—ABSTRACT—

High-Temperature Reactors for In Situ Recovery of Oil from Oil Shale

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The world is exhausting its supply of crude oil for the production of liquid fuels (gasoline, jet fuel, and diesel). Liquid fuels can be produced from alternative feedstocks (natural gas, shale oil, or coal); however, this results in large increases in the emission of greenhouse gases per vehicle mile. For example, in the coal liquefaction process, the quantity of carbon dioxide released in the production process equals that released in burning the liquid fuel.

The United States has sufficient oil shale deposits to meet our current oil demands for ~100 years. However, traditional shale oil processes release large quantities of carbon dioxide to the atmosphere from the process and from the energy to drive the process. A new method to produce high-quality shale oil without such releases is proposed based on (1) the new Shell process for shale oil production, (2) the characteristics of U.S. shale deposits, and (3) the use of high-temperature reactors.

Shell is developing an in situ process for oil recovery where wells are drilled into the shale, electric heaters raise the temperature of the shale oil deposit to ~370°C (significantly higher near the heaters), the heat causes chemical reactions that produces light crude oil, and the oil is pumped to the surface from other wells. Large quantities of electrical heat are required—equal to one-sixth the heating value of the product.

It is proposed that heat be supplied by high-temperature reactors using liquid-salt heat transport loops from the reactor to the shale deposits and thus avoid losses in converting heat to electricity. Nuclear heat is potentially viable because of a particular characteristic of many oil shale deposits: they are thick (200 to 700 m) and can yield up to 2.5 million barrels of oil per acre, or about 125 million dollars/acre of oil at $50/barrel. (Current estimates indicate the process may produce oil for less than $30/barrel using electric heat.) The concentrated characteristics of shale-oil deposits make it practical to transfer heat over limited distances from a reactor to the deposit.

Two types of reactors have the capability to supply high-temperature heat: modular high-temperature, gas-cooled reactors, and the liquid-salt-cooled Advanced High-Temperature Reactor. Both reactors use the same high-temperature graphite-matrix coated-particle fuel. The shale oil process, its requirements for heat, the characteristics of the intermediate heat transport loop, and the reactor options are described.