CONQUERING CO_2

by JIM PHILLIPS

TO ALLEVIATE GLOBAL WARMING, ENGINEERS DESIGN NEW WAYS TO REMOVE, STORE, AND NEUTRALIZE THE PROBLEM GAS

ENGINEERING

The carbon dioxide GENERATED FROM BURNING FOSSIL FUELS IS BELIEVED TO BE HEATING UP THE PLANET, PUTTING IT AT RISK FOR DISASTROUS CLIMATE CHANGE.

The solution? The power industry, oil-and-gas industry, and government agencies are exploring how to pull CO_2 out of smokestack emissions, compress it, and then pump it deep into the earth, where it can't amplify the greenhouse effect in the atmosphere.

But deep in the earth, the gas poses a new problem: Under very high pressure, CO_2, now a weird, volatile hybrid of liquid and gas (the so-called "super-critical" CO_2), develops new properties—including a bigger appetite for eating through pipelines and compressors.

Engineers at Ohio University's Institute for Corrosion and Multiphase Technology—a world leader in CO_2 and H_2S (hydrogen sulfide) corrosion research—are hoping to give the power and oil-and-gas industries a better handle on the technology they may need, if they plan to sequester CO_2 in geologic formations.

"You have to be able to compress it and transport it to a site where you're going to inject it into the ground," explains David Young, a researcher and assistant director for academic affairs at the institute. But under the pressures used—over half a ton per square inch—CO_2 enters the super-critical state, unrecognizable as the innocuous gas we expel in every breath.

For one thing, it's much more reactive chemically—which can mean serious corrosion problems for steel pipelines and machinery.

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assistant director for academic affairs,
Institute for Corrosion and Multiphase Technology

How much more depends partly on what trace impurities it contains—such as water, oxygen, or nitrogen or sulfur compounds—and in what amounts. Water plus CO_2, for example, equals carbonic acid, which, especially at high pressures, can gnaw away at steel.

Institute researchers are creating a model that would allow engineers in industry to predict corrosion problems they'll face with each chemical profile of CO_2 they're working with, explains Yoon-Seok Choi, the institute's associate director for research.

The challenge, Young adds, is "looking at what role the contaminants have in corrosion processes, and how to handle and control that."

Adaptations could include finding more corrosion-resistant materials, or making sure impurity levels are in a range that minimizes corrosiveness—figuring out, in Young's words, "what you can get away with" in terms of contaminant concentrations.

Whatever approach industry experts end up taking, Ohio researchers are giving them not just a bundle of facts, but mathematical formulas that give usable results, says Marc Singer, the institute's associate director for project development.

Both private industry and government agencies are tapping the institute's expertise and are funding projects ranging from "amine scrubbing," a well-established method for removing CO_2 from flue gas, to the mitigation of corrosion of pressurized CO_2. The institute has published or presented findings in the last few years that have contributed new perspectives to the field.

The corrosion problem is huge in economic terms. Young says he's seen figures suggesting it costs the oil-and-gas industry around $2 billion annually. And the institute is uniquely situated to address it.

For more than a decade, the institute, the largest facility of its kind in the world, has worked with a consortium of the world's 19 top oil and chemical companies, seeking ways to arrest the corrosion that ravages oil-and-gas pipelines and which, if not checked, can lead to disastrous spills.

The facility's many "flow loops" allow researchers to simulate conditions inside pipelines, and help attract projects from around the globe, from Australia to Uzbekistan. Most of the institute's $2.5 million annual budget comes from the private sector, and while the institute is a top-flight outfit for corrosion research in general, it's probably the world's number one center for study of CO_2- and H_2S-related corrosion.

Bob Brown, clean coal technology manager with the Ohio Coal Development Office, says that when the state looked for someone to study corrosion connected to CO_2 transport, the institute was the clear choice.

"Based on their experience in doing similar studies for the oil-and-gas industry, it seemed like they were a natural to look at this question for us as well," he says.

Another research project, just getting underway at the Russ College of Engineering and Technology, complements the CO_2 work at the institute.

Before CO_2 from power-plant flue gas can be sequestered, it must be separated. Loehr Professor of Mechanical Engineering David Bayless, director of the Ohio Coal Research Center, is trying to improve a method of removing CO_2 from smokestack gas. If it works, it may result in lower impurity levels in CO_2, which could make dealing with corrosion simpler.

Some coal-fired power plants already scrub emissions to remove sulfur dioxide. The process Bayless is examining to remove CO_2, which uses carbonates (such as baking soda), takes advantage of the hot, wet conditions inside a smokestack sulfur-scrubber.

The carbonates Bayless and other researchers study are natron and/or trona, natural minerals obtainable by mining. Bayless is exploring a cost-effective way to greatly increase the surface area and reactivity of these carbonates, by using something he calls "the popcorn principle."

A piece of uncooked corn contains a drop of moisture, which, when heated, expands suddenly, poofing the kernel into a high-surface-area morsel. Trona and natron, likewise, are "hydrated"– that is, a particle of either contains water. And "if you heat that particle up really, really fast," Bayless explains, "that particle will 'popcorn' on you."

If the process can be perfected, he says, it will multiply the surface area of a gram of natron dust—about one square meter—up to 15 times.

So while the corrosion institute is studying how impurity levels affect CO_2's corrosion properties, Bayless' work offers the prospect of extracting CO_2 in high-purity form. This could make it easier to address corrosion, because industry would be working with a dry, uniform mix of CO_2, regardless of the fuel whose combustion it came from.

That could be good news for global temperatures, if it eases pulling carbon from the air and storing it underground. While questions still need to be answered about sequestering CO_2—will it move around? Will it react with underground minerals?—the U.S. Department of Energy hopes this approach can form part of a strategy to bring many power plants and factories down to near-zero carbon emissions.

The agency notes that many big U.S. carbon emitters are near sites that could sequester CO_2, and cites estimates that deep saline formations in the United States could store up to 500 billion metric tons. Expand this to an international scale—the Norwegian oil company Statoil is already injecting about 1 million metric tons a year of CO_2 into a saline formation, roughly the output of a 150-megawatt coal-fired power plant—and global warming starts to look, while still daunting, a bit less hopeless.

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