

## WASTEWATER TO FUEL

M.GELENIDZE, D.GELENIDZE, Z.TADUMADZE, TS.GELENIDZE

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*A cleaning problem of wastewater solved as follows: the impact of long electric arc burning in the wastewater, has a combined character. An electrical arc affects the wastewater chemically, by cavitation effects, UV, light, ultrasonic and infrared radiation, by alternating magnetic and electric fields.*

*A problem producing fuel, which enriched by hydrogen and reducing carbon dioxide of wastewater is solved as follows:*

*Device for the combined treatment of wastewater is placed in the wastewater. The long arc is burned directly in the wastewater, between the cathode and the anode.*

*By decomposing the wastewater by the long electric arc, atomic oxygen formed directly. Thus during the decomposition of wastewater by long electric arc, a very strong oxidizing medium is formed and all contents of wastewater are oxidized and they might be converted into the fuel.*

**Key words:** *wastewater, producing fuel, atomic oxygen, hydrogen, carbon dioxide, electric fields.*

The aim of the work is to design electric arc reactor to clean the wastewater and produce fuel from wastewater and carbon dioxide via decomposing them in the long electric arc, which burns in wastewater.

The work is dedicated to design of electric arc reactor for cleaning the wastewater, producing fuel, which enriched by hydrogen and reducing carbon dioxide.

Hydrogen is an energy carrier and can be used to store and deliver energy as needed. When used in a fuel cell, the hydrogen atom dissociates into a positively charged hydrogen ion and a negatively charged electron, which diverted to an electric load. A fuel cell can be used to power anything in much the same way that batteries are used. According to the U.S. Department of Energy, "Eventually hydrogen will join electricity as the major energy carrier, supplying every end-use energy need in the economy, including transportation, central and distributed electric power, portable power, and combined heat and power for buildings and industrial processes."

It is known that hydrogen is most environmentally clean and renewable fuel and it is mainly accumulated in the water, resources of which are inexhaustible. However, water (H<sub>2</sub>O) is the most stable chemical compound. If one takes into account that the energy of

water splitting is equal to the energy of water formation and that the splitting of the water accompanied by additional energy loss, then splitting of water to produce hydrogen seems energetically not beneficial. However, if water decomposition by electric arc, is accompanied by other economically beneficial process (such as cleaning the wastewater and producing hydrogen from wastewater and carbon dioxide via decomposing them in the long electric arc which burns in wastewater), then the decomposition of carbon dioxide and wastewater via electric arc for producing hydrogen is cost-effective.

There are various methods of discharges in water (Alexander Fridman, Plasma Chemistry, Drexel University and Cambridge University Press: Chapters 5.9.1, 5.9.2, 5.9.3, 5.9.4, pg. 331-334, 2008). However, these methods are complex, expensive and have a low power (less than 10 kW).

The subject of the project is: the creation of an economically effective and technically simple electric arc reactor with a long arc, which is powered by a fixed current source having rectangular volt-ampere characteristic, and which is assigned to cleaning the wastewater and producing fuel from wastewater and carbon dioxide via decomposing them in the long electric arc, which burns in wastewater.

Thus must be solved three problems: cleaning the wastewater, producing fuel, which enriched by hydrogen and reducing carbon dioxide.

A cleaning problem of wastewater solved as follows: the impact of long electric arc burning in the wastewater, has a combined character. An electrical arc affects the wastewater chemically, by cavitation effects, UV, light, ultrasonic and infrared radiation, by alternating magnetic and electric fields.

1. Chemical acting. The generation and plasma chemical reactions of several chemically active species, such as  $\text{H}_2\text{O}_2$ ,  $\text{O}^\bullet$ ,  $\text{OH}^\bullet$ ,  $\text{HO}_2^\bullet$ ,  $\text{O}_3^*$ ,  $\text{N}_2^*$ ,  $\text{e}^-$ ,  $\text{O}_2^-$ ,  $\text{O}^-$ ,  $\text{O}_2^+$ , etc, which are produced in the electrical discharges and are important. Most of these species are stronger oxidizers than ozone. Therefore, wastewater treatment by direct electrical discharges may provide a means to utilize these species.

2. The effects of cavitations. In the border area of electric arc, burning in the wastewater, highly rarefied bubbles of wastewater vapor are formed, pressure inside which is close to the vacuum. These bubbles move inside the wastewater due to increased ambient pressure, are condensed and slammed, as a result a lot of micro hydraulic shocks of high intensity are happening. Waves of these hydraulic impacts destroy organic contaminants in polluted wastewater. Trial observation of the process of the arc in the water shows that the power of these hydraulic shocks that occur due to cavitations

phenomena is so great that it shakes the vessel in which the experiment is performed. Naturally, these waves also are destroying intensively the cells of living organisms in the wastewater.

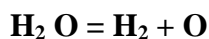
3. Ultraviolet impact. The disinfection by UV light makes it possible to provide necessary effect at absence of side products with negative influence on living organisms. The UV disinfection of water at right choice of sources and dose of UV radiation is not accompanied by the change of its chemical composition or by appearance of some toxic side products. For the achievement of the necessary disinfection effect it is required only several seconds. The bactericidal action of UV light is well known. The spectrum of "bactericidal action" of UV light coincides with adsorption spectrum of DNA (200 nm). The bactericidal light effectively destroys DNA molecules of bacteria, viruses and other types of microorganisms present in wastewater.

4. Exposure to ultrasound. Introduction to the processing area of the elastic vibrations of sufficient capacity at an ultrasonic frequency, allows one to get the levels of disinfection, the achievement of which only by the radiation energy is impossible. Achieving desired level of inactivation is possible at lower overall energy levels, which leads to a low cost of disinfecting wastewater with a stable result. Wastewater is exposed to the integrated ultrasonic impact, at which the crushing of bacterial clusters into smaller elements, destruction of microorganisms and the transformation of the organic phases are happening.

5. The other important factor is the treatment of incoming wastewater by the alternating magnetic field. Although the processes taking place at the magnetic treatment of water are not fully understood, this method nevertheless found already its positive practical applications. Accordingly the ionic hypothesis, basing on assumption on the influence of magnetic field on the moving ions due to the Lorentz force at fast intersection by ions of a high gradient magnetic field regions, they experience the significant accelerations resulting in the deformation of hydration layer surrounding them .

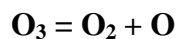
A problem producing fuel, which enriched by hydrogen and reducing carbon dioxide of wastewater is solved as follows:

Device for the combined treatment of wastewater is placed in the wastewater. The long arc is burned directly in the wastewater, between the cathode and the anode. The long electric arc is powered by the fixed current source. Several processes are happening in the wastewater. First, arc decomposes wastewater into two components - the hydrogen and atomic oxygen:



The oxidation potential of the atomic oxygen is very high and it is superior to the oxidation potential of the ozone.

Actually, ozone is a strong oxidizing agent because secondary product of decomposing ozone is atomic oxygen:



By decomposing the wastewater by the long electric arc, atomic oxygen is formed directly. Thus during the decomposition of wastewater by long electric arc, a very strong oxidizing medium is formed and all materials are oxidized and they might be converted into the fuel.

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The principle of generating plasma by a long electric arc (fed from a fixed current source with a rectangular volt-ampere characteristic) discharging in the wastewater has been developed. This is achieved by using USA patent (# 4,378,522), several patents USSR and Georgia, also by using new ideas, innovations and Know-How that we have now.

Based on these principles, we first carried out a stable operation under water long powerful arc and its industrial application.