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Technologies For Obtaining Deuterium Depleted Water

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ABSTRACT

The principal manufacturers of deuterium depleted water currently apply the method of distillation in rectifying columns. The disadvantage of this method is the low separation coefficient. Multiple stages are needed in order to significantly reduce the deuterium content which makes the method expensive. We have designed the electrolytical method with a recuperation unit which allows reducing by 4-6 power consumption required for producing light water comparing to rectification methods applied nowadays.

Keywords: deuterium depleted water, light water, rectification, electrolysis, recuperation system, MHD generator.

1. INTRODUCTION

The light water in which the content of deuterium is lower compared to that in standard mean oceanic water (SMOW D/^{1}H=155.76 ppm) modifies the velocity of chemical reactions, ions' solvation, their mobility, etc. Taking light water leads to normalization of carbohydrate and lipid metabolism, weight improvement, elimination of toxins from the organism. It is determined that the taking such water improves work efficiency, physical activity, endurance and resistance of organism [1, 2].

The Institute of Medico-Biological Problems of the Russian Academy of Science has determined that deuterium-rich water has stimulating effect on the organism' reproduction function and has no toxic effect on laboratory animals' organisms, and a long use of deuterium depleted water leads to diminishing the severity of radiation injuries caused by gamma radiation every day exposure with low doses [3].

The main effect of light water is a graded decrease of deuterium content in the body's liquids due to isotope metabolism reactions. The use of water with low deuterium content results in decrease of this element's concentration in blood plasma, in erythrocytes and in homogenate of laboratory animals' hearts. Such changes induce in their turn the decrease of pro-oxydant load in organism and recover of pro-oxidant/anti-oxydant system balance which is further accompanied with higher immunity of laboratory animals [4, 5].

2. Existing methods for obtaining light water

The principal manufacturers of light water currently apply the method of distillation in rectifying columns [7] which uses the difference in different mass isotopes' evaporation rate which grows as the atom mass reduces. Light water has the boiling point in normal conditions at 100.0 °C, while heavy water's boiling point is at 101.4 °C. The study describes a deuterium depleted water plant (fig. 1) consisting of the unit of producing vapor from initial water 1, the unit for feeding water vapor into the rectifying column 2, the unit of interaction vapor-liquid 3 with a contact device inside 4, of the unit for water vapor condensation 5. The vapor pressure inside the rectifying column is from 0.05 to 0.6 bar, the outcome of condensed light water is from 0.001 to 0.25 to the total volume of water vapor fed through the column. The plant allows industrial production of light water with the content of $^1H_2{}^{16}O$ no less than 997.13 g/kg and with total content of $^1H_2{}^{17}O$, $^1H_2{}^{18}O$, $^1HD^{16}O$, $^1HD^{17}O$, $^1HD^{18}O$, $D_2{}^{16}O$, $D_2{}^{17}O$, $D_2{}^{18}O$ no more than 2.87 g/kg of the total quantity of H_2O.

The disadvantage of this method is the low separation coefficient due to the complicated process of maintaining a stable temperature of boiling liquid. Multiple stages are needed in order to significantly reduce the deuterium content which makes the method expensive.

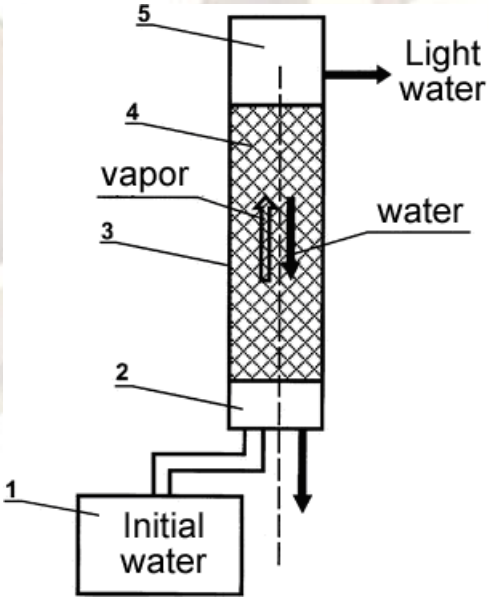

Fig. 1 – Light water producing plant with a rectifying column

Membranes are also proposed to obtain light water [8]. The plant is shown in fig. 2 and consists of the initial water tank 1, the pump 2 for feeding the initial water into the filtering element 3, of the vessel 7 and flow regulator 6 in the form of a laminar resistance. Inside the filtering element 3 the water flow passes along the membrane 4 axe. Under the pressure amounting from 0.1 to 30 bar some water penetrates through membrane 4 and passes to the vessel 7 in the form of light highly pure water. The second water flow bypasses and regenerates the membrane 4, then is fed again to the discharge 5 via the regulator of flows ratio 6. The produced volume of deuterium depleted water is from 0.05 to 0.8 of the total initial water volume. The content of light molecules of $^{1}H_{2}^{16}O$ in the produced light water amounts to no less than 99.734 % of the total quantity of H_2O, the concentration of ^{17}O in the obtained light water is no more than 372 ppm, and the concentration of ^{18}O does not exceed 1960 ppm.

The weakness of this method is a high cost of membranes which require extra pure initial water and wear out fast, and the method does not enable to reduce the deuterium content below 117 ppm.

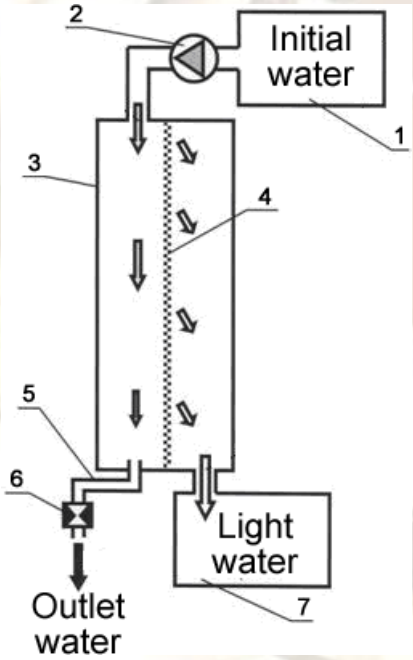

Fig. 2 – Light water producing plant with membrane

The crystallization method allows reducing the deuterium content at most to 136 ppm which is good for health but not enough for medical application. This method may be used as a preliminary phase for further refinements.

Multiple other methods are known which may be used to separate hydrogen isotopes [6], although most of them have a low separation coefficient about 1.01, others are too expensive in installation and operation. Thus, there is a need to design a more cheap and effective method to produce light water.

3. New method for obtaining light water

We have designed a method for producing water that is poor in heavy hydrogen and oxygen isotopes which bases on the difference of oxidizing and deoxidizing potentials and kinetic properties of hydrogen oxido-reducing process from light and heavy water [9-14]. The electrochemical method has been used earlier for the reverse process, i.e. for obtaining heavy water in nuclear power industry.

The separation is carried out as follows. Water is electrolyzed when most decomposed molecules are those containing protium due to lower covalent link strength. Then water is synthesized from an oxygen/hydrogen mixture rich in protium. In order to increase the coefficient of separation and to reduce the hydrogen's overvoltage the electrodes are made of nickel. The plant allows the outcome of product with any specified depletion down to a very low deuterium content – 10 ppm.

The method is implemented using various designs [9-14] and, contrary to other methods permits returning a part of energy back into the production cycle which importantly reduce the power consumption and thus to reduce the final product prime cost.

The energy may be recuperated using the following:

1. Fuel hydrogen/oxygen element [9-10]. The line is equipped with gas mixture separator including a membrane made of palladium and silver installed between the drying unit and the fuel element, and the electrolysis gases into water converter is designed as a low temperature hydrogen/oxygen fuel element with ion exchange membranes providing that the fuel element is electrically connected to the electrolyzer.

2. Gas turbine [11-12]. Electrolysis gases converter is designed as a high temperature gas turbine the shaft of which is mechanically connected to that of the generator supplying the power to the electrolyzer.

3. Magnetohydrodynamic (MHD) generator [13]. The gas mixture is fed into a magnetohydrodynamic generator where it is heated, being burned, up to 2700-3000 °C. The formed plasma while passing through a magnetic field produces electric power supplied into the electrolyzer.

4. Thermoelectrical generator [14]. It is a leak-tight metal rectangular vessel having inside opposite partitions which are offset relatively to each other in the way to prolong to maximum the distance the gas passes. Thermoelectrical modules are fixed to the unit's surface which converts a part of heat into electrical power by virtue of Seeback's effect.

5. A line using simultaneously a magnetohydrodynamic (MHD) generator, thermoelectrical cooling generator and low temperature turbine [14] is shown in fig. 3. The alternative current from an external power distribution network is transformed into direct current by the power supply 1, then flows to the electrolyzer 2 into which distilled water is also fed. The mixture of oxygen and deuterium-poor hydrogen so formed in the electrolyzer, in order to prevent the reverse isotope exchange with water vapors, is passed through the dryer 3 filled with regenerated water absorbing substance. Then the dried gas mixture is fed into the MHD generator 4 in which it is heated, being burned, up to 2700-3000 °C and into which a salt solution with the salt content required to produce drinking water is injected from the vessel 10. The salt is ionized at that. The forming plasma passes through a transversal magnetic field of the MHD generator, and Lorentz force separates it into a positive and the negative flows which get onto the appropriate electrodes, and the produced electric power is supplied into the electrolyzer. The gas temperature is reduced down to 1000-1200 °C. Then water vapor is fed into the cooling generator 5 in which it passes via a coil tubing with thermoelectrical generators attached. After that the gas is fed into the turbine 6 where it rotates the shaft of the generator 7 which produces the electric power that is supplied into the electrolyzer through the rectifier 11. Then water vapors are fed into the condenser 8 and then to the collector 9.

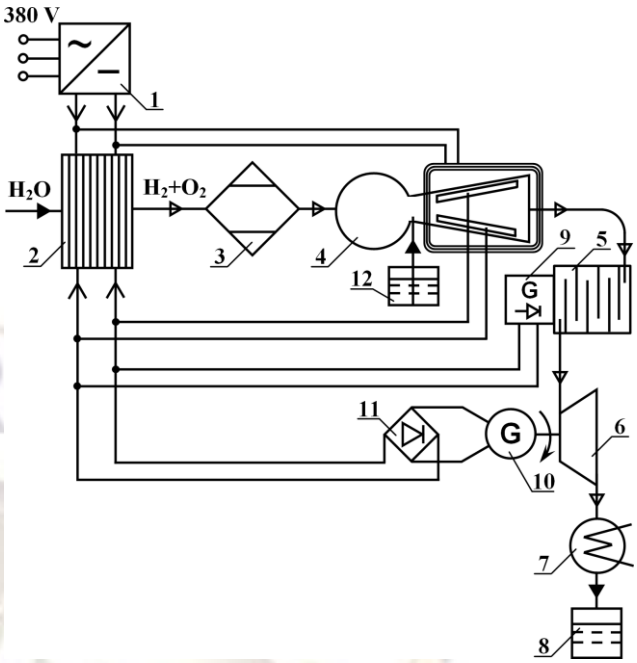

Fig. 3 – Production line for obtaining light water using a MHD generator, thermoelectrical modules and gas turbine

CONCLUSION

The use of the electrolytical method with a recuperation unit allows reducing by 4-6 power consumption required for producing light water comparing to rectification methods applied nowadays. Thus we may draw a conclusion that in the nearest time this method will became one of the main ways to produce light water.

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