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COAL REVITALISATION AS A PROMISING WAY TO PRODUCE FUEL AND VALUABLE CHEMICAL COMPOUNDS

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In Russia, the history of research on the creation of technologies for processing solid minerals into products for fuel and chemical purposes is about 100 years. The chemical and technological research has showed the prospects of using coals with high hydrogen content in the organic mass as raw materials for chemical, oil and gas chemical industries [1-4].

By the early 1930s, pilot and industrial coal hydrogenation plants were put into operation in Germany, the USSR, Great Britain, and Japan [5]. On the territory of the USSR in the 1930s were built several plants for coal processing (in Moscow and Kemerovo), but these plants were not perfect and different from foreign ones, and due to the war in the 40s, the plants fulfilled defence orders [3]. In Germany during the Second World War there was a difficult situation with fuel for military equipment. A. Hitler ordered to build large-scale plants for processing coal into motor fuels. As a result, 14 plants have been built (4 million tonnes of fuel per year were produced).

In the end of the war, "trophy" plants from coal processing plants were brought from Germany but all of them were in poor condition and could not be used. Since 1948, large oil deposits have been discovered and the active coal use in industrial energy was developing. The research on the production of "liquid coal" was suspended.

Nowadays the situation in the world and the region has changed. Now one of the most important factors of the raw materials use is their environmental friendliness (it should lead to a decrease in coal consumption in the world). In recent years, the limited oil reserves and the increasing costs of oil production, became a resurgence of research into the use of oil shale and coal to produce liquid products. There are also low metamorphosed coals. An example is Barzass coal basin coals, which are not relevant for conventional combustion due to high ash content and volatile yield, but they have a very high degree of hydrogenation. Such coals are the result of transformation in anaerobic conditions of lakes and shallow seas of organic mass of plankton, spores and pollen of plants, which resulted in formation of peculiarities of these coals - high hydrogen content up to 12% and high yield of volatile substances (50-60%).[6]

The most effective and universal method of obtaining liquid products from coal is direct hydrogenation using hydrogen-bearing solvent. To date, despite a wide range of studies and technologies for processing of coals of low degree of metamorphism, there are no justified technologies for liquefaction of sapropels of the Barzass deposit. The process of transferring the developed technologies of low degree of metamorphism coal and oil shale annealing to the raw materials of the Barzass deposit is complicated due to the differences in composition and properties. Studies related to obtaining information. The analysis and construction of the main regularities of thermal transformations of Barzass sapropel coal (in the course of the liquefaction using tetralin) are relevant for the development of theoretical foundations in the development of the coal-chemical cluster in the territory of Kuzbass.

The works on coal liquefaction from the Barzass deposit [1,3] have shown the need for a more detailed study of the behaviour of low-metamorphosed coal in the processes of their thermal treatment. In direct liquefaction, in order to turn solid coal fuel into a liquid, it is necessary to break large coal molecules into smaller ones and add hydrogen [7]. In addition, coal can react with increased liquid yields if hydrogen is supplied outside (in addition of solvents or catalysts).

It has been shown [8] that among Kuzbass coals the plate form of Barzass sapromyxites and the weathering product are the most suitable raw materials for technologies of direct liquefaction with subsequent production of motor fuels and valuable chemical compounds from products of hydroconversion of solid fuels. We have carried out experiments to determine the thermodynamic and regime characteristics of thermal transformation of Barzass coal in the presence of hydrogen-donor solvent (tetralin). Tetralin is a hydrogen donor in many modern schemes for obtaining liquid products from coal. When it is added to pulverised coal, two effects are achieved: firstly, dissolution of coal in tetralin, and, secondly, hydrogenation of coal by hydrogen transfer from tetralin to hydrogen-deficient coal.

To carry out the study, an apparatus based on a 400 mL non-flow type reactor was used. Fig. 1 shows the scheme of the experimental setup.

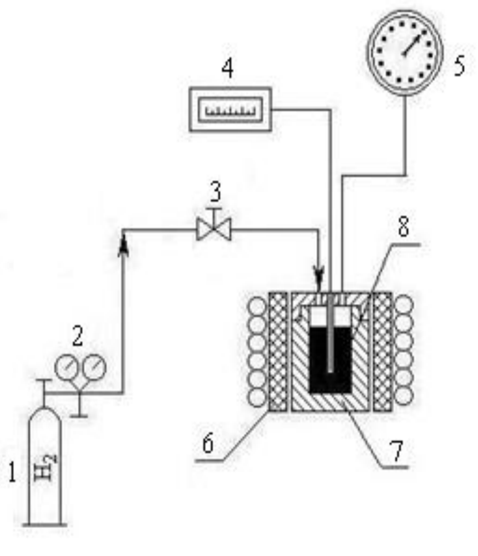

Fig. 1. Schematic diagram of the experimental setup
1 - hydrogen cylinder; 2 - gas reducer; 3 - valve; 4 - thermoregulator; 5 - pressure gauge; 6 - electric furnace; 7 - autoclave; 8 - charcoal sample with solvent;

When conducting experiments in the reactor-autoclave is loaded coal (fraction 2-3 mm.) in different ratio with solvent (tetralin), after which gas (hydrogen) with initial pressure from 1 to 2 MPa is fed into the reactor through the valve located in the upper part of the reactor. In the muffle furnace the reactor is heated up to the temperature specified in the experimental procedure with a gradual increase in pressure up to 20 MPa. The rate of heating of samples in the reactor is 8-12°C/min. The process temperature is controlled by a chromel-alumel thermocouple and the pressure in the system by a manometer. When the temperature inside the reactor set in the research methodology is reached, the heating is switched off and the energy supply is regulated with the help of a temperature regulator to maintain the set process temperature. The duration of the process is 20 minutes. Then, the reactor is removed from the furnace and cooled to room temperature. The solid, liquid and gaseous fractions (after the reaction) are collected and sent for the analysis.

The preliminary results of the research should include the values of thermodynamic values of the process of thermal treatment of Barzass sapromyxites in the presence of tetralin: the maximum yield of liquid products is achieved (pressure 12-13 MPa and temperature 440°C). It should be noted that with increasing pressure, the yield of liquid products increases, but there is an increase in the viscosity of the obtained liquid. In experimental studies to determine the effect of the duration of heat treatment at the optimal parameters of the process it was found that with an increase in holding time from 10 to 40 minutes, the yield of liquid products decreases, while at the same time increases the yield of solid products. It was also determined that the use of hydrogen-donor solvent increases the yield of liquid products, with the highest yield of liquid products observed at a ratio of coal / tetralin equal to 1/2.

As a result of these experiments, we obtain petroleum products (maltene and asphaltenes) and about 38% yield of liquid products from Barzass sapromyxite, whose composition includes: indane (from 4%), benzene (from 15%), methyl (from 25%), naphthalene (from 30%), butyl benzene (from 3%), trimethyl (from 2%), limonene (from 2%), ethyl benzene (from 5%), dimethyl (from 2%), dimethylnaphthalene (from 2%), trimethyl (from 3%), curcumin (from 2%), methane (from 2%), dimethylbutyl (from 2%), tetrahydronaphthalene (from 1%), tetrahydro-2-naphthalenol (from 1%) and many other products, the percentage of which in the obtained liquid depends on the conditions of the experiment (pressure, temperature, holding time, ratio of coal and solvent (tetralin)).

The analysis of the gas obtained during heat treatment of one of the samples showed the following components: methane (from 21%), ethane (from 9%), propane (from 2.5%), isobutane (from 0.2%), butane (from 0.4%), as well as higher molecular weight hydrocarbons, including alkanes and isoalkanes, alkenes and isoalkenes.

Thus, the development of a technological scheme for animate sapropelite solid fuels will allow to obtain a wide range of products such as: fuel in the form of liquid and gas, various chemical elements used in medicine, chemical and petrochemical industry.

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