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Excess Heat Measurements in Glow Discharge Using Flow "Calorimeter-2"

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ABSTRACT

Experimental facts and results of heat and electric power measurements (including nuclear products) are presented.

1. INTRODUCTION

Excess heat was registered using a continuous flow calorimeter. These measurements confirmed our previous results [1] obtained with a dynamic calorimeter. The main limitations of the dynamic calorimeter were; non-stationary conditions of the experiment, and low precision of heat power measurements. A continuous flow calorimeter measured excess heat in the glow discharge system with better precision.

2. EXPERIMENTAL METHOD

Experimental device "Calorimeter-2" consists of vacuum chamber having a volume of 1200 cm^3, a gas pumping system, a water cooling system, a power supply and a measuring system. The vacuum chamber consists of a quartz tube having a diameter of 56 mm and a length of 500 mm (Fig. 1). Two flanges of the cathode and anode assembly were mounted on the top and bottom of the tube. Another quartz coaxial tube is put on the vacuum tube with a gap of 0,5-0,7 mm. Thise gap is water cooled chamber jaket. The cathode and anode assemblies have water conveyances to the cooled surfaces of the cathode and anode. The design of cathode assembly permits placement of samples made of different materials on the cooled cathode surface.

The gas system provided a residual pressure of less than 10^{-5} Torr. After evacuation, the chamber was filled with gases such as D_2, H_2, Ar and Xe at low pressure. The pressure in the chambere was controlled by diaphragm micromanometer.

The cathode, anode and quartz discharge chamber of the discharge device were cooled separately. The water cooled system consisted of three separate channels, which included two differential termoresistors. Two termoresistors were placed in the cooling water inlets and outlets of the anode, chatode and chamber respectively. The termoresistors were pairs of silicicon KTS 394 transistors. The water flow rate was measured by the volume control in each channel.

The time dependences of current I(t) and voltages U(t) were registered by a shunt, voltages divider and digital oscilloscope S9-27. The discharge power P_{el} was calculated using the equation.

$$P_{el} = \int U(t)\, I(t)\, dt$$

The system for excess power heat measurement was calibrated as follows. The electric heater was placed at the inlet of each cooling channel on the anode, cathode and chamber outlets. The electric heater was powered by a requalated power supply. Uniform water flow rate g_{wi} was used in calibration (index "i" means respectively cathode, anode or chamber). The calibration results are presented in Fig. 2.

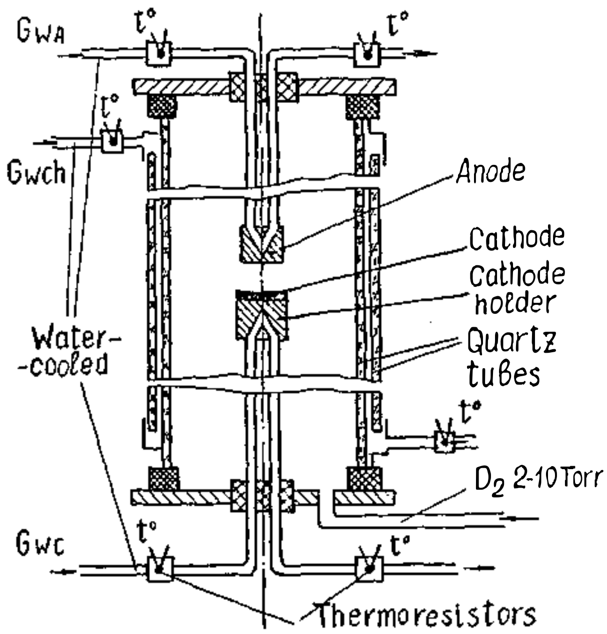

Fig. 1. Experimental glow discharge device "Calorimeter-2".

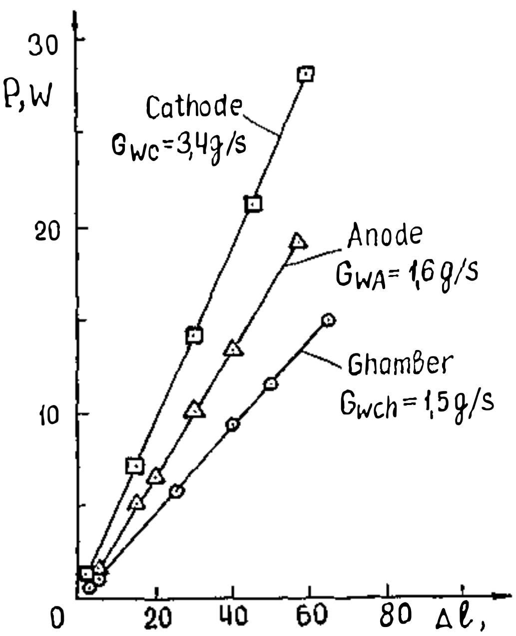

Fig. 2. Calibrated curves of heat power measurement system.

The cooling water temperature rise ΔT_i was calculated as

$$\Delta T_i = P_{el} / (g_{wi} \cdot Cw)$$

The heat balance was calculated at given time moment as

$$P_{EH} = (P_{HC} + P_{HA} + P_{HCh}) - P_{el}$$

$$P_{Hi} = C_w \cdot g_{wi} \cdot \Delta T_i$$

The heat efficiency η was determined by a reference experiment with a silver cathode which was presumed to be inert on the basis of previous experiments with glow discharge in deuterium and hydrogen as

$$\eta = (P_{HC} + P_{HA} + P_{HCh}) / P_{el}$$

The cummulative measuring error was no more than 3 % .

3. EXPERIMENTAL RESULTS

The D/Pd loading ratio was determined by the measurement of D_2 pressure drop in chambere (Fig. 3). The loading ratio presented here is the average through the cathode thickness. The loading ratio is probably much higher in thin near-surface layer.

Aproximately 30 experiments were conducted for the system D/Pd to determine excess heat. The duration of a separate experiment was from 10 min to 1 hour. Excess heat power was registed in most experiments. The typical time dependence of the excess power is shown in Fig. 4. The excess heat power increases as the current density increase (Fig.5). At the same time, the efficiency of the process (ouput to imput ratio) goes down with current density. In some of the experiments the efficiency was 170-190%.

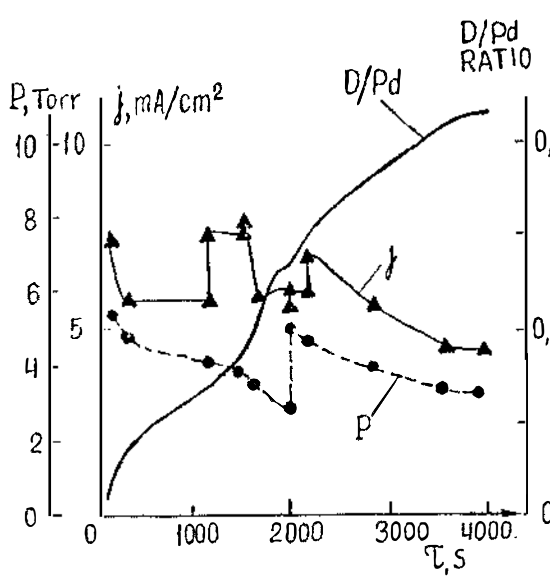

Fig. 3. Time dependence of D/Pd loading ratio, current density and D_2 pressure.

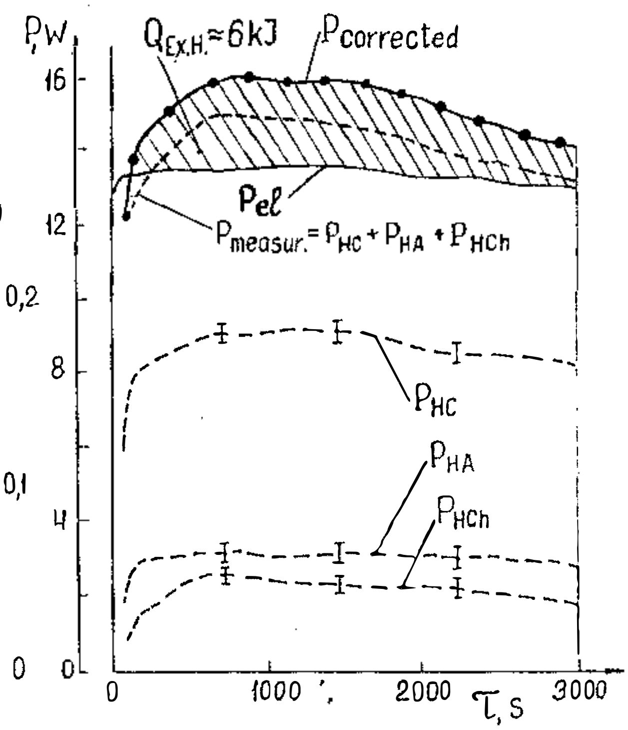

Fig. 4. Typical time dependence of heat power in "Calorimeter2".

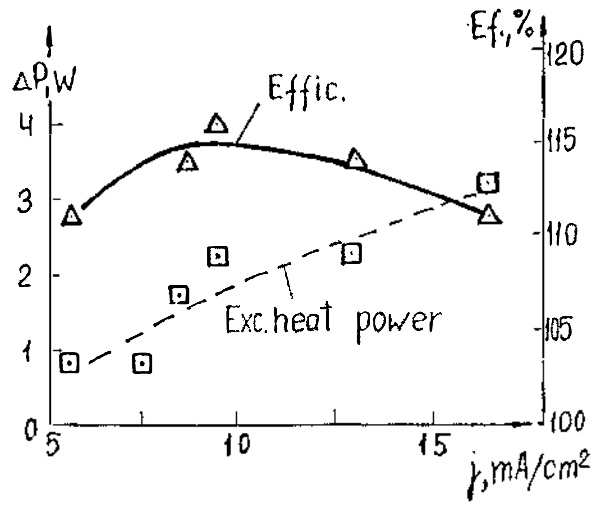

Fig. 5. Dependence of excess heat power and efficiency on current density.

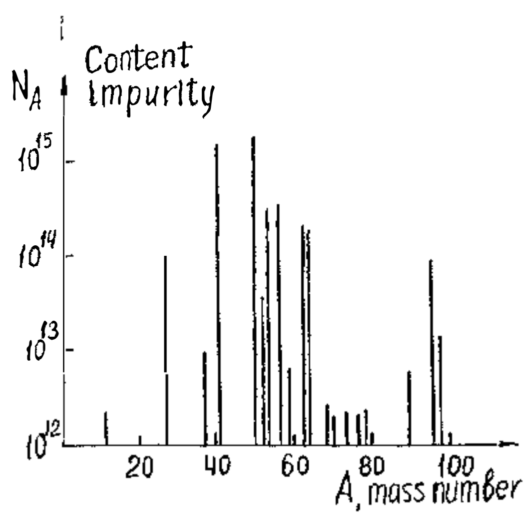

Fig. 6. Impurity in Pd-cathode after glow discharge.

Note that the low power input region with a higher efficiency described in our previous work [2] was not included in this work, because of unsufficient accuracy of a flow calorimeter in this region.

4. DISCUSSION

The analyses of the impurities, appeared in pure palladium foil after glow discharge treatment[2], give a satisfactory correlation between the quantity of impurities (Fig. 6) and the registered excess heat, estimated on the basis of mass defect from isotopic shift [4]. Gamma- and beta- radiation was found to be very weak and is not the basis for explaining excess heat.

5. CONCLUSIONS

Summarize some of the experimental facts [1-4]:

1. Excess heat (~10 kJ per hour).
2. Gamma-radiation after glow discharge with intensity $(10^3-10^4)\ s^{-1}$ and energy 0.1-3 MeV.
3. Beta-radiation from cathode samples after glow discharge with intensity $(10^4-10^6)\ cm^{-2}\ s^{-1}$ and energy 0.01-2.0 MeV.
4. Fast electrons-beamed radiation with intensity $(10^8-10^{11})\ cm^{-2}$ in 10^{-8} s bursts and energy 0.01-2.0 MeV.
5. Weak neutron signals with intensity $(10-10^4)\ s^{-1}$ and energy 2-18 MeV.
6. Heavy charged particles registration (He,Li,B,C and other) with energy more than 10 Mev.
7. Increase of impurities concentration in Pd-cathode up to $10^{18}-10^{19}\ cm^{-3}$.
8. Change of the natural isotope ratio for some elements (B,C,Ni and other).

These results provid good ground for developing glow discharge device "Calorimeter -2" as a heat producing reactor.

List of Symbols

C_w - water specific heat capacity, J/(kg·°C); g_{wi} -water flow rate, kg/s; P_{EH} -excess heat power in watts; P_{el}-discharge power, watts; P_{HC}, P_{HA}, P_{HCh} -heat power of cathode, anode and chamber respectively, watts; ΔT - water temperature rise,°C; I -discharge current, A; U -voltages,volts; η -heat efficiency.

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