Chapter 6
Energy Balance During Elettrolysis and Cavitation Experiments

A. Carpinteri, O. Borla, A. Manuello, and G. Niccolini

Abstract Literature presents several cases of nuclear anomalies occurring in condensed matter, during fracture of solids, cavitation of liquids, and electrolysis. Previous papers by the authors have recently shown that, on the surface of the electrodes exposed to electrolysis, visible cracks and compositional changes are strictly related to nuclear particle emissions. In particular, a mechanical interpretation of the phenomenon was provided accounting the reactions due to hydrogen embrittlement effect. On the other hand, the authors have recently reported that appreciable neutron emissions far from the background level take place in hydrodynamic cavitation. In the present paper, specific measurements have been conducted during two experimental campaigns in order to evaluate the energy balance and the heat generation and its possible correlation to the same nuclear origin during both electrolysis and cavitation phenomena.

Keywords Energy Balance • Heat Generation • Hydrodynamic Cavitation • Electrolysis • Neutron Emissions

6.1 Introduction

Low energy nuclear reactions occurring in condensed matter were observed by different authors during last 20 years [1–15]. All these tests are characterized by extra heat generation. Some of these researches reported also significant evidences of chemical changes after the micro-craking on the surfaces of the electrodes. At the same time recent experiments provided evidence of anomalous reactions occurring in condensed matter during fracture of solids, cavitation of liquids, or electrolysis. These experiments were characterized by neutron and alpha particle emissions, together with appreciable variations in the chemical composition. Based on these evidences a mechanical reason for the so-called Cold Nuclear Fusion was introduced [16, 17]. The hydrogen embrittlement due to H atoms due to the electrolysis itself seems to play an essential role in the micro-cracking of the electrode host metals (Pd, Ni, Fe, etc.). On the other hand, as mentioned previously, during the cavitation of liquid solutions similar measurements regarding neutron burst ad compositional variations can be recognized. In particular, gas bubbles in the medium undergo highly nonlinear amplitude and volume oscillations [18–22]. In the expansion phase, liquid vapor diffuses into the bubble due to evaporation at gas–liquid interface. During the subsequent compression phase, pressure inside the bubbles increases and vapor starts to condense. However, depending on the nature of the pressure variations, the collapse can be so quick that the bubble wall velocity reaches or even exceeds the velocity of sound in the medium. This “trapped” vapor is subjected to extreme conditions of temperature and pressure reaching the adiabatic collapse of the bubble. As stated before, when cavities are carried to higher-pressure regions, they implode violently and high-pressure shock waves can occur contributing to give a suitable environmental condition to induce also in the solution the anomalous nuclear reactions already encountered in solids during compression and cyclic loading conditions. In the present paper, specific measurements have been conducted during two experimental campaigns in order to evaluate the energy balance and the heat generation and its possible correlation to the same nuclear origin during both electrolysis and cavitation phenomena [23].

A. Carpinteri • O. Borla • A. Manuello (✉) • G. Niccolini
Politecnico di Torino, Department of Structural, Geotechnical and Building Engineering, Corso Duca degli Abruzzi 24, 10129 Torino, Italy
e-mail: amedeo.manuellobertetto@polito.it

L. Starman, J. Hay (eds.), *Micro and Nanomechanics, Volume 5*, Conference Proceedings of the Society for Experimental Mechanics Series, DOI 10.1007/978-3-319-63405-0_6

6.2 Experimental Equipment and Measurement Set-Up

Over the last years, specific experiments have been conducted on an electrolytic reactor (owners: Mr. A. Goi et al.). The reactor was built in order to be filled with a salt solution of water and K_2CO_3. The electrolytic phenomenon was obtained using two metal electrodes. The solution container is a cylinder-shaped element. A Ni-Fe-based electrode as the positive pole (anode), and a Pd-based electrode as the negative pole (cathode) were used. The second kind of experiments were performed by an hydraulic horn as the reactor. In this case, the hydraulic circuit was design and developed test using in pure water and aqueous solutions with iron salts. The system provides a constant water flow by means of a centrifugal pump. In order to inspect the water before and after the cavitation, a plastic tank was placed upstream of the pump. Each material of each component has been carefully selected basing on its chemical stability and in order to avoid any kind of contamination. Durng the two experimental campaigns the temperature of the electrolytic reactor and the hydrodynamic circuit was acquired by a thermocamera FLIR a 300 and by specific temperature probes (PT-100). For an accurate neutron emission evaluation, a He^3 proportional counter was employed with pre-amplification, amplification, and discrimination electronics directly connected to the detector tube. The detector is also calibrated at the factory for the measurement of thermal neutrons; its sensitivity is 65 cps/$n_{thermal}$ (±10% declared by the factory), i.e., the flux of thermal neutrons is one thermal neutron/s cm^2, corresponding to a count rate of 65 cps.

6.3 Test Results

In the first kind of tests, the input energy E_{in} is related to the electric power exchanged between the two electrodes and can be quantified by means of electric power consumption. The corresponding electric power E_{in} can be calculated as the average power absorbed by the system and is given by direct electric measurements:

$$E_{in} = \frac{\int_{ti}^{tf} E_{in}(t)dt}{t_f - t_i}, \tag{6.1}$$

where t_f and t_i are the final and initial time instants respectively of the testing session. The instant input energy $E_{in}(t)$ is:

$$E_{in}(t) = V_{in} \times I(t), \tag{6.2}$$

where $V_{in}(t)$ is the measured voltage between the electrodes and *I(t)* is the electric current intensity measured by means of a virtual oscilloscope placed before the cell, neglecting the circuit dissipations. The main terms of energy transformation during testing are: (i) vaporization, and (ii) the heat convection exchange. The energy equilibrium equation, involving the main energy terms, has the following formulation in steady state conditions:

$$E_{in} + E_X = E_v + E_H \tag{6.3}$$

Where E_{in} represents the term due to the power of the electric circuit, measured at the connection between the circuit and the electrodes just before the cell; E_X represents the unknown energy term correlated to the anomalous reactions; E_v and E_H represent the terms due to vaporization and convection, respectively. Electrolytic transformations and turbulent flow are considered quantitatively negligible in a first approximation. According to Eq. (6.3), in three different time windows related to the main peaks of the neutron flux, reported in Fig. 6.1a, the ratio E_{in}/E_{out} was respectively equal to 2.49, 2.74 and 2.39. At the same time also the integrated neutron flux increment at the end of the test is about the 16% (see Fig. 6.1b). Similar evidence have been obtained during hydrodynamic experiments. During the cavitation tests neutron emissions have been measured. In Fig. 6.1c, d the neutron counts and the cumulative curve of the emissions are reported for a representative test. At the end of the experiment an increase of 34% concerning the energy in the form of integrated neutron flux was obtained. On the other hand, the temperature variation measured in the steady state was equal to 12.4° C. Considering the mass of the solution (22 kg) and the specific heat of the solution equal to 4.186 J/kgC an out-put energy of 1.14×10^6 J has been obtained. A the same time, the instantaneous active power consumed and used for the hydraulic pump get an average value of 257 W corresponding to $9{,}25 \times 10^5$ J, during the steady-state condition. The ratio between the E_{out} and the E_{in} is equal to 1.23.

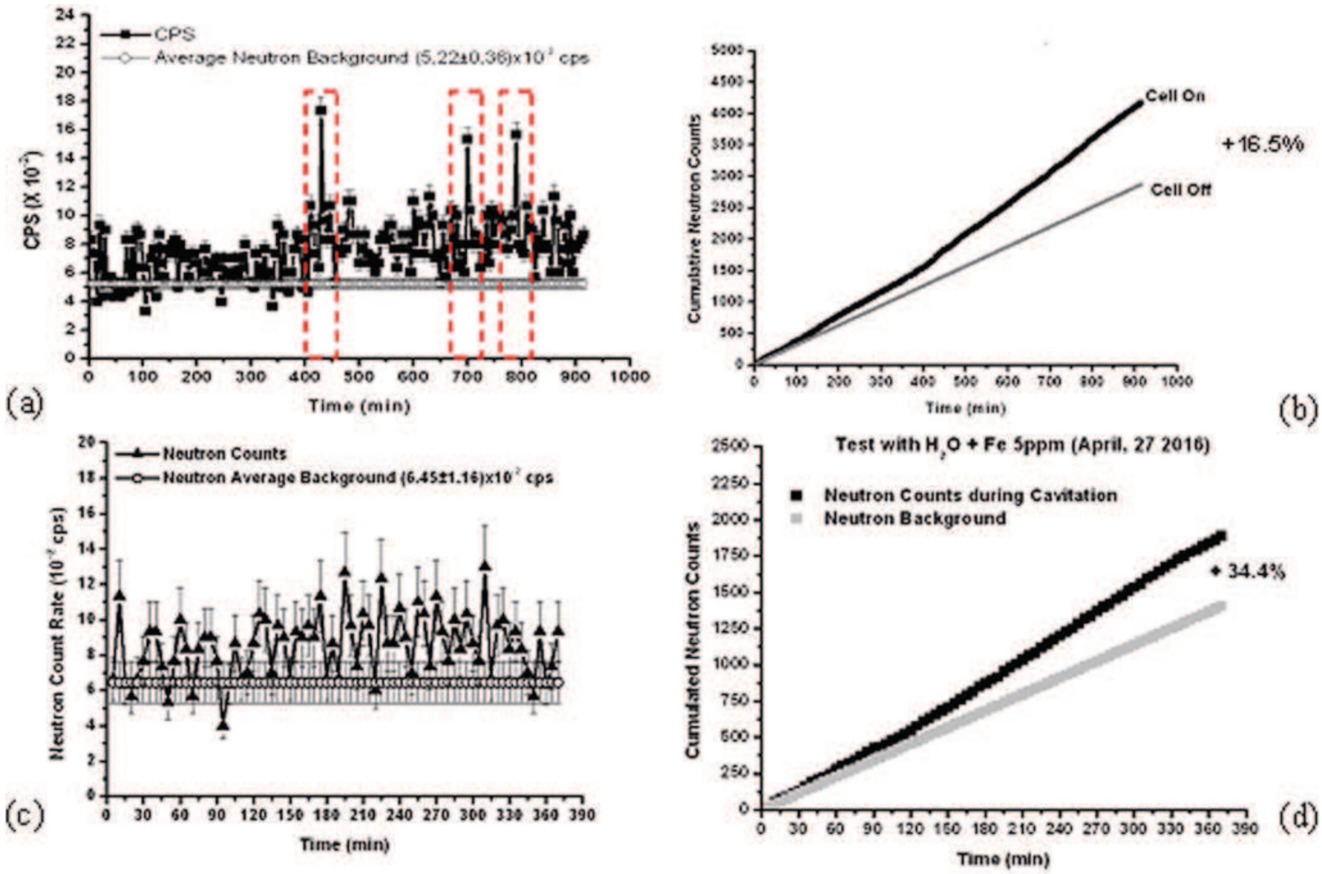

Fig. 6.1 Neutron counts (**a**) and cumulative curve (**b**) of the emissions during the electrolytic tests. The increase of the integrated neutron flux is 16% (**b**). Neutron counts (**c**) and cumulative curve (**d**) of the emissions during the hydrodynamic cavitation. The increase of the integrated neutron flux is 34% (**b**)

6.4 Conclusions

Specific measurements have been conducted during two different experimental campaigns involving electrolysis and cavitation. In both the two cases the energy balances have shown appreciable out-put energy amount greater than the input energy. This evidence appear to be directly confirmed by the integrated neutron flux obtained at the end of the tests.

Acknowledgements The authors gratefully acknowledge Mr. A. Goi the owner of the electrolytic device. Special thanks are due to Prof. C. Baiocchi and Dr. G. Mariella for the solution preparations and the ICP-MS analysed before and during the experimental campaign. Mr. F. Alasia and Eng. R Malvano are gratefully acknowledged their support in the hydraulic circuit construction.

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A. Manuello is Assistant Professor at the Politecnico di Torino, is the author or co-author of over 100 publications, of which more than 35 are papers in refereed international journals (SCOPUS h-Index=16, more than 480 citations). Among his research there are topics as: Acoustic Emission monitoring, energy emissions from fracture, Structural instabilities.