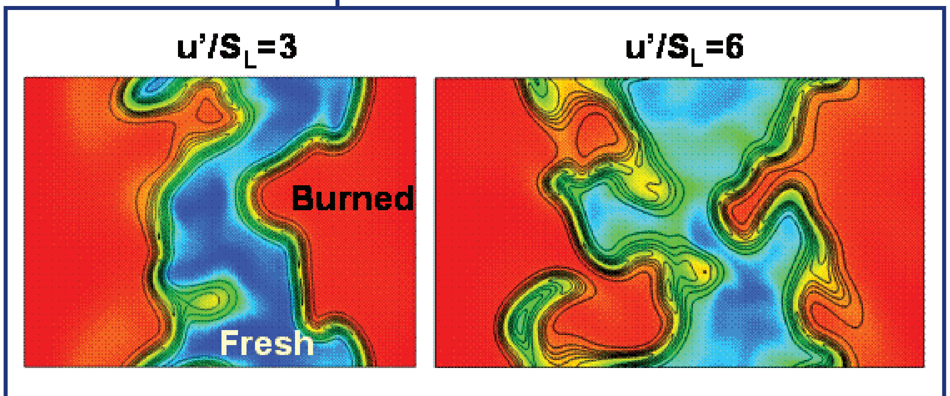
NATIONAL CENTER
FOR COMPUTATIONAL SCIENCES

Combustion Researchers Resolve Turbulence Issue



Instantaneous slices showing progress variable (color contours) and heat release rate isocontours (lines). Increased disruption of flame observed at higher turbulence intensity.

Combustion researchers using the National Center for Computational Sciences' (NCCS') Jaguar Cray XT3 system have answered a question that defied resolution by experiment.

Specifically, they have verified that intense turbulence causes a lean, premixed flame to thicken—a finding that will eventually increase the efficiency of stationary gas turbine power generators.

Experiments aimed at this question have produced contradictory results. Simulations carried out by the project "High-Fidelity Numerical Simulations of Turbulent Combustion—Fundamental Science Towards Predictive Models" were able to provide an answer and will help answer an even more important question: How fast can these flames burn and remain stable?

The flame being studied contains relatively high concentrations of air and low concentrations of fuel. This "lean" flame burns at a lower temperature and produces less nitrogen oxide (NOx) than a richer flame. Lean combustion has the potential to reduce NOx emissions—which have been linked to acid rain, production of ozone, and aggravation of asthma—from stationary gas turbines.

The simulations fully resolved all turbulence and flame scales. "This work produces highly accurate data that model developers can use to validate and improve models used in engineering computational-fluid-dynamics codes," said Ramanan Sankaran, the NCCS liaison to the project.

The project, led by Jacqueline Chen of Sandia National Laboratories, is also exploring stabilization of lifted jet flames and soot formation in turbulent nonpremixed ethylene flames.

The largest of the simulations used 200 million grid points and ran over the course of 7 to 10 days on 7,200 cores, or about three-quarters of the Jaguar system. Over the last year the simulations have generated 30 terabytes of data.

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