Catalytic combustion for the elimination of methane, BTEX and other VOC

Examine the effectiveness and feasibility of using catalytic combustion technology to eliminate certain emissions from upstream petroleum operations

What is the purpose of this project?

This project is part of an initiative to address methane and volatile organic chemical (VOC) vent emissions, in upstream oil and gas operations, that are currently considered uneconomic and technically difficult or impossible to reduce by other means. The objective is to develop proven concepts for reactor technologies so as to economically reduce these emissions from various sources, including small, isolated and fugitive sources.

This project concerns solutions of concentrated methane that typically contain higher hydrocarbons – both BTEX (benzene, toluene, ethylbenzene and xylene) and non-BTEX compounds. Typical sources include glycol dehydrators and tank vents. Such streams have a high variability between sites and over the course of a year, and their emissions create potential problems.

Methane, although not toxic, is a strong greenhouse gas, and the oil and gas industry is under pressure to reduce such emissions. Of greater importance, compounds such as benzene are considered quite toxic, and strong controls on their emission are either in place or being considered. The purpose of this research project is to examine the effectiveness and feasibility of using catalytic combustion technology to solve this problem.

How is the project being conducted?

Researchers are studying the use of counter diffusive catalytic radiant heaters and their adaptation to the project’s purpose. Catalytic diffusive radiant heaters have proved, in industry field trials, to be effective in controlling fugitive emissions of solution gas and are familiar to oil and gas field workers. Still, there are many remaining issues for improving their design, control, optimization and operational limitations with feed gas containing higher hydrocarbons, especially BTEX compounds.

The research involves a two-pronged approach, using experimental investigations and computer simulations. On the experimental side, a micro-reactor has been constructed to evaluate catalyst activity and study destruction efficiency of different hydrocarbons. A small radiant heater has been installed in the lab and fully instrumented to help determine the operating parameters.

Complex computer modelling of the reactor is also being used to investigate the effects of various operating conditions. Researchers are especially interested in the relative destruction efficiency of the different organic compounds and the issue of fuel slippage, which is the passing of unreacted fuel thorough the reactor. For BTEX compounds, slippage is not acceptable.

What are the results?

In the study of relative reactivities of BTEX and methane, the BTEX compounds have been much easier to destroy catalytically than methane. Several platinum and palladium catalysts have been tested, including several commercial platinum ones. Some of the commercial designs have been less than optimal, suggesting room for catalyst improvement.

In the commercial radiant heater, the effect of fuel flow rate on fuel slippage has been studied. At lower flow rates, there is almost complete conversion, albeit some methane is still detected at the outlet. As the flow rate increases, the concentration of methane that slips through unreacted also increases. With toluene present in the feed, little unreacted toluene breakthrough has been detected. This observation is consistent with the higher reactivity of BTEX compounds.

Most of the conversion occurs near the front of the catalyst pad, because of limitations on the diffusion of oxygen. The maximum reactor temperature is at the back of the catalyst pad, however, because of heat transfer effects, an observation confirmed by experiment and modeling. The temperature distribution in the catalyst pad is non-uniform. It is speculated that this effect may be caused by transport limitations of oxygen at the front face of the heater.

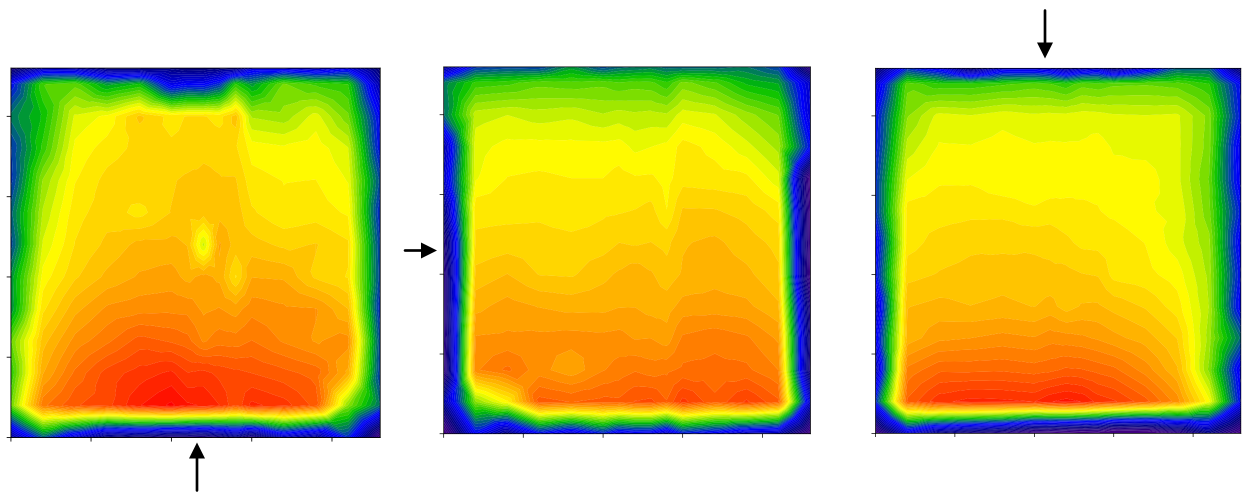
What happens next?

The fuel distribution and flow rate effects will continue to be investigated, with a goal of achieving more uniform temperatures. The effects of operating parameters, including catalyst loading and geometry, will also be investigated, and kinetic studies on a variety of catalysts performed.

The next stage will also involve a fundamental investigation of the catalyst and its properties so that better catalysts can be developed. Sophisticated characterization techniques will be used to develop a detailed understanding of the catalyst system.

Program funding and in-kind support

The project is funded by Canadian Association of Petroleum Producers and the Natural Sciences and Engineering Research Council of Canada. Technical advice and in-kind support is provided by several oil companies, as well as Scott-Can Ltd., manufacturers of catalytic radiant heaters.



Catalyst Characterization