Models will enable safer deepwater oil production

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Rice University researchers are developing a comprehensive model that will predict how brine, oil and gas drawn from ultra-deep wells react to everything encountered on the way up to the surface and to suggest strategies to maintain the flow.

Deepwater production involves hydrocarbons but also formation water (brine), chemicals, and materials that make up the complex machinery of modern oil extraction. Under high pressures and temperatures, the brine can form acidic mixtures that corrode pipes or form solid mineral deposits, called scale, that inhibit flow in a well.

Rice professors Walter Chapman, Kenneth Cox and Mason Tomson will combine their expertise in materials and computer modeling to analyze the brine and its environment on the molecular to macro scales. Their research is supported by $1.2 million awarded last fall by the Research Partnership to Secure Energy for America, a contractor for the US Department of Energy, through Brine Chemistry Solutions LLC.

A molecular-level model based on Chapman's Statistical Associating Fluid Theory (SAFT) equation and on Tomson's expertise with the Brine Chemistry Consortium will predict the likelihood that scale and corrosion will hinder the flow in a well based on variables found at the site. That will save money, cut risk and make deepwater production safer and more environmentally sound, Chapman said.

"This is all about flow assurance," he said. "Companies want to maintain their ability to produce by knowing how to deal with potential obstacles—scale, asphaltenes, natural gas hydrates, wax—anything that could prevent them from being able to flow the fluids. Rice works in each of these areas, but the current project involves scale and corrosion."

The degree of difficulty increases as explorers drill further out to sea. Ultra-deepwater wells are those with water depths greater than 7,500 feet. In these fossil fuel reservoirs, extreme temperatures up to 500 degrees Fahrenheit and pressures greater than 25,000 pounds per square inch can turn benign mixtures into pipe-eating acids or clogging solids.

"There are a lot of components," said Cox, who spent 17 years as a research engineer at Shell before entering academia. "You have water, all kinds of salts and other species in a very complex mixture over many extreme combinations of temperature and pressure. But most of the data we have to base our models on, to calibrate the models against, are taken near room temperature and at atmospheric pressure.

"It's kind of like sending someone to the moon, when you only know what you've experienced on Earth," he said. "We mean to take this limited body of data and make the best possible use of it."

"Our idea is to have a single model able to describe all the phases—for gases, water and aqueous solutions, and hydrocarbons—from very hot, high-pressure conditions down hole all the way through the platform and even through transmission and refining," Chapman said. "We want to use one model to describe conditions along this entire path."

Samples from the deep are difficult to analyze, even when they can be obtained, he said. "Even though sample cells can maintain pressure, and a very few will maintain temperature, by the time they come up to the surface, the samples are completely different," he said. "So we have limited data from which to project a highly complex system."

That system not only includes the oil and gas, briny water, sodium chloride, calcium carbonate, barium sulfate, carbon dioxide, hydrogen sulfide and other elements found in the chemical stew in and beneath the sea, but also the hardware used to extract oil. Every pipe, every seal, every tank and every part of every pump has to be accounted for in the equation, to see how each might react. Pressure and temperature changes along the entire path affect how – or if – the product flows.

"The temperature's high enough for water to dissolve sand," Cox said. "That's an interesting problem in itself, because at very high temperature it forms volatile silicic acid. The presence of this kind of thing is what we try to pin down."

"We're trying to get basic data into a fundamental model that, given the water chemistry and the conditions at any site, allows us to model what should be expected of that site," Chapman said.

He said a good model would help companies plan their approach to a potential well before committing millions of dollars to set up a platform. "They want to know what they're going to find. Their inhibition strategy (to limit corrosion), the materials they're going to use and the separation equipment will all be based on their knowledge of the fluid properties down hole."

The Rice team is working with project leader Brine Chemistry Solutions LLC, a Houston company founded by Tomson's son, Rice alumnus Ross Tomson. Chapman is the William W. Akers Professor of Chemical and Biomolecular Engineering. Cox is a professor in the practice of chemical and biomolecular engineering. Tomson is a professor of civil and environmental engineering.

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development program authorized by the Energy Policy Act of 2005. The program is funded from lease bonuses and royalties paid by industry to produce oil and gas on federal lands and is designed to assess and mitigate risk, enhancing the environmental sustainability of oil and gas exploration and production activities.

More information: Chapman Group: www.ruf.rice.edu/~saft/chapman.htm

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