Energetics

To the Problem of Production of Hydrogen and Sulphur from the Black Sea

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ABSTRACT. One of the most urgent problems of power engineering is the search for alternative sources of energy. While being in search for alternative nontraditional energy sources, the attention is paid to hydrogen whose indisputable advantage is in its considerably good ecological safety. In the present paper the method of hydrogen sulphide extraction from water of the Black Sea depths is described. *© 2014 Bull. Georg. Natl. Acad. Sci.*

Key words: *hydrogen sulphide extraction*

Hydrogen sulphide can make an ecological problem related to flora and fauna deep in the Black Sea. Also it can cause hydrogen sulphide inflammation on the Black Sea surface. However, it can be successfully used for the development of hydrogen energetics.

As the economic prognosis shows the energy consumption by the 50s of the 21st century is going to be increased by 15 times compared with the end of the 20th century. Thus, it will become necessary to consume 80% of the planet natural and liquid gas supply. By 2100 the total consumption of energy will twice surpass present supply of the natural resources available. So today search for the alternative sources of energy is the main challenge for power engineering. While being in search for alternative nontraditional energy sources, the attention is paid to hydrogen whose indisputable advantage is in its considerably good ecological safety (high caloricity, possibility for long storage, non-toxicity, easy transportation, etc). It also can be used without converting the thermal equipment constructions. Though the problem of its not economic production still remains. More than 600 firms, companies, scientific center laboratories and public scientific technical centers in Europe, USA, Australia, Canada and Japan work on the problem of hydrogen production in a much cheaper way.

Successful solution of this most important problem can sharply change the world economics and make the environment healthy.

Number of methods of water dissociation is known: chemical, thermochemical, electrolysis, etc., but all of the methods are not economic enough and prospective.

All the mentioned methods have great disadvan-

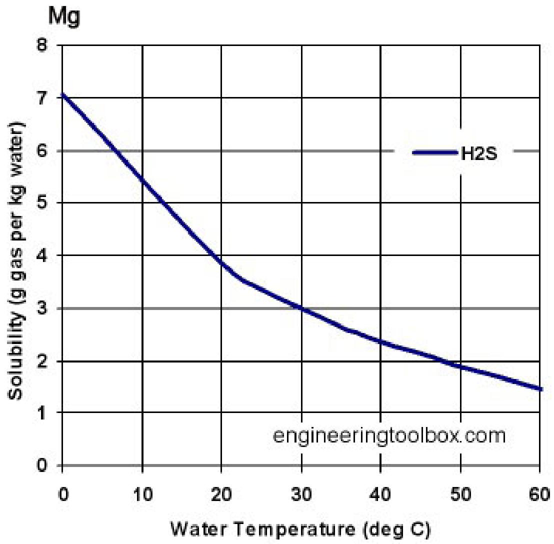

Fig. 1. Dependence of hydrogen sulphide solubility on water temperature.

tage as in the technological process of production of hydrogen high potential energy generated from deficient fossil fuels, such as coal, natural gas, oil products or hydro- and atomic electric power should be used. To produce hydrogen in that way is obviously ecologically dangerous and not prospective. It is well-known that the Black Sea is the largest hydrogen sulphide reservoir in the world. It is possible to produce hydrogen sulphide fuel in a huge amount by extracting water from the depths of the Black Sea using it for thermal power stations. However, it is necessary totally to consume the waste material containing sulphur to make it ecologically safe. According to heat combustion 1m^3 hydrogen is equivalent to 1.49m^3 of natural gas. Hydrogen sulphide inflames at 300^0 C and in case of excess of oxygen it burns. The following reaction occurs:

$$2H_2S+3O_2 = 2H_2S+2SO_2 + 1125 \text{ kj} \qquad (1)$$

In case of less oxygen sulphur and water are obtained:

$$2H_2S+O_2 = 2H_2S+2S + 531 \text{ kj} \qquad (2)$$

As sulphur dioxide (SO_2) is dangerous poisonous gas, reaction (1) is not desirable, though in the process of burning about 2 times as more energy is released. Thus, the technology should be developed with reaction (2).

It is evident that hydrogen sulphide can be used for fuel when adequate ecological safety is completely followed and reaction (2) is used. It is more important to decompose hydrogen sulphide into sulphur and hydrogen, because hydrogen is the most prospective, economic and ecologically clear source of energy today.

It is possible to obtain water vapour by burning hydrogen. The hydrogen weighing thermal capacity (28630 kcal/kg) exceeds petrol thermal capacity by 2.8-times. That is why hydrogen can substitute oil, natural gas and coal and become the basis of future energetics.

It must be noted that hydrogen sulphide dissolves well in water and its solubility decreases with water temperature increase (Fig. 1). In the upper layers of the sea the amount of hydrogen sulphide is rather small (0.13-0.15 mg/l) while in the saturated water with hydrogen sulphide at $8^\circ C$ its amount reaches 5.1 mg/l. Water should be extracted from the depth of the sea. It should also be considered that hydrogen sulphide solubility increases sharply by pressure increase (e.g. hydrogen sulphide solubility at 2000 m depth is 50-times more than at 200 m depth). Thus, it is better to extract hydrogen sulphide from the maximal depth.

As the temperature of water in the depth of the sea is about $8-9^\circ C$ both in winter and summer, by extracting hydrogen sulphide water and heating it up to $60^\circ C$, about 3l gaseous hydrogen sulphide can be released from every liter of water. It is assumed that because of high pressure in the Black Sea depths hydrogen sulphide is in a liquid state and mixes with water. It is possible that there could be hydrogen sulphide lakes nearby the sea bed and it will potentially increase the efficiency of hydrogen sulphide extraction.

Water extraction process is complicated because while extracting some part of hydrogen sulphide releases from water (gas bubbles appear that hinder performance of water pumps). Method (1) of cleaning natural water reservoirs from hydrogen sulphide is well known. The process consists of bringing wa-

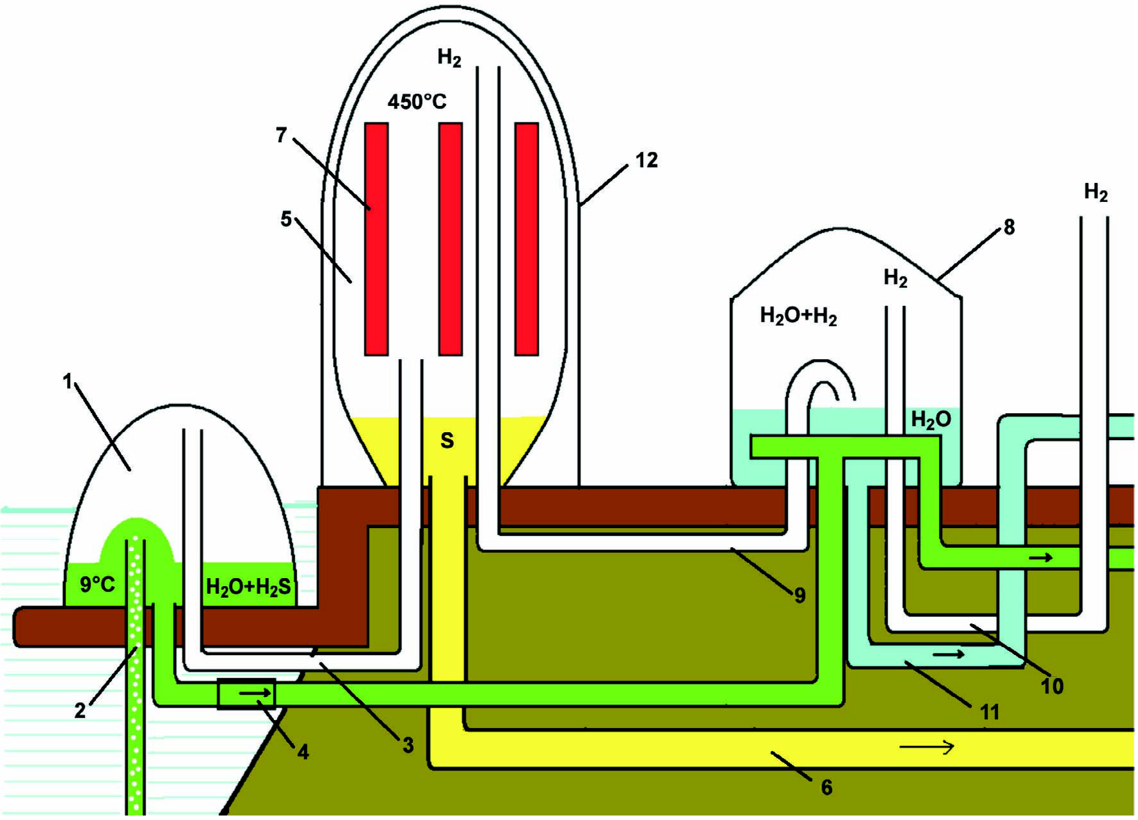

Fig. 2. Sulphur-hydrogen containing water extraction from the Black Sea depths and obtaining hydrogen and sulphur.

ter containing hydrogen sulphide on the surface, releasing hydrogen sulphide out of it and decompose them into elements.

The drawback of the method is usage of electrolysis for decomposition of sulphur-hydrogen. It causes huge consumption of electric energy.

The purpose of the project is to release hydrogen sulphide from natural water reservoirs for further decomposition by applying solar energy and to obtain hydrogen, pure sulphur and fresh water. The purpose can be reached by pipelining water up to the surface from the depth of the water reservoir with the lower part of the pipeline placed below 100-150 m and the upper part in the sealed glass vessel from which the water vapour and gaseous hydrogen sulphide are pumped out and pass to another glass vessel where as a result of hydrogen sulphide photodissociation sulphur is released from gas. The mixture of gases passes to the third vessel, where hydrogen and water vapour are released as a result of water vapour condensation [2].

The present method is based on the hydrogen sulphide photodissociation by means of infrared radiation and is particularly effective in the summer period. It stipulates high economic effectiveness in obtaining hydrogen and pure sulphur.

The presented method implies the procedure of pumping out hydrogen sulphide and water mixture from the depth of water reservoir based on the pressure reduction of gas mixture in a sealed glass vessel.

It should be noted that suphur-hydrogen molecule dissociation energy is little (unlike the water molecule), therefore photodissociation by means of the solar rays is possible. Also the hydrogen sulphide low solubility in water especially at high temperature should be taken into consideration.

The essence of the method is illustrated in Fig. 2.

The appliance consists of three parts. The first part is a sealed, egg-shaped transparent glass vessel of about 100-150 cm diameter and 2-3 m height with a pipe of 10-30 cm diameter placed inside it in a vertical position with the upper part in the vessel at the height of 1-1.5 m from the bottom and the other part in the water reservoir at 150-200 m depth. There is a pipe (3) for vessel (1) pumping out gas and another pipe with a water pump (4). The other part of the equipment is an egg-shaped transparent sealed glass vessel (5) with a cone form bottom. Heating plates are placed in the vessel (7) and three pipes (3), (6), (9) for releasing gases and sulphur liquid. The third metal vessel consists of three pipes (9), (10) and (11) (Fig.2).

The pump in the pipeline (3) provides lower pressure in the vessel (1) compared to the atmospheric pressure (0.7-0.8 atm) so the water and hydrogen sulphide mixture go through pipeline (2). The pressure in the vessel reduces releasing hydrogen sulphide from the mixture in the form of gas bubbles. Water vapour and hydrogen sulphide gas pass from the vessel (1) via pipeline (3) to the vessel (5). There the hydrogen sulphide photodissociation occurs under the solar energy. The hydrogen sulphide photodissociation partly occurs in the vessel (1) too and released sulphur in a solid form mixes with water.

To achieve complete hydrogen sulphide dissociation the gases in the vessel (5) are heated up to 440^0C by means of heating plates (7). The released sulphur as a result of hydrogen sulphide dissociation in a liquid form is accumulated in the lower part of the vessel (5) and through pipeline (9) it comes out from the appliance. Hydrogen gas and water vapour mixture passes from the vessel (5) to the vessel (8) through pipeline (9), where as a result of water vapour condensation, hydrogen is released from water vapour. For more effective condensation some cold water coming from water reservoir depths can be introduced from the vessel (1) to the vessel (8) by means of a spiral pipeline isolated from condensed water. From the appliance the condensed fresh water passes through pipeline (11), hydrogen passes through pipeline (10) to hydrogen collector. In the vessel (1) the necessary level of water is maintained by means of pump (4). Salty sea water with solid sulphur passes to the water reservoir for further treatment. For thermal isolation of the vessel (6) it is covered with transparent egg-shaped glass vessel (12).

For increasing the effectiveness of water extraction from the water reservoir, the sealed vessel (1) is sunk into the reservoir so that to provide the level difference in the vessel and water reservoir necessary for water pumping. In this case there is no more necessity pumping gas out of the vessel (2). It makes the appliance simpler and more economic [2].

The efficiency of the mentioned method of water extraction from natural water reservoirs is ascertained by the experiments carried out by the expedition in Batumi in 2011, where water was extracted from the depth of 200 m.

ენერგეტიკა

შავი ზღვიდან წყალბადისა და გოგირდის მიღების პრობლემა

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დამუშავებულია მეთოდი, რომელიც შეიცავს შავი ზღვის სიღრმეებიდანგოგირდწყალბადისა და სხვა მარილებით გამდიდრებული წყლის ამოღების სისტემას ზედაპირზე წყლისგან გოგირდწყალბადის გამოყოფით გოგირდწყალბადის შემდგომი დისოციაციის გზით აიროვანი წყალბადის, გოგირდისა და სხვა ელემენტგების მიღების მიზნით.

REFERENCES

1. *I. Varshavskii*, et al. (1008), Patent of Russia Federation, #5063095/25. 20.12.1998.
2. *M. Jibladze,* et al. (2011), Method for Production of Hydrogen and Sulphur from the Natural Reservoir, Patent of Georgia P20115334, Tbilisi.
3. *M.18 Jibladze, G. Varshalomidze, I. Sharabidze* (2014). J. Georgian Oil and Gas, 29, Tbilisi.

Received July, 2013