UTILIZATION OF HIGH-SULFUR SHALE OIL IN POWER PLANT INTEGRATED WITH GASIFICATION SYSTEM

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The problem of possible ways of utilization of oil shales from the Middle Volga land deposits is being studied in the USSR. These shale are characterized by extremely high contents of sulfur (up to 8% of m.a.f. mass) and ash (from 40 to 70%).[1]

In spite of the favourable shale mining conditions in the Middle Volga area, the practical utilization of the oil shale can be effected only on the basis of ecologicaly safe and waste-free technology of complex processing for obtaininng chemical products (e.g. thiophens, hydrogen sulfide), meliorative preparations, roadway coverings, bulding materials, etc. as well as high-sulfur power-generating fuels (liquid and gaseous).[2]

We have considered a possibility of using high-sulfur shale oil, which is a residue of complex processing of shales, in combined-cycle power plants integrated with a gasification system for demonstration processing of a 180-ton batch of shale oil.

The intercycle gasification of sulfur-containing fuels is presently considered worldwide as a promising way meeting the most stringent requirements on harmful emissions of NO_x and SO_2, while increasing the thermal efficiency of steam power plants.

The IVTAN has developed basic principles of this technology patented in the USA, BRD and other countries[3,4] and has made theoretical and design work terminating by building a large demonstration power generating plant with intercycle gasification, which is mounted at the Dzerzhinsk electric power station.

This plant includes the following units: a compressor driven by a gas turbine, an oxidation gasification reactor, a waste heat boiler, a

gas cooler, a scrubber for removing soot and ash particles from the fuel gas, a unit for chemisorption purification of gas from hydrogen sulfide followed by conversion of H_2S into elementary sulfur using the Klaus process.

The purified gas having a calorific value of combustion of 4400 kJ/nm³ runs the gas turbine and then is fired in a power boiler furnace[5].

This plant was designed not for shale oil but for residual oil having a 3% sulfur content. The objective of our study was to prove a possibility of using this technology for shale oil as well with practical demonstration of this process.

Preliminary thermodynamic calculations were performed with the following aims in view:

-study of the sulfur behavior in the gasification process: its rate of conversion into easily removable compounds, such as hydrogen sulfide and a possibility of condensation of sulfur vapors on the components being cooled;

-correction of the gasification parameters and difference in the composition of the gas produced from the shale oil and that from fuel oil.

The reological characteristics of the shale oil compared to the residual oil were measured for prediction of the operation of the pumps and burners.

The conditions of ignition of the shale oil, stability of the process of practical oxidation in the reactor, the dynamics of growth of deposits in the waste heat boiler tubes, etc., were studied using a small experimental fuel gasification unit having an input capacity of up to 30 kg/hour.

Finally, demonstration processing of a large batch of shale oil containing 7% of sulfur was successfully carried out at the Dzerzhinsk pilot plant. During 24 hours of operation of the plant more than 150 tons of shale oil were processed, in which case the plant capacity was 38,000-45,000 nm³/hour of purified gas with shale oil consumption of 7-9 t/hour. Under the most favourable operating conditions the efficiency of removal of hydrogen sulfide from the fuel gas was equal to 85%. The gas provided stable combustion in the power plant boiler.

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