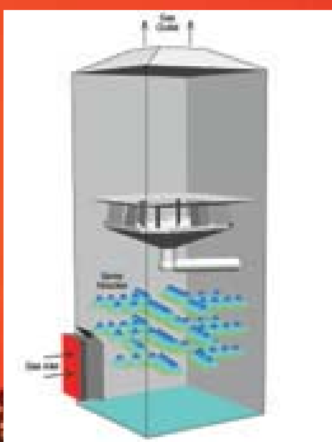
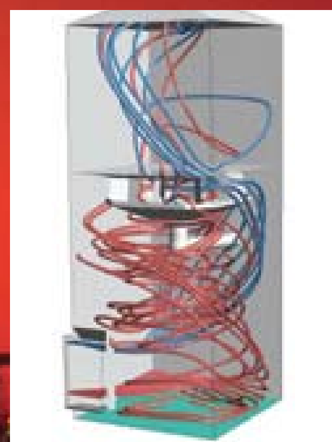
Efficiency improvement of flue gas desulfurization unit

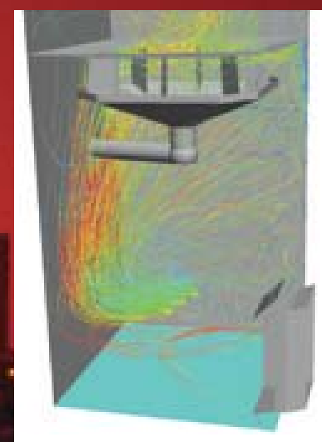
by Mark Denlinger, URS Corporation, USA



The sulfur present in nearly all fossil fuels combines with oxygen when the fuel is burned and is released into the atmosphere as sulfur dioxide gas. After combustion, sulfur dioxide can be removed or scrubbed from flue gas in a process known as FGD. The flue gas enters the bottom of the FGD tower tangentially in such a way that it strikes the side of the tower and swirls as it rises in order to increase its residence time. In wet FGD systems, limestone containing calcium carbonate is ground to a powder in a wet ball mill then mixed with water. Spray nozzles are arranged in the tower to spray the limestone/water slurry into the power plant boiler flue gas. When the flue gas contacts the slurry mist generated by the spray nozzles, the sulfur dioxide is removed from the flue gas stream and converted to gypsum or calcium sulfate which can be used in the manufacture of plaster products.



The blue streamlines reveal that flue gas from the upper part of the inlet duct short circuits the quench section below the bowl by traveling directly up the wall opposite the inlet. The lower gas residence time and decreased gas/liquid contact caused by this short circuit behavior decreases the SO_2 removal efficiency of the unit. The red streamlines indicate that gas from the lower part of the inlet duct swirls in the quench section before passing around the bowl which is necessary for high SO_2 removal efficiency.



Pathlines of 500 micron slurry particles from 3 nozzles located in the gas short circuit path indicate that slurry particles are entrained by the high velocity gas in this region and are carried directly up the wall opposite the inlet without the swirling motion necessary for effective SO_2 removal. Using CFX and our own Fortran code, we were able find a spray nozzle distribution which eliminated the gas short circuit path. This resulted in better gas/liquid contact and higher SO_2 removal efficiency.

A coal-fired power plant operating a wet flue gas desulfurization (FGD) scrubber was having trouble meeting strict environmental regulations for SO_2 emissions. URS Corporation was asked to redesign the scrubber to minimize the operational costs while maintaining compliance with the SO_2 emissions regulations.

URS Corporation is a 26,000 employee planning, design and construction firm with a group dedicated to the optimization of air pollution control equipment, and has extensive experience working with FGD scrubbers.

URS used CFX to analyze the operation of the scrubber. The simulation of the original scrubber configuration revealed that channeling or short circuiting in the gas flow field caused untreated flue gas to move straight through the scrubber without the swirling motion that maximizes gas/liquid contact and results in thorough gas quenching. The greatest challenge was modeling the approximately 100 liquid slurry spray nozzles that are contained within the scrubber.

The Fortran programming interface in CFX-4 was used to write a set of subroutines to quickly and easily position the slurry spray nozzles within the mesh geometry. The key advantage of this set of Fortran subroutines is that the location, orientation and spray pattern of the nozzles in 3-D space can be specified independently from the scrubber mesh. De-coupling the spray nozzles from the mesh eliminates the need to modify the mesh when the spray nozzles are created or changed. This allows us to locate the spray nozzles, point them in any desired direction, and configure their spray angle and pattern very efficiently. Using our own Fortran code within the open structure of CFX allows us to model a large number of potential nozzle configurations in a matter of days.

The efficiency of modeling a large number of potential spray nozzle configurations allowed us to quickly find a configuration that eliminated the gas short circuit path and provided better gas/liquid contact. The solution developed was inexpensive to implement because the only modifications to the scrubber involved repositioning the existing spray nozzles.