IMPROVING PREDICTIONS OF HYDROCARBON RESOURCE VOLUMES

DENSITY AND VISCOSITY EXPERIMENTATION AND MODELING AT EXTREME CONDITIONS

BACKGROUND

Increasing offshore domestic oil and natural gas activities associated with ultra-deepwater reservoirs, such as in the Gulf of Mexico, poses unique technical and operational challenges. One of the challenges is to develop critical data for predicting in situ conditions that are required for assessing recoverable oil, drilling design, and control of blowouts in offshore hydrocarbon settings.

NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

PROJECT GOALS

The project goals are to 1) expand and disseminate the database for crude oil viscosity/density at extreme temperature and pressure conditions associated with deep drilling and 2) further develop and refine predictive crude oil density and viscosity models. These data, models, and tools improve the quality of the predictions of hydrocarbon properties at extreme operating conditions.

OBJECTIVE

The objective of this project is to develop methodologies and technologies to reduce subsurface uncertainty and improve deep drilling safety and oil production under high-pressure/high-temperature (HPHT) conditions by increasing the accuracy of equation-of-state (EOS) models and viscosity correlations.

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PROJECT DESCRIPTION

The U.S. Department of Energy's National Energy Technology Laboratory (NETL) is working to improve the accuracy of thermodynamic and transport properties models under HPHT conditions, allowing for better characterization of reservoir fluids and the dynamics of these fluids during extraction. Improved models will decrease uncertainty associated with fluid quantity and flow at and near the borehole. Accurate understanding of the reservoir and associated well behavior is an important component of NETL's ability to predict the behavior of wells under both controlled and uncontrolled scenarios. The current lack of information and understanding of these extreme environments inhibits the ability to predict well behavior and develop methods for safely handling fluids under these conditions.

Figure 1: NETL Phase and Composition Analysis Laboratory, Pittsburgh, PA.

NETL researchers have expanded the density and viscosity databases for hydrocarbon compounds to span HPHT conditions. The results have been integrated with existing lower pressure and temperature data, resulting in a comprehensive database. This work is reviewed in the publication, *High Temperature, High Pressure Equation of State Density Correlations and Viscosity Correlations*, and an interactive database and an associated application to interface with the database. The preliminary databases have been released through NETL's Energy Data Exchange (EDX).

BENEFITS

The ability to reliably predict the thermophysical properties of hydrocarbons over wide ranges of temperatures and pressures, will provide a means for accurate predictions of the recoverable reserves and will promote safe and secure production from these critically important reservoirs. Experimental and theoretical studies of various thermodynamic and rheological properties and phase equilibria of broad range of systems will be used to improve predictions of subsurface reserves in HPHT environments and promote safe and secure processes for oil production.

ACCOMPLISHMENTS

Density and Viscosity Cells at Extreme Conditions

NETL researchers have developed research capabilities to operate density and viscosity cells at extreme conditions and then accurately predict the physical properties of hydrocarbon compounds. The newly developed density and viscosity cells to operate at these extreme conditions are unmatched by other research groups worldwide.

Innovative Technologies

NETL has collected the fundamental data needed to create innovative technologies to further expand the acquisition of domestic natural gas and oil from reservoirs found in very harsh conditions, such as in ultra-deep reservoirs four to five miles beneath the sea floor.

Novel Approach for Reservoir Fluid Densities

The EOS research team developed a novel approach for reservoir fluids densities based on group contributions and the perturbed-chain statistical associating fluid theory (PC-SAFT). Implementation of this predictive method in reservoir simulators could substantially improve density predictions over the complete range of temperature and pressure encountered in ultradeep reservoirs.

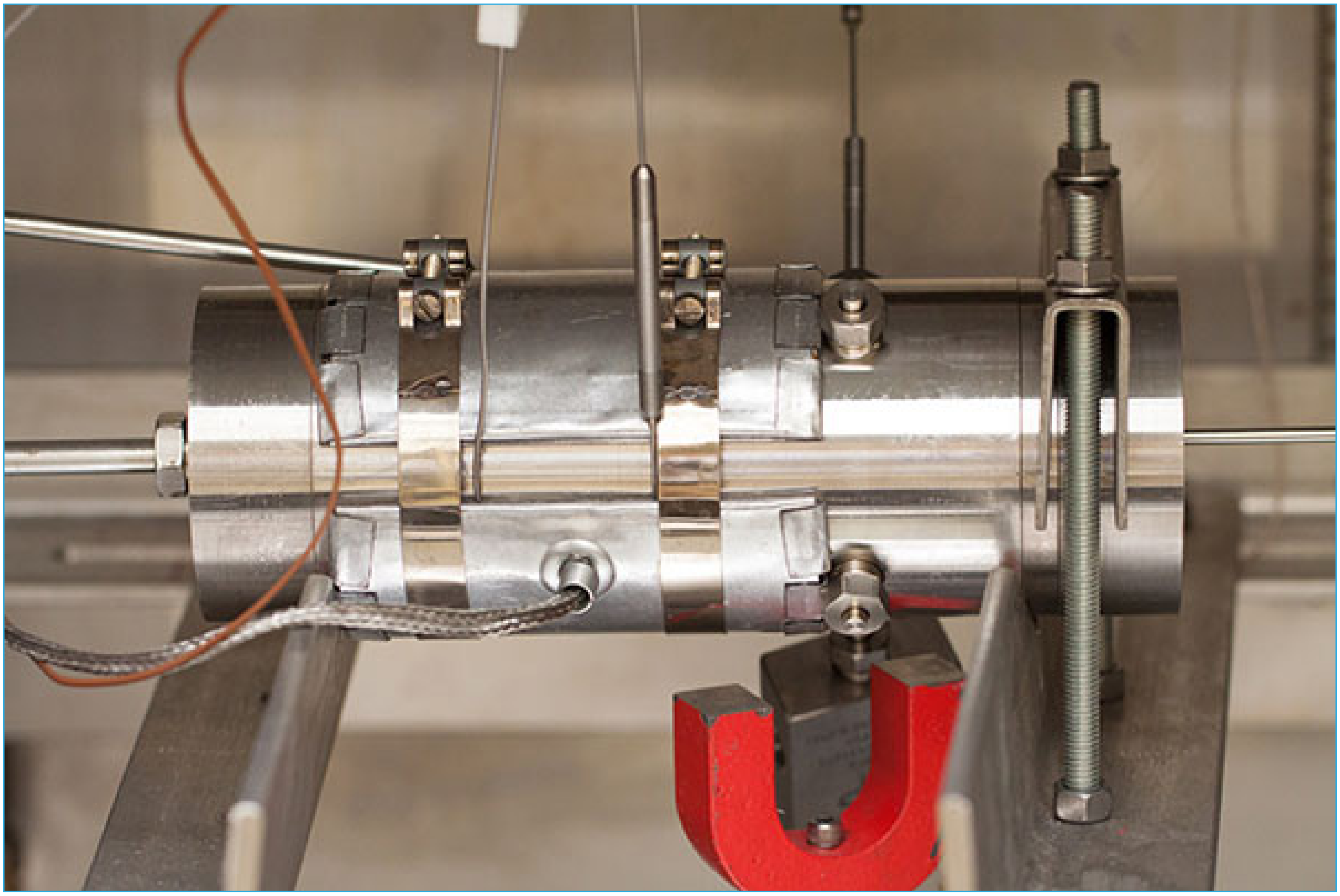

Figure 2: NETL high-pressure, high-temperature density cell installed in an environmental chamber. The cell is rated to 260 °C and 40,000 psi.

Deepwater Viscosity Standard Candidate Fluid

The NETL research team has identified a promising deepwater viscosity standard candidate fluid desired in the petroleum industry for HPHT viscosities studies associated with oil production from ultra-deep formations beneath the deepwaters.

Research findings produced by this project are now being tested by 19 international research groups in South and North America, Australia, and Europe.

Recent project work expanded earlier efforts focused on single-phase, pure hydrocarbons to investigate density and viscosity properties of multi-component hydrocarbon mixtures and crude oils at extreme pressures and temperatures. In addition to these experimental studies, researchers will 1) develop and test new predictive models for HPHT crude oil viscosity; 2) identify a well-characterized, surrogate fluid as a deepwater viscosity standard that can be used to calibrate and validate viscometers at extreme conditions representative of ultra-deep oil reservoirs; and 3) begin to incorporate brine into EOS and viscosity models and develop reliable density models to predict phase behavior of HPHT hydrocarbon-brine systems.

For additional information, we invite you to visit
https://edx.netl.doe.gov/offshore

NATIONAL ENERGY TECHNOLOGY LABORATORY

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