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APPLICATION NATURAL ORE MATERIALS AS CATALYSTS AT HYDROGENATION OF KENDERLYK COAL

Abstract. This work discusses the effect of bauxites as catalysts of hydrogenation of the coal from Kenderlyk deposit. According obtained results output of liquid and gaseous products increased with the increase of iron content in the catalyst was established. Also, dependent output of liquid products on the temperature at the various catalyst mass have been studied. It was shown the increase of the catalyst mass due to increase of liquid products by 50% in comparison without catalyst.

Key words: coal, Kenderlyk, catalyst, bauxite.

Introduction. The concept of coal hydrogenation catalyst has indefinite, often conditional meaning, since this process involves many chemical reactions (destruction of coal multi-structure, activation of molecular hydrogen, its interaction with coal substance, etc.) and the compounds and mixtures used as a catalyst which undergo irreversible changes. The objective of development of active catalysts is complicated by small level of knowledge in molecular and supramolecular structure of coal, causes of high reactive power when heating, and the nature of transformation of coal substances [1, 2].

It is commonly supposed that the coal hydrogenation catalysts comprise compounds that promote the increase of level of transformation of coal into liquid products soluble in benzene. Such compounds include oxides, sulfides of metals with mixed valence (Mo, W, Co, Ni, Fe, etc.), natural formations, production wastes and their compounds [3-5].

Recently, there are ongoing studies of possibility to apply the wastes of metallurgical industry and natural ore materials as catalysts of coal liquefaction. In some cases, for activation of ore catalytic systems are used sulfur and sulfur compounds or various natural additives containing nickel, cobalt and molybdenum. The economic feasibility of the use of such catalytic systems resides in their law cost, availability, avoidance of catalyst extraction from hydrogenation mud [6].

The variety of combinations of micro- and macro-components in natural ore materials, changes of their content and structure at the stage of enrichment and preliminary processing for production assume availability of wide range of catalytic properties both of interim products and mill tailings [7].

EXPERIMENT

As an object of hydrogenation study it was decided to select the coal from Kenderlyk deposit with the following physical and chemical properties: W^a – 8,0 %; A^d – 15,2 %; V^{daf} – 38,2 %; C^{daf} – 65,2 %; H^{daf} – 3,9 %; N^{daf} – 1,7 %; Q^{daf} – 7244 kcal/mol.

The testing of catalytic properties for coal hydrogenation involved Turgai bauxite with different iron content and red mud (wastes from processing of bauxite ore from Pavlodar Aluminum Plant). The testing was performed at flow unit with the chamber of 100 cm^3.

RESULTS AND DISCUSSION

The results of testing of Turgai bauxite and red mud for hydrogenation of Kenderlyk coal are shown in table 1. As is seen from the table, the most active catalyst is Turgai bauxite – 094 and red mud. The catalytic activity of the tested catalysts was evaluated against output of liquid products (OLP). In coal hydrogenation without a catalyst OLP was 38.1% from coal amount upon distillation of the generated mass after the test within the temperature range from 80 to 320 ^oC without use of vacuum. At the same time the main amount of the liquid product (LP) (50-60 %wt) comprise high-boiling fraction (250-320 ^oC).

According to the obtained extreme values (figure1), an output of valuable liquid and gaseous products is increasing with the increase of ore content in the catalyst.

An optimal way that may be considered is the use of bauxite 094, which application leads to production of 53.1 % of liquid products and 45.5 % of gas from mud with the loss of 3.2 %.

As is seen from figure 1, OLP has linear dependence on the ore content in the catalyst (R^2=0.765). Therefore, further testing was performed on bauxite 094 catalyst.

Table 1 – Effect of catalyst nature on output of liquid products from hydrogenation of Kenderlyk coal

Catalyst	Chemical composition	Content of Fe in catalyst,%	OLP, %	Sludge, %	Losses, %
Without catalyst		–	38,1	53,9	8,0
Bauxite 706	$Fe_2O_3 – SiO_2 – Al_2O_3 – TiO_2$	1,55	42,0	50,8	7,2
Bauxite 710	$Fe_2O_3 – SiO_2 – Al_2O_3$	10,29	44,0	49,3	6,7
Bauxite 916	$Fe_2O_3 – SiO_2 – Al_2O_3$	11,55	46,5	47,7	5,8
Bauxite 704	$Fe_2O_3 – SiO_2 – Al_2O_3$	14,40	47,6	54,6	2,8
Bauxite 094	$Fe_2O_3 – SiO_2 – Al_2O_3$	16,59	51,3	45,5	3,2
Bauxite 110	$Fe_2O_3 – SiO_2 – Al_2O_3 – TiO_2$	16,94	49,2	44,3	6,5
Red mud	$Fe_2O_3 – SiO_2 – Al_2O_3 – TiO_2 – MnO_2$	28,40	49,6	45,7	6,3

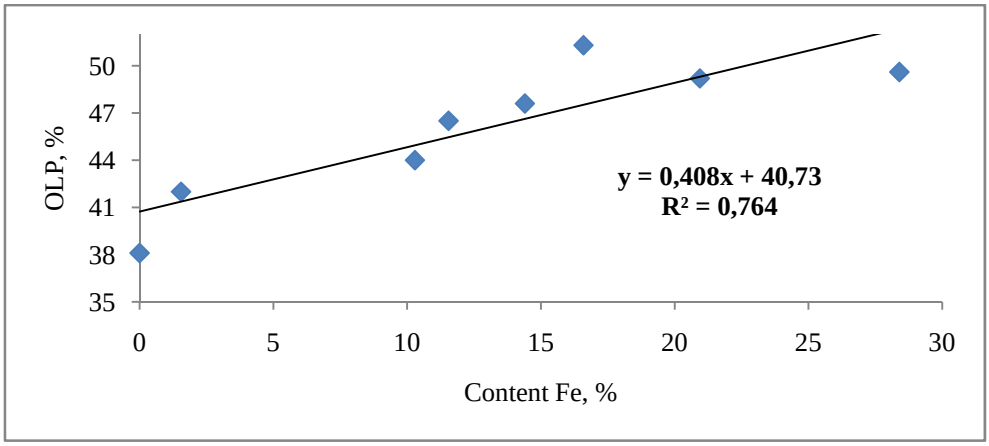

Figure 1 – Dependence of output of liquid products (OLP) on Fe content in the catalyst

An output of LP within wide range of temperatures (from 350 to 440 °C) upon contacting with bauxite 094 is 31.7 to 51.3% (table 2). At the same time, LP output is increasing at the range temperature from 350 to 420 °C, and above the 420 °C, the output decrease (figure 2) This, presumably, happens due to the fact that at >420 °C the side processes are identified, particularly, generation of gas and semi-coke. An output of light fraction is also symbatically increasing (3.1 % to 8.0 %) with the increase of temperature from 350 to 420 °C with further decrease.

Therefore, an optimal temperature of hydrogenation reaction for Kenderly coal is the temperature within 400-420 °C, at which further tests have been performed.

A positive effect on transformation of coal in hydrogenation under low pressure provides the amount of catalyst (table 3). With the increase of the catalyst amount from 0.34 to 0.67 g an output of liquid products is increasing more than twice and further increase of the catalyst amount to 1.68 g does not affect liquid products output. Based on the data of table 3 we produced diagrams

Table 2 – Effect of temperature on output of liquid products from hydrogenation of coal (m_{coal}=10 g, m_{PU}=20 g, m_{kt}=0,67, τ=30 min., Kt- bauxite 094)

T, °C	P_{max}, MPa	V_{gaz}, l	OLP,%				Sludge, %	Losses, %
			to 180 °C	180-250 °C	250-320 °C	Σ фр		
350	1,1	1,8	2,4	3,1	26,2	31,7	64,8	3,5
385	2,1	3,8	4,6	5,2	31,5	41,3	55,1	3,6
400	2,6	4,6	4,4	5,0	36,9	46,3	51,0	2,7
420	3,8	4,0	14,4	9,0	27,9	51,3	45,5	3,2
440	4,4	9,0	10,2	7,8	22,5	40,5	54,4	5,1

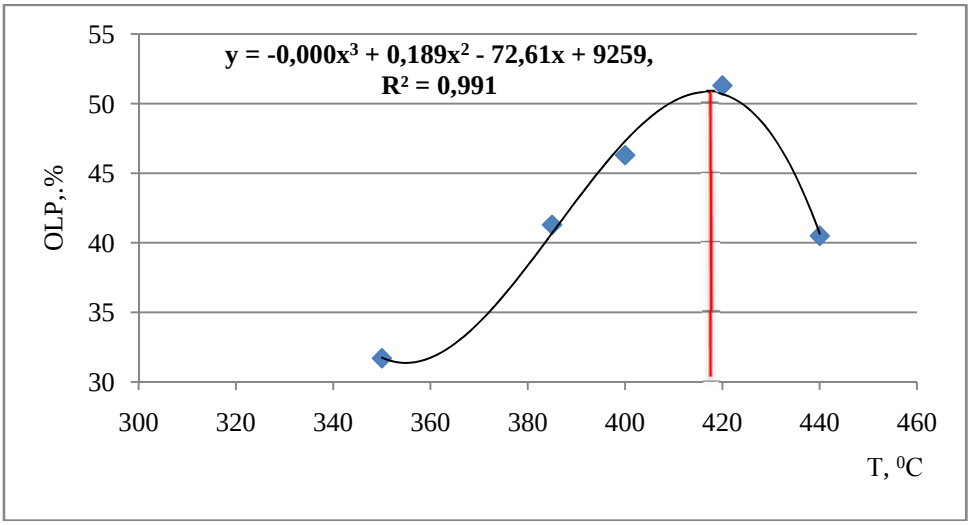

Figure 2- Dependence of output of liquid products on process temperature.

Table 3 – Effect of catalyst amount (bauxite-094) on output of LP from hydrogenation (m_{coal}=10 g, m_{PU}=20 g, T=420 °C, τ=30 min)

Mass of catalyst, g	P_{max}, MPa	V_{gaz}, l	OLP,%				Sludge, %	Losses, %
			to 180 °C	180-250 °C	250-320 °C	Σ fraction		
–	2,8	3,1	5,7	6,5	14,5	26,7	67,2	6,1
0,34	2,0	4,2	6,2	7,3	14,8	28,3	66,9	4,8
0,67	3,8	5,0	14,4	9,0	27,9	51,3	45,5	3,2
1,0	3,9	5,1	11,7	11,2	14,7	37,6	58,2	4,2
1,34	4,2	6,0	15,6	8,1	23,6	47,3	45,4	7,3

of dependence of catalyst amount (figure 3) and pressure (figure 4) on the output of liquid products.

Conclusion. Thus, based on the obtained results there could be made a conclusion on sufficiently high activity of Turgai bauxite 094 in hydrogenation of coal from Kenderlyk deposit, where its activity depends on of iron content in the catalist. It was demonstrated that with increase of catalyst mass to 0.67 g an output of liquid products is increasing almost by 50% in comparison with the process without a catalyst.

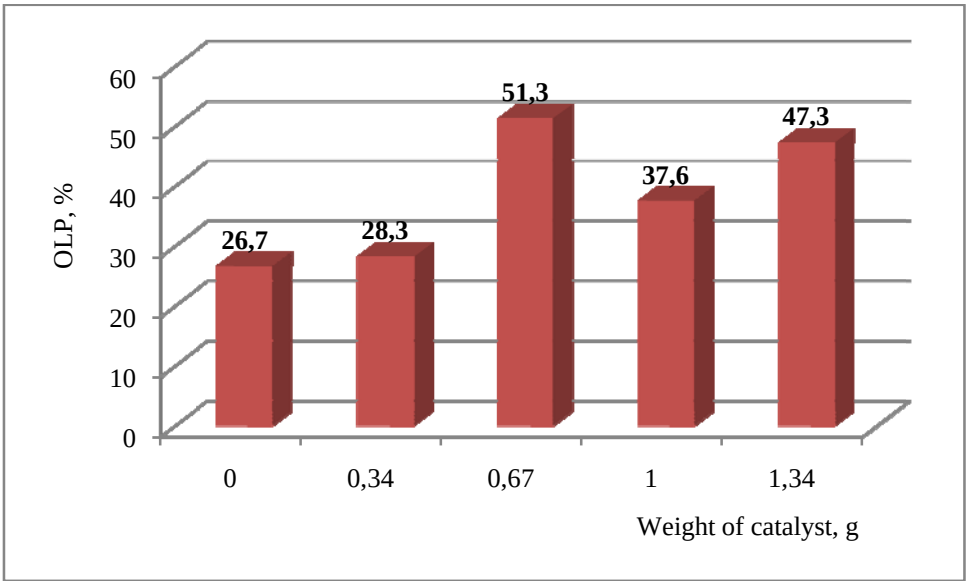

Figure 3 – Dependence of output of liquid products on catalyst amount

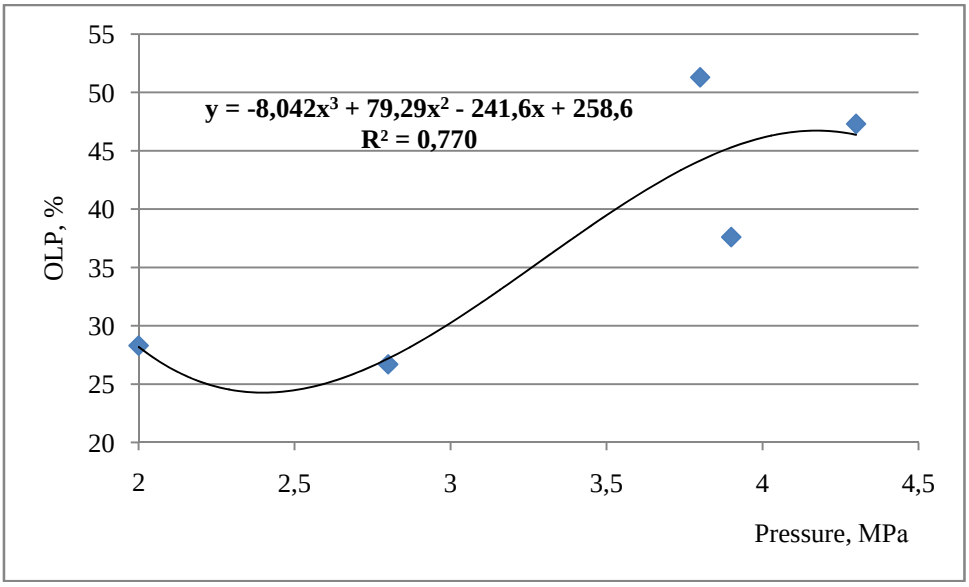

Figure 4 – Dependence of output of liquid products on process pressure

REFERERENS

[1] Golovin G.S., Maloletnev A.S. Catalog-reference book "Complex processing of coals and increasing the efficiency of their use". Moscow: STC "Track", 2007. 292 p., 28 ill.

[2] Gyulmaliev A.M., Golovin G.S., Gladun T.G. Theoretical foundations of coal chemistry. Moscow: Izd-vo MGGU, 2003. 556 p.

[3] Kairbekov J.K., Yemelyanova V.S., Zhubanov K.A., Myttykbayeva Zh.K., Bayzhomartov B.B. Theory and practice of coal processing: Monograph. Almaty: Publishing house "Bylim", 2013. 496 p.

[4] Kairbekov J.K., Toktamysov M.T., Zhalgasuly N., Yeshova Zh.T. Complex processing of brown coals of Central Kazakhstan: monograph. Almaty: Kazakh university, 2014. 278 p.

[5] Kairbekov J.K., Zhalgasuly N., Aubakirov E. New technologies of mining and processing of minerals: Monograph. Almaty: Kazakh university, 2014. 224 p.

[6] Kairbekov J.K. Processing of solid fossil fuels: Book. Almaty: Printing house «BTS print», 2014. 260 p.

[7] Rusyanova N.D. Uglekhimiya. Moscow: Science, 2003. 316 p. ISBN 5-02-033064-7.

Резюме

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КЕНДЕРЛІК КЕН ОРНЫ КӨМІРІН ГИДРОГЕНДЕУ ҮРДІСІНЕ КАТАЛИЗАТОР РЕТІНДЕ ТАБИҒИ КЕНДІ МАТЕРИАЛДАРДЫ ҚОЛДАНУ

Берілген жұмыста «Кендерлік» кен орны көмірін гдрогендеу үрдісіне катализатор ретінде бокситтердің әсері қарастырылған. Алынған тәжірибелік деректерге сәйкес, бағалы сұйық және газ тәрізді өнімдердің шығымы катализатордың құрамындағы темірдің жоғарылауымен арта түседі. Сондай-ақ сұйық өнімдердің температурасы мен катализатор массасына тәуелділігі зерттелінді. Катализатор массасының ұлғаюымен сұйық өнімдердің шығуын катализаторсыз өңдеуге қарағанда 50%-ға арттыру байқалады.

Түйін сөздер: көмір, Кендерлік, катализатор, боксит.

Резюме

Ж. К. Каирбеков, И. М. Джелдыбаева, Э. Т. Ермолдина

ПРИМЕНЕНИЕ ПРИРОДНЫХ РУДНЫХ МАТЕРИАЛОВ В КАЧЕСТВЕ КАТАЛИЗАТОРОВ ГИДРОГЕНИЗАЦИИ КЕНДЕРЛЫКСКОГО УГЛЯ

Рассмотрено влияние бокситов в качестве катализаторов гидрогенизации угля месторождения «Кендерлык». Согласно полученным экспериментальным данным, установлено, что выход ценных жидких и газообразных продуктов повышается с увеличением содержания железа в катализаторе. Также была исследована зависимость выхода жидких продуктов от температуры и от массы катализатора. Показано, что с увеличением массы катализатора наблюдается увеличение выхода жидких продуктов на 50 % по сравнению с осуществлением процесса без катализатора.

Ключевые слова: уголь, Кендерлык, катализатор, боксит.