Numerical Simulation of a Sour Gas Flare

Develop a numerical model of sour gas flares based on Large Eddy Simulation techniques and use that model to investigate the effects of hydrogen sulphide on flare performance and emissions

What was the purpose of this project?

Hydrogen sulphide (H_2S) is a common component of gas streams flared in western Canada. The impact of H_2S on flare combustion efficiency and overall flare emissions is not well characterized due to the difficulty of performing wind tunnel tests with this hazardous gas.

This project sought to develop a numerical simulation model of a sour gas flare of the type typically used in Alberta. The model will include detailed hydrocarbon and sulphur chemistry so as to predict concentrations of pollutants, combustion products and unburned reactants in the flare. The project will apply the tool that is developed to a range of flare operating conditions to give insight into the impact of H_2S concentration and operating conditions on sour flare performance and emissions.

How was the project conducted?

Open-air flames, such as flares, are characterized by a large range of turbulence length and time scales. The Large Eddy Simulation (LES) method can capture this large range of scales, although considerable computer resources are needed for the simulations. Over the past five years, the Combustion and Reaction Simulations (CRSIM) research group at the University of Utah has been developing a massively-parallel LES code (ARCHES), which is linearly scalable up to 1,000 processors, for the simulation of open flame problems.

This project has benefited from the previous LES model development at the University of Utah, as well as from the large computer resources available to the group at the university. Researchers there are incorporating the necessary H_2S, sulphur dioxide (SO_2) and sulphur reaction chemistry and other modifications to their existing model to enable the simulation of industrial-scale flares.

Numerical model development requires experimental results to verify the accuracy of model predictions. Results of the wind tunnel flare research conducted at the University of Alberta and the Alberta Research Council DIAL measurements of a well test flare are two sets of data being used by the University of Utah to validate its model.

What were the results?

To test the capability of the existing LES combustion model, the numerical model was used to predict the large range of conditions tested during the University of Alberta wind tunnel flare studies. The model accurately predicted flame shapes for these lab-scale flares and showed similar trends in decreasing combustion efficiency with increasing cross-wind speed. The model also predicted the flame shape and appearance of a full-scale well test flare (10-inch diameter).

Several sulphur chemistry reaction models were reviewed, and the Lindstedt mechanism model was selected as the current best model for this project. The existing computer code has also been modified to enable tracking of the various hydrocarbon and sulphur species and the calculation of mass fluxes needed for combustion efficiency calculations.

What happens next?

Once the model predictions have been verified, the remainder of the project will use the simulation model to predict flare characteristics for a range of sizes, H_2S concentrations, cross-wind velocities and other parameters. The results of these simulations should provide insight into the impact of H_2S on flares.

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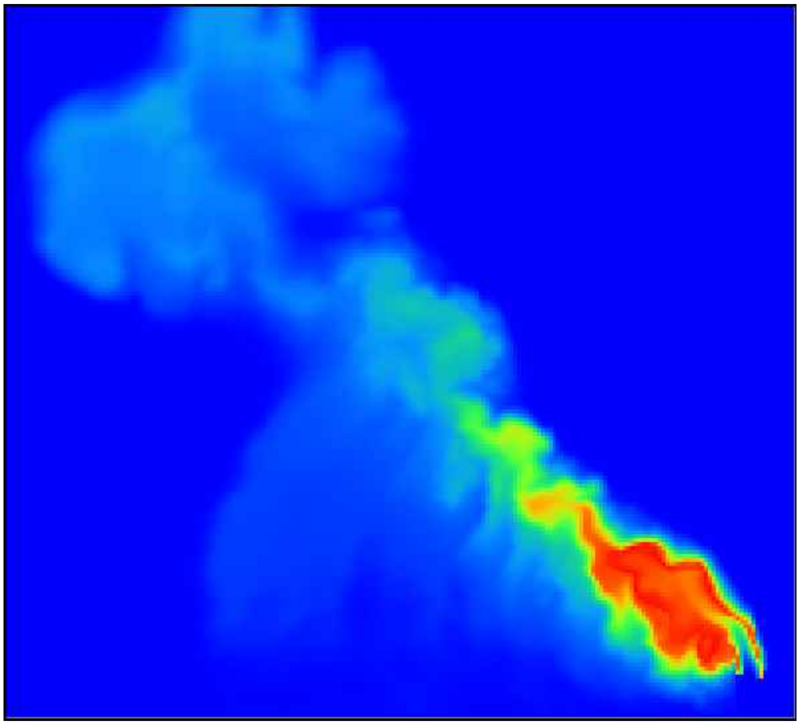

Predicted SO_2 Concentration in a Sour Flare (10-inch diameter)