08.3

Hydrogen Firing for a High-Capacity Rotary Kiln

Ralph E. Coates, L. Douglas Smoot, Kent E. Hatfield

Combustion Resources, Inc., Provo, UT, United States

A unique surface process, referred to as the Clean Surface Oil Shale Process (C-SOS) [patent-pending] makes use of a rotary kiln to drive the oil from the shale. One of the process claims is the near-elimination of carbon dioxide emissions. A novel [patent-pending] design for a rotary kiln for processing oil shale has been constructed and tested at pilot-scale (5 tons/day of shale) with positive results. First results of these tests were presented at the 28th Oil Shale Symposium. Data confirmed a high shale processing capacity (2-3 times that of conventional kilns), the capability of controlling the temperature along the kiln chamber length, and simplicity of configuration. Kiln tests were made with use of natural gas. An important step among the five process steps in the C-SOS Process to eliminate carbon dioxide emissions is to fire the rotary kiln with hydrogen gas in place of natural gas, thereby eliminating the carbon dioxide combustion product. Various sources of hydrogen are identified with the least cost option likely to be on-site gasification of coal. The hydrogen thus produced provides the kiln fuel and hydrogen for hydrotreating of the raw shale oil. A series of tests have recently been completed to demonstrate the firing of hydrogen for the kiln burners. Pilot-scale burners from commercial manufacturers, which were capable of firing both natural gas and hydrogen, were considered and a Maxon Wide Range burner was acquired. Installation of the burner included purging capability of the up-front gas manifold between the shut-off and ignition points to prevent hydrogen flash-back. The burners were fired first with natural gas and then switched over to hydrogen. A series of six natural gas tests and thirteen hydrogen tests were performed. Given the very broad flammability limits of hydrogen/air, the firing rate was successfully varied from 90,000 to 150,000 BTU/hour with H_2/air ratios from 0.3 to 3.5 tested. A bright yellow flame, not due to impurities, allowed for ready detection of the flame, as did the bright glow of a thermocouple probe on the edge of the flame. No unstable burning, pre-ignition or explosions were observed in these tests. Plans include the addition of the spent shale oil separation recovery unit to pilot-scale plant, followed by testing of the C-SOS Process with this addition.