MODERN EFFICIENT TECHNOLOGIES OF OIL SHALE MINING AND USE IN FUEL AND ENERGY COMPLEX.

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Abstract. Oil shale is one of the promising types of organic raw materials that can largely compensate for, and in the future, replace, oil products and gas. The development of oil shale mining and its subsequent processing is mostly hampered by the problem of utilization of large amounts of carbon dioxide (CO2) emitted during shale tar extraction. In this research, a rather large number of modern thermal technologies for oil shale processing have been studied. Based on comparative analysis, the most optimal environmental technologies are proposed. The main purpose of all processes is to produce marketable products in the form of liquid oil shale and semi-coking gas. Prerequisites are being created in Uzbekistan for the organization of the oil shale industry. Therefore, the use of recommended modern, effective technologies for oil shale mining and use in fuel and energy complex of Uzbekistan will lead to positive results in the diversification of fuel balance of the country.

Keywords: oil shale, organic raw materials, mineral raw materials, the industrial processing of oil shale, ecological technologies, gasification of oil shale, diversification of fuel balance.

1. Introduction

Taking into account modern economic realities, the government of Uzbekistan will activate the process of establishing the production of oil products from alternative sources of raw materials. One such source is oil shale. Based on the data that organic energy resources in the Earth's oil shale are at least 10 times greater than in oil fields, some experts assume that in the next decade, we can expect an "oil shale boom." With the help of "shale" technology, it is possible, among other things, to extract oil residues that exist in the deposits where oil production is finished.

In Uzbekistan, it is planned to apply the technology of oil shale solid coolant installation (SCI) developed by Russian specialists. The project as a whole envisages the construction of eight such plants with a total capacity of 8 million tons of oil shale processing per year and production up to 1 million tons of oil products annually. Besides, the utilization of residual heat from shale ash and semi-coke gas will provide for power generation at the Company's power plant with an installed electric capacity of 120 Megawatt. According to specialists' calculations, when processing 500 thousand tons of oil shale per year, each SCI becomes profitable, and when the amount of oil shale processed further increases, it becomes profitable. In 2015 development of the "Sangrantau" deposit in the Navoi region was started.

According to "Uzbekneftegaz," today oil shale deposit development projects are being worked out not only with "Atomenergoproekt" but also with Japanese Japan Oil, Gas & Metals National Corp (JOGMEC), Estonian Estia Oil and several Korean and Chinese companies [1-2].

There are two main ways of obtaining necessary raw materials from oil shale [3]. The first one is a mining of oil shale by open-cut or mine method with its further processing at special reactor units, where the oil shale is exposed to pyrolysis without air access, resulting in the release of oil shale resin from the rock. The second method is the production of shale oil directly from the formation. The method involves drilling horizontal wells with subsequent multiple hydraulic fracturing of the formation. Thermal or chemical heating of the formation is often necessary. Both methods suffer from some or other essential drawbacks.

The development of oil shale production and its subsequent processing is largely hampered by the problem of utilization of large amounts of carbon dioxide (CO_2) emitted during shale tar extraction. The problem of CO_2 recovery has not been resolved yet, and its release into the atmosphere threatens large-scale environmental disasters. Scientists from Stanford University have recently proposed a solution to this problem. The new EPICC technology, which combines power generation and carbon dioxide capture, may make the currently closed energy resources available [4].

Processing of oil shale can be carried out in two ways: first - gasification, in which the organic mass of oil shale is converted into a mixture of carbon oxides and hydrogen, the second - pyrolysis (or semi-coking) - with the formation of gaseous, liquid and solid products. Thermal decomposition starts already at 300 ° C, but the speed and intensity of semi-coking with the release of tar, gas and residual carbon are maximum in the temperature range of 480 - 520 ° C. Improvement of existing and development of new pyrogenic processes of oil shale processing require in-depth study of pyrolysis processes. At present there is no theory, which would allow to predict the course of thermal processing and determine the composition of the resulting products on the basis of the chemical and petrographic composition of oil shale and its structure [5].

Gasification of coal, oil shale and other organic fuels is the process of complete conversion of the oil mass of these fuels into combustible gases by means of air, water, steam, oxygen or their mixtures at high temperature. The solid fuel gasification process is a set of oxidizing and reducing processes, as a result of which the organic substance of the source fuel is transformed into a mixture of gases containing combustible components (CO, H_2, CH_4) and ballast impurities (CO, N_2, H_20). Gasification is carried out for transformation of low-grade multi-ash fuel into a gas energy carrier suitable for heating of steam boilers and industrial furnaces of various purposes or for the purpose of obtaining gas mixtures for synthesis of mineral fertilizers, alcohols or synthetic liquid fuel and other chemical products. Gasification is carried out in devices called gas generators operating at atmospheric or elevated pressure. The main products of gasification of oil shale are gas, tar and gasoline [6-8]. For thermal processing of coals and oil shale to produce environmentally friendly gas energy carriers and valuable chemical products can be used technologies with high temperature regimes, in particular, pyrolysis [7].

The main factors influencing the formation of pyrolysis products, their composition and quantitative yield are the final temperature, particle heating rate and the environment in which pyrolysis takes place. The composition of the medium can be variable. The high-speed controlled pyrolysis can be realized only at the processing of raw materials, ground to the state of coarse grinding dust. It can be assumed that the process of using natural or shale gas, as well as coal and shale gasification products as raw materials, soon, will be able to compete with existing methods of obtaining motor fuels. This is primarily due to the high environmental characteristics of the resulting hydrocarbon mixtures, which do not contain sulfur and nitrogen containing compounds as well as aromatic hydrocarbons. At the same time, the wide implementation of this process requires the development of highly effective catalysts for selective synthesis of narrow hydrocarbon fractions.

The combustion of oil shale in boiler plants of power plants is associated with significant air pollution with nitrogen oxides, sulfur dioxide, hydrogen chloride and particulate matter. Concentrations of harmful substances in flue gases primarily depend on the type of furnace, design of burners, excess air and conditions of its mixing with fuel, type and composition of the fuel.

ISSN 2515-8260 Volume 07, Issue 02, 2020

Concentrations of particulate matter are usually determined by the efficiency of the gas cleaning system. On average, 60-80 % of fly ash produced at power plants is captured by inertial cyclones and electrostatic precipitators. Reduction of emissions can be achieved by increasing the efficiency of ash traps at boilers. The main measures to reduce harmful emissions from thermal power plants operating on oil shale include the construction of efficient electrostatic precipitators for flue gas purification and replacement of old boilers with pulverized combustion of oil shale with boilers with circulating fluidized bed [9-10].

There are quite a several thermal technologies of oil shale processing aimed at obtaining marketable products in the form of liquid oils and semi-coking gas. Such processes as "Galoter", "Kiviter" and "Enefit" are implemented in Estonia, " ToscoP", "Paraho", "Chevron STB", "LLNL HRS", "Union" and "Superiormultimineral" in the USA, "Petrosix" in Brazil, "LurgiRurgaz" in Germany [11].

At the same time, any industrial technology should ensure the environmental safety of the region during the development of the deposit and after oil shale processing is stopped for a long time. We have studied quite a large number of thermal technologies of oil shale processing in ground vehicles (Table 1). The main purpose of all processes is to obtain marketable products in the form of liquid oil shale and semi-coking gas. Let us consider some of them as an example.

Process "Galoter." Oil shale 0-25 mm in diameter is mixed with hot ash at 800 °C, obtained by burning spent oil shale (semi-coke). The mixture is moved to an airtight rotary kiln, where heat is transferred from hot ash to oil shale particles, pyrolysis occurs (temperature 520 °C). The resulting oil shale resin vapor and gas are cleaned and transferred to the condensation system [18].

The "Enefit" process is a modification of the "Galoter" process. The main change is the replacement of semi-coke ovens "Galoter" on the CKS oven (with circulating fluidized bed). In comparison with traditional "Galoter", "Enefit" provides complete combustion of coal residue [12].

Table 1

Classification of the main ground thermal technologies oil shale processing

Process name, location	Oil shale performance	Retort configuration	Heat carrier
"Galoter, Estonia, Narva.	125 t/hr		ash
"Enefit, Estonia, Auvere town.	125 t/hr		ash
"Alberta Tasiuk, Australia, Stuart.		Horizontal retort	ash
"Petrosix, Brazil, São Mateus do Sul.	6200 t/day	Vertical Retort	gaz
"Kiviter, Estonia, Kohla-Järve, Kiviõli.	40 t/hr	Vertical Retort	gaz
"Tosco II, USA, Parachute, Colorado.	1000 t/day	Inclined rotary kiln	marbles
"Fushun, China (Fushun city)	about 4 t/hr	Vertical cylindrical generator	gaz
"Paraho, USA, Rifle, Colorado.	230 t/day	Vertical cylindrical generator	gaz
"Lurgi-Ruhrgas, Germany	11 t/day	Vertical cylindrical generator	ash
"Chevron STB, Richmond, California, USA	320 t/day	Vertical cylindrical generator, fluidized bed reactor	ash

"LLNL HRS, Colorado, Parachute, USA		fluidized bed pyrolysis reactor	ash
"Union, USA, Parachute Creek, Colorado.	1080 t/day	Vertical Retort	gaz
"Superior Mineral, USA, Cleveland, Ohio.	-	Horizontal retort	gaz

The technologies presented in Table 1 use two sources for heating oil shale:

- solid heat carrier (shale ash, ceramic balls) - processes "Galoter", Estonia, Narva; "Enefit", Estonia, Auvere settlement; "Alberta Tasiuk", Australia, Stuart;

- gas heat carrier (with internal heating - Union A, Paraho Direct, Kiviter, Superior Direct, Kentort II and external - Union B, Paraho Indirect, Petrosix, Superior Indirect, Fushun).

Based on the selected criteria, it was found that the most advanced technology is "Enefit," as in this process, the minimum environmental impact and maximum yield of the target products (90-95%). The minimal environmental impact is explained by the use of potential heat of fly ash, the possibility of processing of oil shale of small fraction in the production of up to 30%, high yield of oil shale, and low consumption of water resources. Complete combustion of carbon residue provides relative safety of groundwater and leads to the possibility of using ash capable of replacing clinker in cement production. Besides, the use of waste heat for electricity generation also helps prevent carbon dioxide emissions.

To date, many countries are conducting extensive research and development and experimental work aimed at creating new technologies to use oil shale. One of the promising thermal methods for complex processing of oil shale is the plasma chemical method. Plasma-chemical technology has wider possibilities because the temperature of the coolant can reach 3000÷5000 K, and at high temperature, accelerates the chemical transformation of hydrocarbons. In this process, the destruction of organic substances is carried out with the energy of low-temperature plasma of reducing gas (hydrogen, a mixture of hydrogen and methane).

The necessary condition of the underground industrial processing method is favorable geological conditions, namely - depth. For example, in the USA, industrial production of shale oil by the underground method was started in 1985, and in the Picence Creek basin (Colorado) maximum capacity of shale formation reaches 600 m (depth 450 m).

The advantages of underground processing include exclusion of losses during oil shale extraction and transportation and the absence of ash dumps [11-12].

Thermal distillation to produce tar and synthesis gas is a promising way to process oil shale. By further processing of tar, one can obtain gasoline, lubricating oils and some other products similar to those emitted from oil.

Based on the conducted researches, it is possible to conclude that shale oil is one of the most essential "reserves" for the further development of fuel and energy complex of Uzbekistan. The use of effective modern technologies of oil shale extraction and use in the fuel-energy complex of Uzbekistan considered above will lead to positive results in the diversification of fuel balance of the country.

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