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The Involvement of the Wide Potential of Alternative Energy Sources of Central Asia the Key to Natural Resources Conservation and Environmental Improvement

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Abstract

The results of the analysis of the potential reserves of organic fuel in the Central Asian region and the consequences of their use consisting in the release of a large number of pollutants into the atmosphere are presented. An assessment of the region's hydropower resources has also been conducted a comparison with the organic reserves of which makes it possible to assess their advantages over organic ones, both from the economic and current requirements to mitigate the impact of Global Climate Change. The paper reflects the results of using the energy aspect of water flowing out of reservoirs to produce a representative of green energy-hydrogen. The results of the development of hydrogen generation technology by electrolysis of idle water discharges from reservoirs and studies of the dependence of the efficiency of the electrolysis process on experimental parameters are presented.

Keywords: Fuel; Central Asia; Water reservoir; Hydropower; Idle discharge

Introduction

Hydrogen power has always been at the center of research in leading scientific centers of the world. Rapid development of researches of this area come to 60^{th} -70^{th} years of last century when intensive researches on synthesis of energy capacity substances on base metal - hydrogen composition known in chemistry as Hydride of metals widely applied as a component of rocket fuel were conducted. Hydrogen energy is an alternative to traditional energy of organic fuels. Fossil fuel reserves in the Central Asian region are more or less stable. Currently, however, of all mineral fuels widely used natural gas. A total reserve of natural gas in the region is about 3.5 Bln. t and oil reserves of more than one Bln. t of equivalent fuel. A similar situation exists in the coal industry; the region has an inexhaustible reserve of coal about 4.0 Bln. t of equivalent fuel. The presence of rich deposits of fossil fuels in a number of countries in Central Asia has contributed to the development of enterprises for the production of heat and electricity using mainly fossil fuels.

State Joint Stock Company UZBEKENERGO in Uzbekistan - is the largest company in the production and supply of the Republic of Uzbekistan by thermal and electric energy with capacity of 11.238 MWt, which covers 98% of electricity requirements and 35% of thermal energy. The fuel uses natural gas, fuel oil, and coal and gas underground gasification of coals. Average annual fuel balance system of UZBEKENERGO: natural gas - 86.7%, oil - 10.26%, coal - 3.04%. Total emissions of toxic gases into the atmosphere is 206.143 Th. t including coal ash - 47.94 Th. t, sulfur dioxide - 120.12 Th. t, nitrogen oxides – 37.166 Th [1].

Kazakhstan need for electricity and heat by 85% satisfied by burning coal. The average efficiency of thermal power station in Kazakhstan 30-32%, whereas, according to the specifications must comply with 42 - 53%. Now in the Republic of Kazakhstan to take a course on the transition from coal to gas and expected that such a transition will be accompanied by the reduction of CO_2 emissions by approximately 40%. This provides the CO_2 emissions to 37 Mln.t annually.

The CO_2 emissions in Kyrgyzstan in 2004 were much higher than 12 Mln.t. The program of strategic development of the energy sector predicted the growth production of electricity and thermal energy in thermal power stations in Kyrgyzstan by use of coal Karakeche coals deposit. Assumed the possibility of building a thermal power plant with capacity of 800 MWt. This will obviously promote to increase the emission of greenhouse gases to the atmosphere.

In the Republic of Tajikistan, there are more 40 coal deposits and occurrences. Diluted industrial significant reserves are more than 670 Mln.t. However, due to lack of infrastructure, coal mining is insignificant 20-25 Th. t per year. According to the strategy of socio -economic development of Tajikistan to 2015 foresee mining of coal 600-800 Th. T, oil production to 100-300 Th. t, natural gas production to 300-500 $Mln.m^3$.

Now one of the most urgent problems of modernity is global climate change. Obviously that in the trend of climate change is a key factor is concentration of greenhouse gases in the atmosphere. Emissions of air pollutants in Central Asia mainly consist of suspended solids (35%), SO_2 (31%), CO_2 (14%) and nitrogen oxide (10%) [2].

Environmental problem and the reduction of the dynamics of global warming stimulate research for define of alternative and clean energy resources.

Hydrogen energy is seen as a potential contender for filling the energy sector with cheaper and cleaner fuels [3]. At present, there is an opinion in the world that, due to unlimited resources, high-energy saturation, technological flexibility and ecological purity of energy

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conversion processes involving hydrogen, it should be considered as the most promising energy carrier of the future [4-12].

In this respect, hydrogen energy can be considered as a potential contender to fill the energy sector with a cheaper and cleaner fuel. Moreover, the main raw material for the production of hydrogen is water.

The total hydropower resources of the Central Asia is estimated 460 Bln. kWt·h per year. Currently used only 10% of total capacity. The main volume of regional hydroelectric potential is concentrated in Tajikistan (69%) and approximately 22% in Kyrgyzstan [13].

It is know that in the summer due to the large volume of river flow all hydropower plants in Tajikistan carried idle discharge excess water. According to the information of the Holding Company "Barqi Tojik», the idle discharge of water from the cascade hydropower plant on the Vakhsh River today is 600 m^3 per second. Moreover, this process continues each year in three months (early July - end of September). A simple calculation shows that every summer idle discharge volume of excess water is more than 4.5 Bln. m^3, which is almost half of the project value of the Nurek reservoir (10.5 km^3). The total amount of single dumping of water from reservoirs of Tajikistan in 2012 made on an electric power equivalent more than 6.0 Bln. kWt·h. According to preliminary calculations, the transportation of hydrogen is almost four times cheaper than transport of electricity. It gives the basis and prerequisite for the development of hydrogen power engineering in the Republic of Tajikistan [14].

Problem of environmental protection and reduction of dynamics of global warming stimulates research for alternative and clean energy. In this plan, hydrogen power can be considered as a potential applicant for filling of the energy sector with cheaper and clean fuel. In the present work, there are problems in the use of water resources from upstream countries of the Central Asian Transboundary Rivers and the surplus of the electric power during the summer period for production of hydrogen by electrolysis and the possibility of storage and hydrogen transportation for long distances are considered.

Methods

Production of hydrogen by electrolysis of water

Electrolysis of water is one of the known methods for production of pure hydrogen (99.6- 99.9% H_2) in one technological stage. The efficiency of the process of hydrogen production by electrolysis, primarily determined by the cost of electricity (85%).

Electrolysis can successfully realized directly at the hydropower plants, thermal and nuclear power plants when excess capacity can used for production and storage of hydrogen. For this purpose can be used a powerful electrolysis with the capacity of 1.0 Mln. m^3 of hydrogen per day. The electrolysis of water on a large plant with capacity of 450 tons per day and its power consumption for 1 m^3 hydrogen can be finished by capacity of up to 4-4.5 kWt·h. At such expense, electricity in some situations power the electrolysis of water, even under modern conditions, can become a competitive method for hydrogen production. Electricity consumption for production of one m^3 H_2 and 0.5 m^3 O_2 under normal conditions and the theoretical equilibrium voltage of water decomposition (1.23 V) will be:

$$WT=1.23\ (2\cdot 26.8:0.0224)=2.95\ kWt\cdot h \quad (1)$$

Where 26.8- number of Faraday's number (A·h) on mole; 2- number of Faradays spent for allocation 1 mole H_2; 0.0224- volume 1 mol. hydrogen at normal conditions.

At thermo-neutral voltage 1.48 V for production of 1 m^3 H_2 about 3.54 kWt·h electropower is consumed. The real expense of the electric power on modern electrolysis makes up to 5.5 kWt·h on 1.0 m^3 H_2. At normal conditions for production of 1.0 m^3 H_2 and 0.5 O_2 it is necessary 805 gallons of water.

Gaseous hydrogen is transportable and can be stored in huge quantities in natural underground storehouses. An identical section pressure passes through the pipelines in the form of hydrogen or methane with the same quantity of energy. Transportation through pipelines in the form of hydrogen is approximately 4 times more favorable, in comparison with transfer of the same energy in the form of electricity. Now in Tajikistan 15 Billion kWt/h hydropower is produced and used which increases in the summer period. However, nowadays condition of hydropower use is not purposeful. With acceptance in reform of hydropower, raising effectiveness of hydropower decreased the demand up to 25%. We can own the valuable hydropower 6 billion kWt/h only for production of hydrogen gas. In the future, Tajikistan is building two large hydropower stations – Rogun (3600 MWt) and Sangtuda (670 MWt) are continued, the hydropower source can increase. Use of these two stations will bring an additional 20 billion kWt of hydropower annually [15]. All these are the evidence that the republic of Tajikistan has already the conditions for growing of hydrogen power (Figure 1).

For achievement were used a well-known mechanisms that in thin layers of solutions of hydroxides of the metals the value of the effective conductivity exceeds the conductivity in electrolyte volume in 1.5-2.5 times depending on the electrolyte composition. The reason for the anomaly high conductivity is an ordered arrangement of dipoles of water at the phase boundary of gas-liquid and the ability of the relay mechanism of charge transfer without changing the orientation of dipoles of water.

Therefore, the introduction of highly hydrated ions or rise in temperature reduces the ordering of the phase separation border and the value of the effective electrical conductivity, as well as the impact on the change in the surface tension of solutions. Study of the effect of hydrating ion on the efficiency of water electrolysis were performed using electrodes of stainless steel and copper at the voltage on the electrodes 0.6-2.2 V. The solution of potassium hydroxide prepared according to GOST 4517-87. The results of studies of water electrolysis at two values of interelectrode distance and voltage shown in the Table 1.

Figure 2 shows that at the concentration of potassium hydroxide in the electrolytic cell of 0.6-0.8 M at using of copper electrodes there is

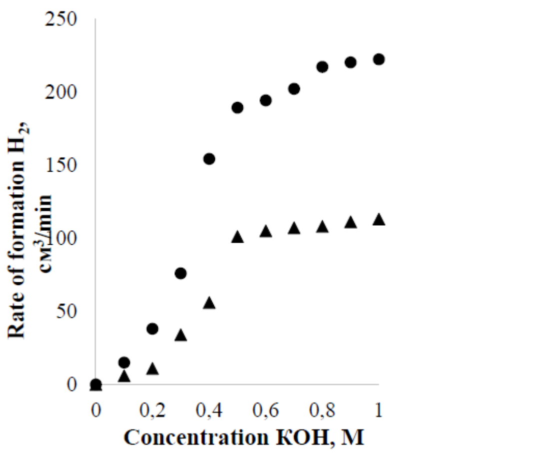

Figure 1: Rate of hydrogen formation at voltage 1.4 V and the interelectrode space of 12 mm by using a copper electrode (●) and stainless steel (▲).

Size of coal particles, mm	W	$V_{micropore}$	$V_{mezopore}$
	cm³g⁻¹		
0.55-0.75	1.57	0.82	0.75
0.75-0.95	1.41	0.73	0.68
0.95-1.20	1.31	0.69	0.62
1.20-1.42	1.15	0.61	0.54

Table 1: The porous structure of coals Fan Yagnob field after treatment.

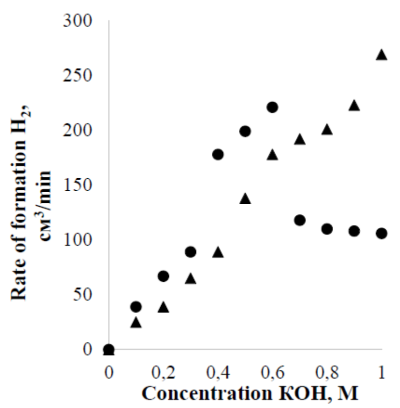

Figure 2: Rate of hydrogen formation at voltage 2.4 V at the electrodes and the interelectrode space of 12 mm by using a copper electrode (●) and stainless steel (▲).

a sharp drop of the rate of electrolysis. Although using stainless steel electrodes occurs a monotonous increase of the H_2. According to our assumption, this is due to the reaction of copper electrodes with KOH alkali and transfer of Cu into solution. To check this assumption, we studied the surface structure of the copper electrodes by use of the electron microscope with a resolution of 200 μm that demonstrated that the microstructure of the copper electrode surface characterized by recesses of different size.

To reduce the erosion of electrode material, electrolysis of water was carried out by increasing the distance between the electrodes to 16 mm.

At comparison of Figures 3 and 4, it is evident that the increase of the interelectrode space leads the beginning of the process of erosion of the electrode material (Cu) at a value of voltage on the electrodes of 2.4 V occurs at higher value of concentration of KOH in electrolytic cell. The structure of the copper electrodes surface shown in the Figure 5.

To prevent erosion of the materials of the electrodes the electrolysis of water was carried out by use of stainless steel electrodes coatings with thin layers of chromium oxide. The influence process of the thin layers of chromium on the efficiency of electrolysis in the presence of potassium alkali in the electrolysis cell was performed using electrodes coated with a layer of chromium 8 and 15 microns. It should note that regardless of the thickness of the chrome layer sharp increase in hydrogen production rate was observed (Figures 6 and 7).

Thus, the obtained results confirm that at the process of electrolysis of water surface catalytic phenomena a crucial role to play.

Figure 8 shows that the application layer of the chrome coating is not subjected to erosion in an alkaline environment even if the duration of 45 hours. To investigate the effect of the active electrode surface on the water electrolysis process have developed methods for producing electrodes from activated carbon impregnated with nickel and cobalt. A large sorption capacity and the developed surface activated carbons served as a good basis for a comprehensive use as carriers for multicomponent catalysts and electrodes used in the chemical industry. For preparation of sorbent as basic materials for production of electrodes has been used Fan Yagnob coals was activated in a muffle furnace at temperatures of 390 - 700 K. Determination of the specific surface of the fine particles of coal before and after processing was carried out at nitrogen gravimetric adsorption on an electronic balance. During the processing of coal Fan Yagnob with an average particle size distribution of 1 mm is observe a significant effect of temperature on the specific surface area of the granules (Figure 9).

The formation of particles with a developed surface at thermal treatment of coal at Taver=723 K is associated with the processes of intensive desorption of gas and thus cracking the starting granules. Naturally, gases desorption and cracking granules are connected by the grinding process as well as increasing the specific surface treatment products. Partial gasification of the organic part and the formation of a sufficient number of pores at treatment should initiate diffusion processes of the mineral components of coal. To determine the influence of the mineral part of coal to the formation of particles with various values of the specific surface area was carried out processing of Fan Yagnob ashless coal (Figure 10).

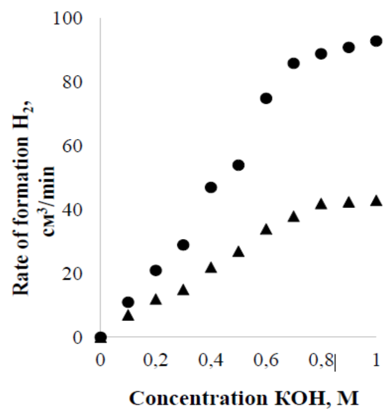

Figure 3: The rate of hydrogen generation at voltage 1.4 V at the electrodes and the interelectrode space of 16 mm by using a copper electrode (●) and stainless steel (▲).

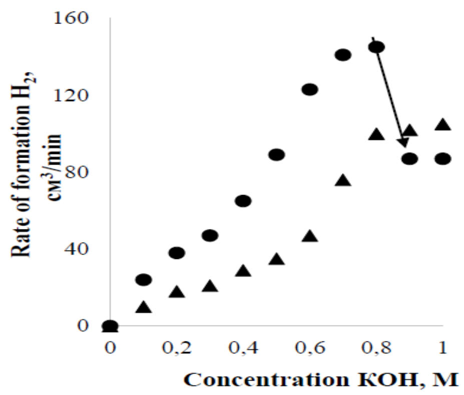

Figure 4: The rate of hydrogen generation at voltage 2.4 V at the electrodes and the interelectrode space of 16 mm by using a copper electrode (●) and stainless steel (▲).

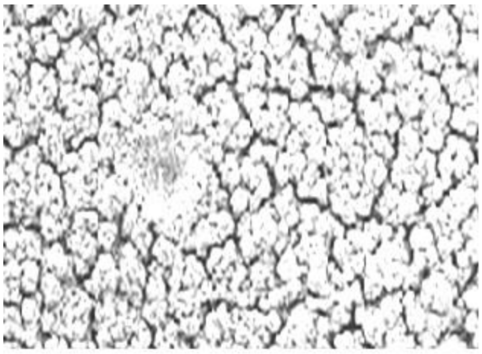

Figure 5: The microstructure of the copper electrode surface.

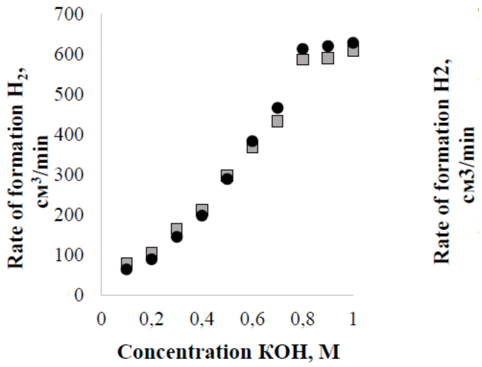

Figure 6: The rate of hydrogen formation at voltages on the electrodes with deposited Cr layer of 8 μ (●) and 15 μ (■) at 1.4 V and an interelectrode space of 12 mm.

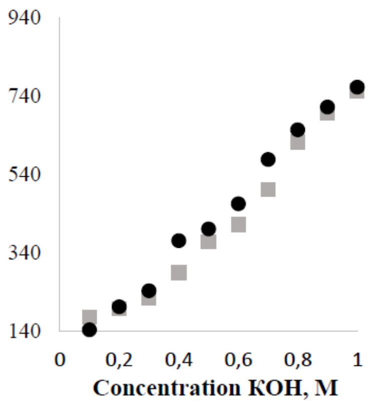

Figure 7: The rate of hydrogen formation at voltages on the electrodes with deposited Cr layer of 8 μ (●) and 15 μ (■) at 2.4 V and an interelectrode space of 12 mm.

Characteristic features of the behavior of coal are not ashless, as seen from Figure 10 it is to achieve specific surface impedance. This indicates a negative contribution to the development of the mineral absorption capacity under high-temperature coal processing. Pore structure of coal after the heat treatment was determined by the standard method of processing the adsorption isotherms of benzene vapors and calculates the mesopore surface. The results are summarized in Table 1.

To form the electrode carrier in an amount of 10 g was charged into a container with a saturated solution of Co and Ni chlorides, incubated for 4, 8; 12; 16; 18; 20; and 24 hours after pre-drying at a temperature 400 K transferred to process RF -discharge. Recovery Co and Ni chlorides carried with hydrogen atoms generated by electric discharge in a stream. Bombing catalyst hydrogen atoms lasted until the full restoration of all Ni chloride and Co (Figures 11 and 12). The degree of completion of the recovery process determined by chemical analysis of the sodium hydroxide solution in a trap installed on the main line from the reactor to the vacuum post. Electrodes fabricated by using the pressing briquetting device. The efficiency of the catalyst obtained was tested for water electrolysis at the electrolytic cell.

Summarizing the experimental results on finding the optimal conditions for the electrolysis of water in order to achieve high yields

Figure 8: The microstructure of the surface of the stainless steel electrode with a thin layer (d=15 μm) of chromium after its operation 45 h.

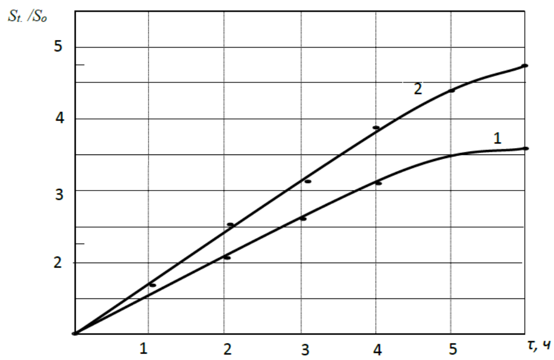

Figure 9: Dependence of the ratio of the coal specific surface before (S0) and after treatment (St) from processing time at 400 (1) and 800 K (2).

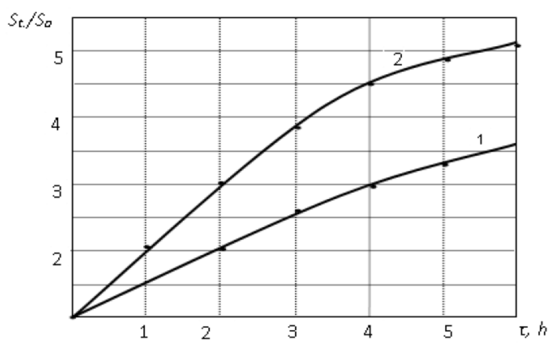

Figure 10: The ratio of the specific surface of the coal before and after treatment for ash (1) and the ashless coal granules (2).

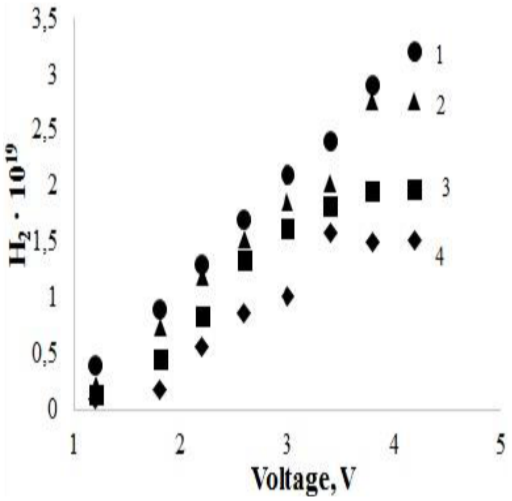

Figure 11: The dependence of the generation of H2 from the voltage values on the electrodes at using activated carbon deposited nickel with the following particle sizes: 1- 0.55-0.75 mm; 2-0.75-0.95 mm; 3-0.95-1.20 mm; 4-1.20-1.42 mm.

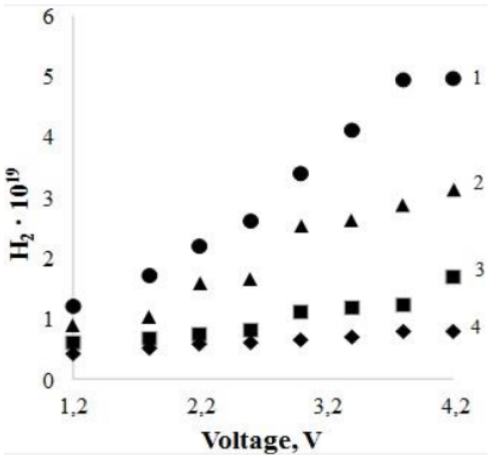

Figure 12: The dependence of the generation of H2 from the voltage values on the electrodes at using activated carbon deposited cobalt with the following particle sizes: 1- 0.55-0.75 mm; 2-0.75-0.95 mm; 3-0.95-1.20 mm; 4-1.20-1.42 mm.

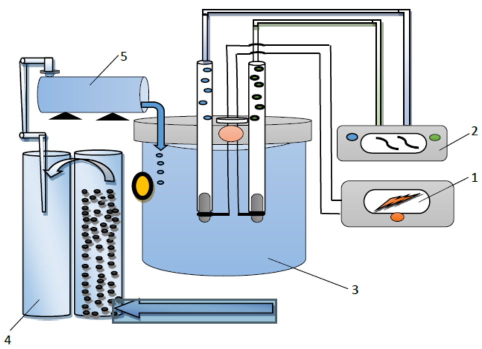

Figure 13: Scheme of the technological line for production of hydrogen by electrolysis of water: 1-power unit; 2 - manometer; 3-cell; 4-cleaning system; 5 - water tank.

of hydrogen gas, a technological scheme for obtaining hydrogen by electrolysis of idle discharges of water from reservoirs was developed (Figure 13).

Conclusion

Thus, it was established that the energy market in Central Asia could be enriched by an alternative energy source based on the widespread use of hydrogen and thereby make a significant contribution to the weakening of the Global Climate Change. The addition of potassium hydroxide during electrolysis greatly accelerates the decomposition of water to produce hydrogen and oxygen. The influence of alkaline medium in the electrolysis process on the microstructure of the electrode surface by formation of recesses on the surface. The use of stainless steel electrodes with a thin layer of chromium deposited significantly accelerates the process of electrolysis, and is resistant to alkaline environment. Shown promising use of multicomponent catalysts based on coal coated with iron family metals (Ni, Co) as the electrodes. For the production of hydrogen by electrolysis of high purity and in a semi-industrial scale, it is necessary to combine the membrane separation method with the pressure swing adsorption (PSA) gas.

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