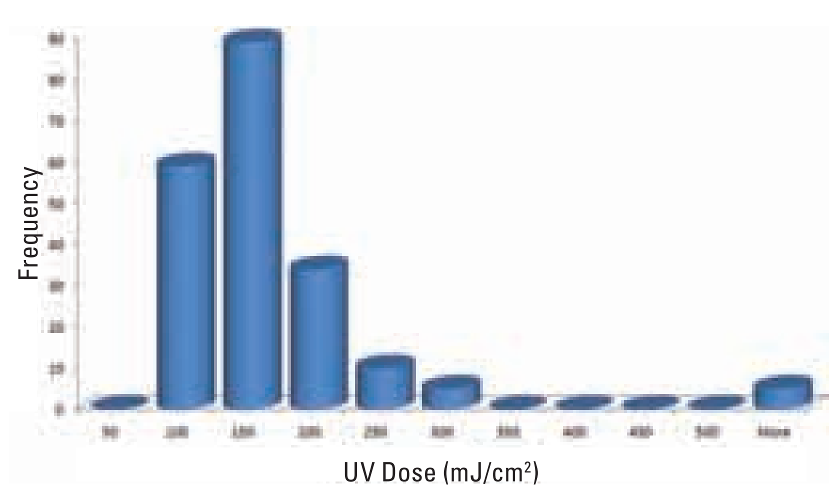
Distribution of UV Dose Using 200 Flow Particle Traces



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