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Research Article

Highly Efficient Water Plasma Vortex Reactor for Obtaining of Extra Thermal Energy and Transmuted Chemical Elements

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Abstract

A highly efficient Water Plasma Vortex Reactor (PVR-W) was designed, manufactured and tested for the first time [1]. The groundwork obtained in plasma aerodynamics, plasma-assisted combustion and LENR physics in our Centre was used in the design of this reactor. This work is a continuation of the previous research [2]–[5]. Pulsed repetitive electric discharge was created inside an argon cavity in swirl water flow in the PVR-W. Electrodes made of clean nickel, copper (99,99% and other metals) were used in this reactor. Double-distilled water was used in our experiment. It was revealed that there is an optimal operating regime of this PVR-W reactor with a high value COP $\sim$ 2 - 10. Extra heat power in this operating regime was about 2-10 kW. Self-sustained relaxation oscillations of current and voltage were obtained in this stable operation regime. It was revealed that there are many new transmuted chemical elements in the water sediment after plasma experiments. Both light chemical transmuted elements (such as carbon, aluminium, silicon, sulphur and others) and heavy elements (such as copper, zinc, iron and others) were found in the sediment sample. Chemical analysis of these sediment dust particles was carried out by the EDS method and the optical spectroscopy method. In this paper, experimental results on the direct extraction of electrical power from a heterogeneous plasmoid created by a pulsed repetitive electric discharge in the PVR are also discussed.
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Keywords: Water Plasma Vortex, Electrical Pulses, COP

1. Introduction

Experimental and theoretical studies on the creation of a highly efficient LENR reactor in our Centre have been ongoing for the past 20 years. The authors have achieved some success in this area using advanced plasma and plasmoid technologies. A special place in our research is given to the possibility of creating a plasma vortex heterogeneous reactor with water steam and a water flow reactor with a non-equilibrium energy-intensive plasmoid. Many fundamental technical difficulties identified during the operation of such power plants have been overcome [1]–[5].

The new PVR-W design has the following characteristics and parameters:

- Significantly increased output thermal power. At present, the output thermal power of PVR-W reaches about 10 kW. There is also a high coefficient of energy efficiency of this reactor, COP = 2-10 (ratio: output thermal

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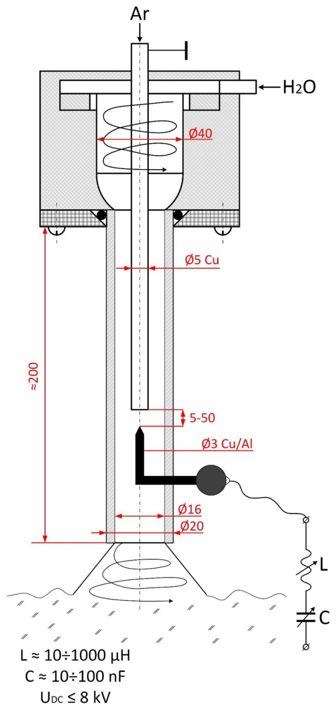

Figure 1. Schematic of the experimental setup PVR-W and additional output LC-circuit used in DC power supply.

power/input electric power). Recall that earlier the output thermal power of the older PVR models did not exceed 1-3 kW.

- For the first time, it was possible in this reactor to extract up to 200 W of electric power directly from the output plasma flow (when the total output thermal power of the reactor was about 2 kW).
- Production of cheap hydrogen. This PVR-W produces more than 10 times the hydrogen the previous PVR versions produced.
- There are significant differences in the mass and overall dimensions of the reactors. The typical dimensions of the PVR reactor was $10 \times 10 \times 100$ cm^3, and the typical dimensions of the PVR-W reached $3 \times 3 \times 20$ cm^3, with other technical characteristics of the two reactors being equal.

The PVR-W reactor does not require the use of a steam generator (unlike the PVR). The electric discharge itself evaporates water flow inside the argon cavity (near the water-argon contact boundary, Fig. 1). The presence of a steam generator certainly reduces the total energy efficiency of the PVR, due to large heat losses from the steam generator itself and the steam pipeline.

The most important distinguishing feature of the PVR-W is: the location of the water heat exchanger in the optimal place of reactor's design, which is near the plasma zone created by the electric discharge. Recall that an optimal location of the water heat exchanger was a difficult technical problem in our previous heterogeneous PVR reactor [2]–[5].

In terms of physics, the work of the PVR-W and the PVR differed significantly. In the PVR-W, a dense working medium is used – the flowing water. In the PVR argon-water steam gas mixture was used. In PVR-W, water flow is evaporated by a powerful pulsed current in the argon gas cavity. The pressure in this cavity can reach 10-100 Bar in this regime. Such hydraulic shock waves are easily measured by a hydrophone. Therefore, there is a dense working medium inside the vapour-gas cavity in the PVR-W. It is known that the productivity of any plasma-chemical reactor increases significantly with an increase in the density of the working medium (or pressure), as well as its heating. The temperature behind the SW front in the gas-plasma cavity was measured, and shown to be significantly higher than in the previous PVR reactor. The typical value of the gas temperature T_g in the plasma in the PVR-W reactor reaches $T_g \sim 10000$ K. Recall that the typical value of the temperature T_g* in the plasma region of the PVR did not exceed T_g*<4000 K [2]–[4]. Therefore, one can suppose that the productivity of transmuted elements and hydrogen in the PVR-W increased significantly compared to the PVR.

The generation of a shock wave and many small cavitation bubbles in the discharge zone of the PVR-W led to a non-linear transformation of the electric discharge parameters due to additional charge separation at the shock wave front in a heterogeneous plasma [2]–[4]. Such an additional separation of charges on the shock wave front allowed us to extract additional electrical energy in this reactor using electric probes mounted on the discharge tube. The second method of extracting electrical power from heterogeneous plasmoid was connected with MHD - technology. Two permanent magnets with magnetic inductance B = 0.1-1T and two transverse electrodes were used in the MHD generator mounted behind the output nozzle of this reactor. Maximal electric power extracted by these two methods was about 200 W in our experiment (at typical output thermal power about 2 kW).

A closed water pipeline was used in the PVR-W. Thus, the transmuted chemical elements created in the PVR-W crossed many times in the plasma aria and were conserved in water flow. So, their concentrations increased with the duration of the reactor operation.

1.1. Experimental setup of PVR-W

A schematic of the experimental setup of the PVR-W is shown in the Fig. 1. This reactor consists of:

- Water swirl generator (1),
- Swirl concentrator-amplifier (2)
- Cathode - argon injector (3)
- Quartz tube and electric discharge chamber (4)
- High voltage anode (5)
- Water pool, (Fig. 2)
- Water pump,
- Water pipeline, (Fig. 2).

A general view of the experimental setup of the PVR-W is shown in the Fig. 2. The water consumption in this installation was 30 L/min. Argon consumption in this reactor was 1 G/s.

DC power supply with an output voltage 8 kV and an output current 2 A was used in this reactor to create electric discharge in the working chamber of this reactor. An additional LC- circuit was used in this power supply to create self-sustaining relaxation oscillation mode in argon-water plasma. Typical frequencies of these oscillations varied in the range F_i = 1000 - 10000 Hz, Fig. 3.

2. Experimental Results

The electric voltage of electric discharge was measured by a high-voltage probe (Tektronix P6015). Electric discharge current was measured by a current probe (TRC P0300).

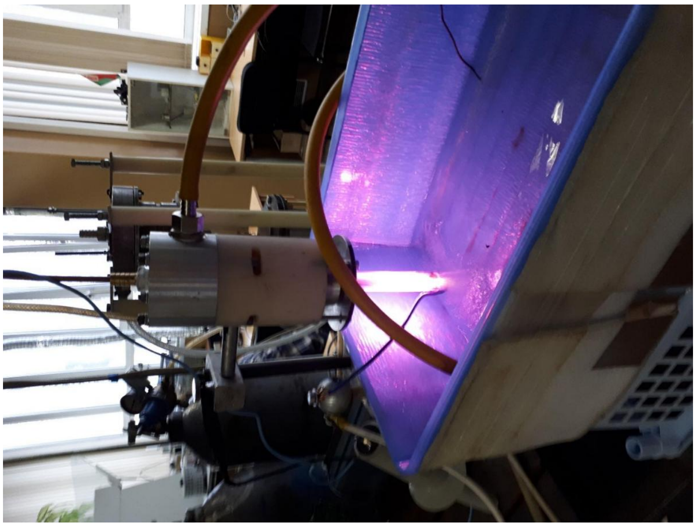

Figure 2. General view of the PVR-W setup during operation. One can see a water pool and water supply pipeline.

The initial temperature T_o and final temperature T_f in the water pool were measured by thermocouples. The water mass M_{H2O} in water pool + water pipeline was measured before and after the experiment.

The experiment was conducted by the following steps: The water pump was turned on at the beginning. Then argon flow was injected in the working chamber of this reactor. Plasma was created by electric discharge in argon cavity inside the swirl water flow. The typical experimental time was about 10 minutes. After this, the plasma was switched off and the final water temperature T_f was measured by thermocouple. After 1 hour the water sediment was collected and dried in a muffle furnace. The powder thus obtained was used in chemical analysis.

It follows from Fig. 3 that the voltage oscillations have an asymmetric form (there is an DC component in this signal's spectrum) after the breakdown of the gas discharge gap. This result can be explained by the separation of charged particles at the front of the shock wave created by a powerful pulsed discharge [2]–[4]. This result makes it possible to generate electric power directly from a heterogeneous plasmoid using electric probes with a resistive load.

The typical experimental calorimetric characteristics of the PVR-W are shown in Table 1. One can see that the value $K_x = COP$ did not exceed 0.73-0.80 in experiments No. 1, 2 where relaxation oscillations were absent (LC-circuit was absent). Production of the sediment powder with transmuted chemical elements was absent in this experiment also (see below). On the other hand, the value of the COP increased to **1.62–2.82** in these experiments No. 3-7. Production of the sediment powder with transmuted chemical elements was about 17 mG/sec in these experiments also.

Table 1, where M_{H2O}- water mass, used in the PVR-W; τ_{exp}- experimental time, N_{el} - mean electric power, Q_{H2O}- water thermal power, obtained in the experiment, Q_{el}- electric energy input in plasma, COP = Q_{H2O}/Q_{el} (without heat power losses)

It should be noted that when calculating the value of the COP, the following energy losses were not taken into account: - heating of the body of the water pool itself, connecting pipes, pump, mass of accumulated water vapour and mass of accumulated hydrogen, EM-radiation from the heterogeneous plasmoid. Taking into account these factors increases the indicated values of the COP by 1.5-2 times.

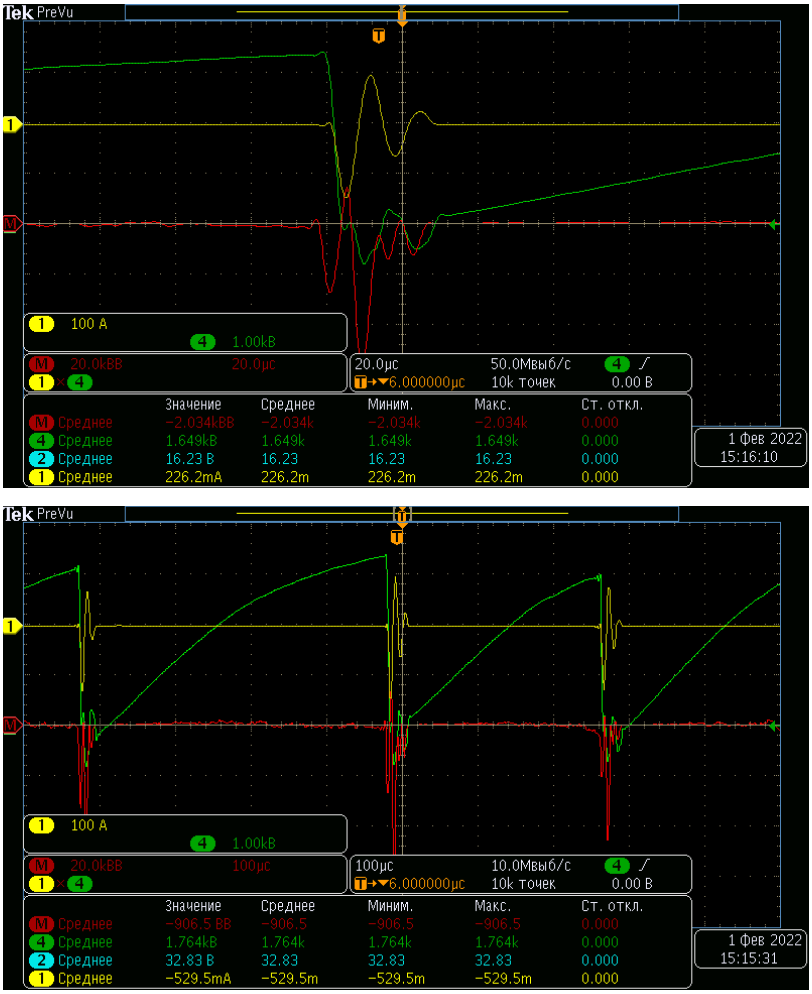

Figure 3. Volt-ampere signals obtained at the discharge gap of the PVR-W. The mode of stable relaxation oscillations. Green - voltage, yellow - current, red - electrical power. Top picture – 20 μs/div, bottom picture – 100 μs/div.

3. Transmutation of Chemical Elements in the PVR-W

Chemical analysis of the sediment powder with dust particles obtained in the PVR-W was performed using the method of EDS spectroscopy and optical spectroscopy. This powder was obtained in the process of drying the sediment of the aqueous solution accumulated in the PVR-W during the experiment. The productivity of the powder in this setup turned out to be many times higher than the one obtained in the previous PVR. Its value reached about 17-20 mG/sec (an order of magnitude higher than in the PVR). At the same time, the measured erosion of the electrodes (loss of their mass) did not exceed 1 mG/s in the PVR-W. One can conclude that the production of transmuted elements was carried out not only in eroded metal clusters, but also in the water itself. Note that double-distilled water was used in our

Table 1.

Exp, №	M_{H2O}, G	T_H,C	T_k,C	ΔT,C	τ_{exp}, sec	N_{el}, W	Q_{H2O}, kJ	Q_{el}, kJ	COP
1	4000	18,0	25,2	7,2	218	690	120,4	150,4	0,80
2	4000	23,6	29,6	6	174	790	100,3	137,5	0,73
3	5000	26,7	33,6	6,9	90	970	144,2	87,3	**1,65**
4	5000	32,2	40,4	8,2	90	700	171,3	63,0	**2,72**
5	6000	17,5	22,4	4,9	60	727	122,9	43,6	**2,82**
6	6000	26,8	31,8	5	55	1071	125,4	58,9	**2,13**
7	8000	28,2	34,9	6,7	90	1540	224,0	138,6	**1,62**

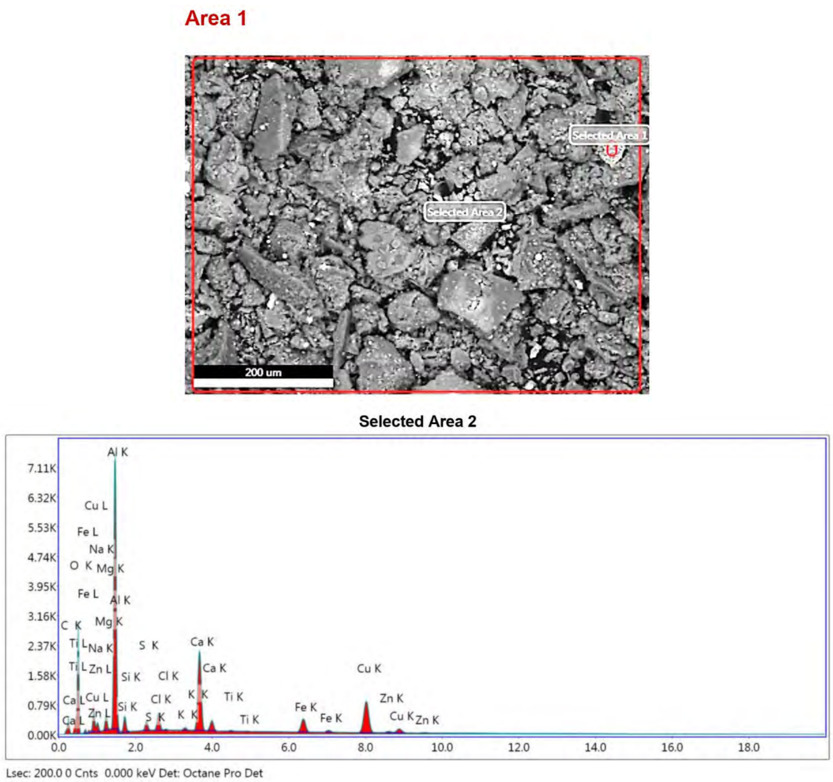

Figure 4. Typical EDS spectrum of sediment in water pool of the PVR-W (bottom) and dried powder view (top).

experiment. Therefore, it is impossible to explain the production of transmuted elements in this reactor with the help of contamination in the initial water. We use clean copper electrodes (99.99%),clean nickel electrodes (99.99%) and clean aluminium electrode (99,99%). Therefore, it is very difficult to explain the production of transmuted elements in this reactor with the help of contamination in the initial unexposed electrodes.

The chemical composition of the powder was studied by EDS spectroscopy. Typical results obtained using this method are presented in Fig. 4, 5 and Table 2. Important conclusions follow from the analysis of experimental data

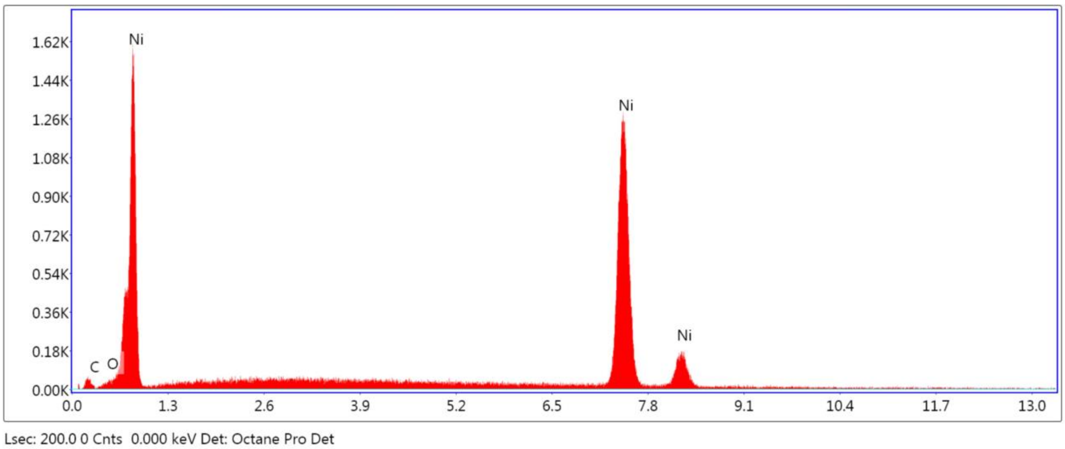

Figure 5. Typical EDS spectrum of unexposed nickel electrode before experiment.

Table 2. Composition of new transmuted elements obtained in the PVR-W. EDS-analysis.

Element	Weight %	Atomic %
CK	4.76	10.96
OK	30.86	53.29
MgK	0.98	1.11
AlK	4.67	4.78
SiK	0.51	0.50
S K	0.19	0.17
ClK	1.17	0.91
KK	0.15	0.11
CaK	1.24	0.86
TiK	0.05	0.03
MnK	0.24	0.12
FeK	52.96	26.20
CuK	1.98	0.86
ZnK	0.24	0.10

obtained using EDS spectroscopy. Both heavy transmuted elements and light transmuted elements (compared to the atomic weight of the electrode material) are measured in the powder. In the EDS spectra, the expected transmuted elements are observed, such as zinc and iron (products of a possible transmutation of copper), silicon and magnesium (products of a possible transmutation of aluminium electrode); as well as completely unexpected elements, such as carbon, calcium in large quantities, and many others. It should be noted that these transmuted chemical elements were absent in the composition of the initial electrode material and initial water before the start of the experiments. Additional analysis of these initial electrodes and initial water sample was performed by the same EDS-method before experiment, Fig. 5. One can see that there is a small concentration O-atoms in nickel oxide film on surface of a initial nickel electrode.

4. Conclusions

1. Further transmutation study requires a thorough analysis of the isotopic composition of the new elements obtained in the PVR-W. The possible difference between the composition of the transmuted elements and the their natural composition can finally confirm the hypothesis of the artificial origin of these elements.
2. The joint results of our experiments using the EDS spectroscopy method and the optical spectroscopy method clearly show that a possible source of additional thermal energy release in the reactor is associated with the process of cold transmutation of the initial chemical elements in it (but it is not associated with chemical reactions). We estimate that the value of the specific thermal energy yield per one hydrogen atom (or one atom of the electrode metal) reaches on the order of q = 1-10 keV/ atom. Note that the q value is much higher than the typical q* value released in any chemical reaction.
3. The physical mechanism of transmutation of chemical elements detected in the PVR-W reactor will be finally clarified by measuring the isotopic composition of exposed electrodes and sedimentary powder obtained during the experiment under consideration. The analysis of the optical spectra with high spatial and temporal resolution in heterogeneous plasmoid created in the PVR-W will allow us to find out the plasma-chemical kinetics of the transmutation of chemical elements. The authors believe that the physical model of a bi- nuclear atom [6] allows us to explain the transmutation of chemical elements detected in the PVR-W reactor.

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