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The Basis of Primary Petroleum Production

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Background

The current petroleum industry relies on Darcy's law to calculate the production rate of a given reservoir. Darcy's law represents a relationship between fluid flow and porous media to perform oil and gas collection, whereby the drainage rate is inversely proportional to fluid viscosity. Through correlation to natural gases with volumetric expansion, this equation has in the past been instrumental when creating extraction equipment and predicting outputs of a given petroleum resource.

The current "shale revolution", i.e. extraction of oil and gas from the nanopores of shale, is unable to be explained through the use of Darcy's law. What the law fails to take into account is the proportionality between the drainage rate, the viscosity of a fluid (or resistance to flow) and the relationship of these variables to pore size. Incorporating these vital factors opens opportunities within the petroleum production industry to better understand and thereby predict the output of oil and gas from shale formations. Therefore, there is a need for a new approach to explain the nonobvious mechanisms of why oil and gas can be produced in large quantities from the nanopores of shale, and more accurately predict the output from a given formation.

Invention Description

Researchers at Arizona State University have developed a mathematical solution for predicting petroleum production in shale formations which is much simpler than the current theory using Darcy's Law. Based upon the Navier-Stokes equation which describes the motion of viscous fluid substances, researchers have shown that fluid can escape the ultra-tight shale matrix with a finite speed, regardless of pore size. This explains why both oil and gas can be produced efficiently from tighly formed shale matrix blocks.

Researchers have shown the following: fluid may be produced from shale through huff-n-puff pumping, involving injection of CO_2 into the matrix, allowing a soak time, followed by extraction. The production rate has been shown to be proportional to the viscosity of the fluid, and the drainage speed is independent of the capillary radius.

These striking and counterintuitive results show that fluid can escape the ultra-tight shale matrix with a finite speed, regardless of how small the pore is. With this innovative predictive technique, based upon a simplified mathematical approach, the petroleum industry may be capable of directly predicting shale output for oil and gas processing, ensuring a stable and consistent domestic supply of petroleum for the foreseeable future.

Potential Applications

- Crude oil extraction
- Hydraulic equipment design
- Enhanced Oil Recovery (EOR) Technologies
- Unconventional Oil Production
- Micro/nano scale compressible flow scenarios

Benefits and Advantages

- Simple – mathematical solution to simplify and explain real world findings
- Accurate – This technique establishes a more accurate method to predict and calculate production rate from shale formations
- Innovative – A new method to predict operating characteristics of oil wells from unconventional sources

For More Information See

Professor Chen's Website