Nuclear Physics Approach

TRITIUM, NEUTRON, AND RADICARBON REGISTRATION WITH THE YUSMAR HYDROFACILITY RUNNING

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Abstract
High statistical (>3σ) and systematic confidence levels have been reached in recording the nuclear products (tritium, neutron emission, and radiocarbon) that occurred in the Yusmar hydrofacility working fluid as predicted by the Erzion model for catalyzed transmutation of nuclei. The pending extension of the Erzion model research is expected to improve the Yusmar properties relevant to energy.

1. Introduction

Cold fusion is well-known to proceed under nonequlibrium conditions, namely, under electrolysis, electric discharge, mechanical impact, sonoluminescence, ultrasonic effects, etc. J.Griggs [1] and Yu.Potapov [2] have reported a feasibility of generating additional power in the hydrodynamic facilities where the nonequilibrium cavitation process is induced in pure water. The increased energy output in the like facilities was accounted for earlier in terms of the Erzion model of cold fusion [3-5]. In the present work, the Erzion model representations are verified using the Yusmar hydrofacility designed by Dr. Yu.Potapov.

The Erzion model assumes that intensive cavitation of a hydrofacility working fluid may prove to be a trigger of nuclear reactions involving enion, $Э_N$, and erzions, $Э^o$ and $Э^-$, should some requirements be met as regards the working fluid composition. Namely, the presence of donor nuclei ($Э_N$, carriers of reaction catalysts) and of fuel nuclei (used in the nuclear reactions involving $Э_N$ together with sporadic $Э^o$ and $Э^-$). The Erzion model predicts that some experiments can give rise to yields of neutrons or gamma-rays that accompany the nuclear transmutation reactions and production of radioactive isotopes. According to the model, ^{16}O, ^{12}C, and ^{64}Ni can be donors. In case cavitation triggers the mechanism of enion emission from a donor nucleus, the following erzion-induced catalytic reactions may proceed if the working fluid comprises such elements as tritium, lithium, and carbon:

$$D + Э_N = Э_o + T + 011\ MeV, \quad (1)$$

$$D + Э^- = Э_N + n + 558\ MeV, \quad (2)$$

$$T + Э_N = Э^- + {}^4He + 12.0\ MeV, \quad (3)$$

$$^6Li + Э^- = Э_N + {}^4He + n + 4.2\ MeV \quad (4)$$

$$^6Li + Э_N = Э^- + {}^8Be(2\times{}^4He) + 9.6\ MeV, \quad (5)$$

$$^{13}C + Э_N = Э^o + {}^{14}C + 2.03\ MeV, \quad (6)$$

$$^{13}C + Э^{0} = Э_{N} + ^{12}C + 1.20\ MeV. \quad (7)$$

In other words, a heavy water admixture to the Yusmar working fluid (light water) may result in production of tritium (reaction (1)), a tritium-contaminated heavy water admixture or lithium admixture in neutron production (reactions (2),(3) or (4), (5)), and carbon-containing admixtures in radiocarbon production (reactions (6), (7)). The main aim of the present work was to verify the Erzion model predictions by detecting eventual products of reactions (1)-(7). The fact the reactions proceed actually may be confirmed by operating the hydrofacility (detection of neutrons) or by analyzing the working fluid samples after the facility is turned off. The hydrofacility was in operation for 16 working days from April to September. 1995. The facility was turned on 142 times (the operation modes are described in Section 2 below). The working fluid was a mixture of tap water, various combinations of LiJ, LiBr, $Li^{2}SO^{4}$, LiCl, LiOH, and $NiSO^{4}$ solutions, and $D^{2}O$; totalling to about 40 different solutions. A fraction of the experimental results thus obtained are reported here.

2. Yusmar hydrofacility

The hydrofacility (see Fig.1) is a closed system of tubes of different cross sections (the largest diameter is 5 cm) connected to an electric pump and an electric motor. The pump capacity is 12 m^{3}/hour, the motor power is 7.5 kW, the working fluid volume is 10 l. Fluid flow control devices placed inside the tubes in the upper part of the facility make the fluid rotate. A cavitation-inducing insert is also mounted inside the tubing. The maximum admissible pressure is 10 amt. The hydrofacility is equipped with heat sensors (1-4, Fig.1), a pressure gauge that supplies its data to recorders, and valves at the facility top and bottom for varying the working fluid composition and for sampling water and solutions.

Single and multiple operation modes were used. In the single mode, the continuous operation time was up to T = 1 hour). In the multiple mode, the facility was turned on up to 15 times for T = 15 min). The turn-off moment was indicated by occurrence of the maximum admissible pressure of 10 atm and the maximum temperature of casing (100°C, normally at point 4, Fig.1). The fluid pressure variation rate (see Fig.2) was defined to a great extent by the volume of an air bubble that remained in the tube system after filling. With an air bubble volume below 10 cm^{3}, the domain of gradual pressure variations (1 in Fig.2) decreased and could actually disappear and turn into the domain of avalanche-like pressure rise (2 in Fig.2) up to 10 atm within a very short time (below 1 min.). In this case temperature inside the facility increased gradually during a single operation run, so any pronounced bend was absent in the P(T) curve. The avalanche-like pressure rise was probably accounted for by initiation of violent cavitation.

3. Tritium measurements

Tritium production was recorded by measuring beta-activity in the working fluid samples taken when the Yusmar facility was not in operation and after it was turned on. The working fluid was a mixture of light (10 l) and heavy (10 ml) water. The tritium beta-activity (the highest beta-spectrum energy is 18.6 keV, the half-life is 12.3 years) was measured by a liquid scintillate.

The initial samples were 50-ml portions of tap water and a mixture of heavy and light water. The activity of two initial tap water samples did not exceed the 0.5 Bq/ml background. The specific activity of the initial mixture sample was 28±0.5 Bq/ml. After the first and second 12-min long operation runs the sample specific activity was 33±0.5 Bq/ml and 34±0.5 Bq/ml, respectively.

Thus, a 20% specific activity excess (5±0.7 Bq/ml) over the background occurred in the Yusmar working fluid with a 0.7% heavy water admixture after a 12-min long facility operation. The second 12-min long operation run failed actually to raise the specific activity of the solution.

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The test study of the tritium measurement method is described in [7]. Reliability of the results obtained was confirmed in the repeated measurement run of the same fluid samples with Beta-2 radiometer a month later. After the first and second operation runs the specific activity was 6±0.8 and 5±0.8 Bq/ml in excess of the background.

4. Neutron measurements

Neutrons were detected in two channels of unit 5 (Fig.1) that included 6 ^{3}He counters encased in Plexiglas (fast and thermal neutrons, channel 1) and six counters of the same type without a moderator (thermal neutrons, channel 2). The effectiveness of either channels (some 0.5% and 0.25%) was experimentally tested with a ^{252}Cr source. Each run of neutron flux measurements lasted for 2 min in either of the channels and, besides, the results of the channels were summed up. Background radiation was measured before each of the runs. The total background measurement time was 24.8 hours. The measurement time of the effect was 29.2 hours. Presented below are the results obtained in three neutron measurement runs using the following working fluid compositions:

(1) 10 l H_2O + 300 ml D_20, a 3.5 Bq/ml specific activity for tritium:
(2) 10 l H_2O + 200 g LiBr;
(3) 10 l H_2O +150 g D_2O (3.5 kBq/ml) + 400 g LiBr + 250 g $NiSO_4$.

Composition (3) was prepared with a view to increasing the contents of neutron converter (D+T and Li) and donor (Ni), thereby intensifying the neutron flux in conformity with the Erzion model.

None of neutrons (an excess of -10.2±25.5 neutrons) were detected for 17 min in the two channels by operating the Yusmar facility without any admixtures to the working fluid. In the composition (1) tests, 38.5±12.3 neutrons were detected for 9 min after two Yusmar operation runs. In the composition (2) tests, 113.3±36.5 neutrons were detected for 34 min after two operation runs. In the composition (3) tests, 304±21 neutrons were detected for 2.5 hours after 13 operation runs (from 1.5 min to 6 min each). In the last case neutrons occurred only after the 8th operation run and were recorded with two interruptions for 80 min after the facility was turned off (Fig.3).

So, admixture of definite elements (D+T or Li) to the Yusmar working fluid results in occurrence of neutron emission. The process is sporadic id gets initiated only at the moment of pressure rise (cavitation) and may proceed after the hydrofacility is turned off (so called life after death).

5. Radiocarbon measurements

The feasibility of beta-active carbon-14 production (E = 156 keV, a 5.7x103 half-life) was tested using Tosol A40M antifreeze (manufactured in October, 1992) as the carbon-containing fluid. The sample activity was measured by the same techniques as in tritium measurements, the only exclusion was that the beta-energy detection threshold was raised).

Specific activity measured in the initial sample proved to be 1.6±0.02 Bq/ml. A 4.6±0.2 Bq/ml specific activity was recorded in the sample for 1.5 hours after 7 operation runs of the facility (from 1.5 min to 10 min each).

So, after repeated operation runs of Tosol-operated Yusmar facility the specific beta-activity of the working fluid due to radiocarbon emission increased by 3.0±0.03 Bq/ml.

6. Discussion of results

Analysis of the tentative experimental results has demonstrated that the predictions of the Ersion model for nuclear transmutation realized with the Yusmar hydrofacility are correct. Namely, as predicted by the model, nuclear products (tritium, neutrons, and carbon-14) were detected quite

safely (the effect magnitude exceeds three standard deviations, and even a hundred standard deviations for radiocarbon). The nuclear products were recorded only in the presence of quite definite elements in the composition of the facility working fluid.

On the other hand, the transmutation product occurrence probability is far from unity and may be 0.2-0.3 (as estimated in the neutron detection experiment). Besides, having been once initiated (by cavitation in the fluid, for instance), the process may last for a sufficiently long time of dozens of minutes (see Fig.3). Therefore, the process has still to be optimized by, first of all, varying the contents of reagents (donor nuclei and fuel nuclei) and modifying the materials and design of the hydrofacility. The pending extension of works in these research lines is expected to improve the Yusmar properties relevant to energy and ecology.

References

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FIGURE CAPTIONS

Fig.1. A schematic of Yusmar hydrofacility
1-4 - heat sensors
5 - fast and slow neutron detection unit

Fig.2. Variations of fluid pressure P within a Yusmar operation run (domains 1 and 2) and after the facility is turned off (domain 3).

Fig.3. Neutron detection (the $\pm\sigma$ range is indicated) during repeated Yusmar operation runs (the black intervals along t-axis) using T+D and Li admixtures.

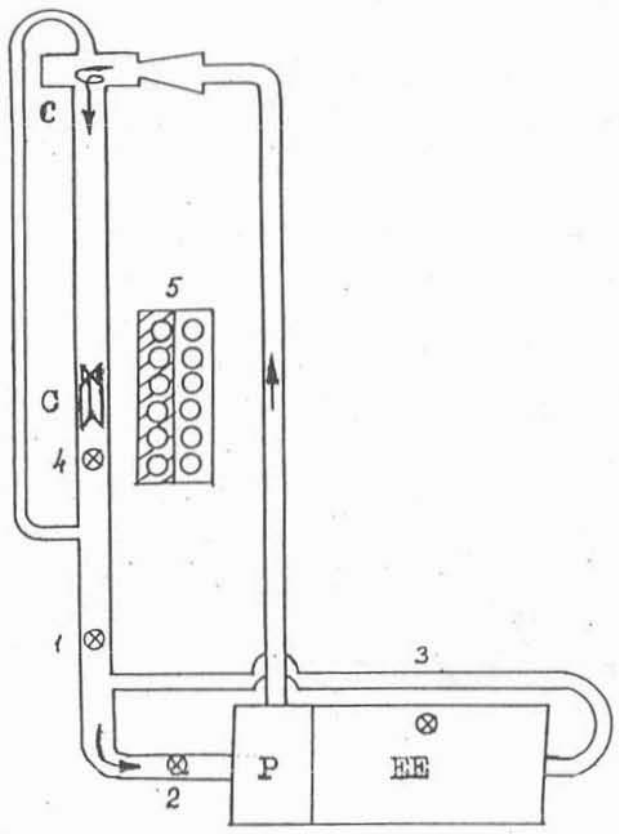

Fig.1. "Yusmar" hydrofacility

EE - electric engine
P - pump
C - cavitators
1-4 - thermometers, manometers
5 - neutron registration block

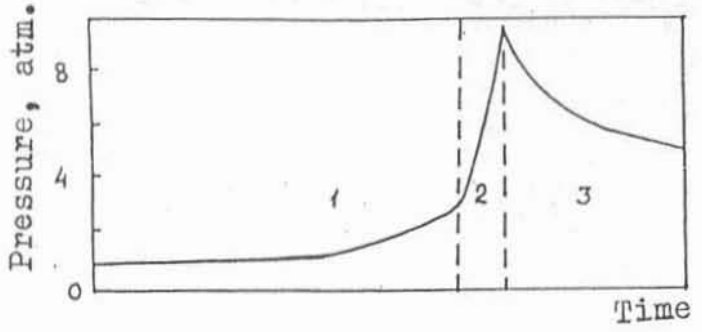

Fig.2. Working liquid pressure during switch-on (1-2) and switch-off (3) periods of the "Yusmar" hydrofacility

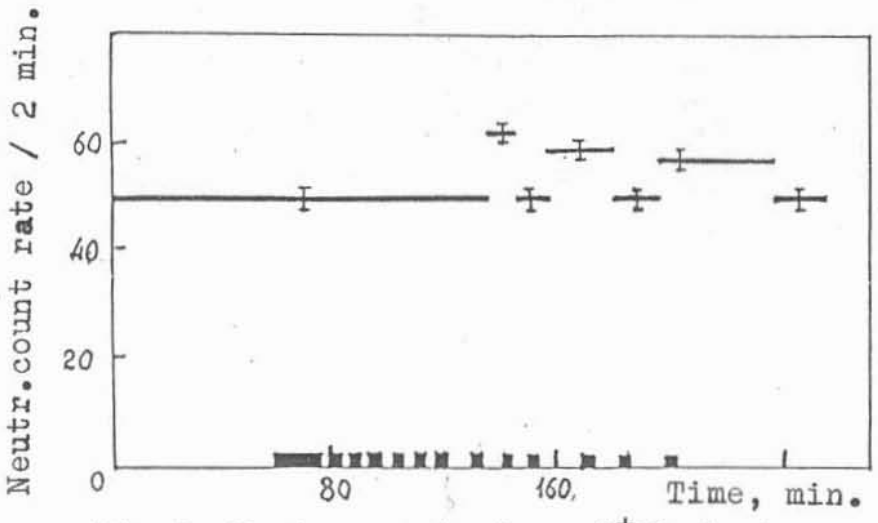

Fig.3. Neutron emissions ($\pm\sigma$) during switch-on (dark regions on time axis) and switch-off periods of the "Yusmar" hydrofacility