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RESEARCH ARTICLE

Neutrons Produced by Heating Processed Metals

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ABSTRACT

We found that neutrons were generated when SUS304 alloy was compressed and tensile processed and heated from 300°C to 800°C, and the energy of the neutrons was 0.7 MeV. Here, we report on the control of neutron generation. The reactor was a cylindrical chamber that made by bending of 2 mm thick SUS304 plates. It was 10 cm in diameter and 40 cm long, with the inside surface buffed with mesh 400. Both ends were closed, hydrogen was poured into the reactor at 1 atmosphere, and then evacuated. By heating the tube and changing the temperature, it was confirmed that excess heat and neutrons were emitted. The neutron energy spectrum was confirmed by distinguishing gamma rays and neutrons using a NE213 liquid scintillator. The neutron energy had a peak at 0.7 MeV, which was significantly different from the 2.45 MeV that had been thought to be nuclear fusion up until now. This reaction was highly reproducible, and the higher the temperature, the greater the reaction.

Keywords: Compression-tension processing, low energy nuclear reactions, neutron energy spectrum, SUS304 container.

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1. Introduction

The author has studied various anomalous phenomena in metal and hydrogen systems, and in 1989, we assumed that this anomalous phenomenon was a nuclear reaction during electrolysis. Neutron energy spectrum analysis confirmed the generation of neutrons by dd reactions [1]. We also reported that the elements produced during this process had isotopic changes that were different from natural ones [2]–[6]. We also reported that anomalous excess heat (heat exceeding the input energy) was generated in subsequent tests. We reported that when a container made of nickel-based alloy material that had been rolled and deformed was heated, an output that exceeded the input was generated [7]. Thus, we considered the generation of neutrons and the isotopic changes of the elements produced to be the result of a nuclear reaction. Here, we report on the positive results obtained from tests he has continued to carry out, especially regarding neutron generation.

In order to evaluate the potential excess heat generation in a reaction container used in low energy nuclear reaction (LENR) research, the thermal output has been measured using an airflow calorimeter [7]. The container was heated to approximately 800°C using a resistance heater of several hundred watts. The total thermal output was 1.25 times the maximum input, exceeding the electrical input with an excess heat generation of 200 W [6]. Chemical reactions were excluded because of the absence of energy density, chemical fuel, and oxygen. The error analysis was ±2 W, and the excess heat was statistically significant. However, the heat measurement does not indicate the reaction that produced it, and even if many heat measurements were performed, it does not prove the existence of a nuclear reaction. In many tests, neutron generation was confirmed emanating from a reaction container in which hydrogen gas was subjected to external heating after treatment by an internal collecting electrode. The nuclear emission and excess heat cannot be explained by known physical phenomena However, it is our hypothesis that these phenomena can be explained if a nuclear reaction in metal is occurring.

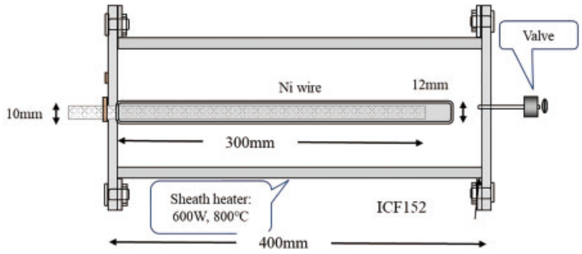

Fig. 1. Cross-sectional view of the reaction container.

Fig. 2. Photo of reaction container exterior.

2. Methods

2.1. *Structure of the Reaction Container*

The structural appearance of the reaction vessel used is shown in Figs. 1 and 2. The reaction container is made of SUS304 stainless steel alloy manufactured by Canon Anelva. SUS304 is known in the U.S. as SS304 or AISI 304. The container is made of tubular SUS304 material that has been subjected to severe deformation processing, and both the inside and outside surfaces are finished to a mirror gloss finish. Both ends are fitted with flanges made of ICF152 and SUS304. A tube with a diameter of 1/4 inch and a length of 100 mm is welded to the flange at one end for vacuum exhaust. The weight of the entire container is 12.7 kg, and the diameter of the tube body is 100 mm and the length is 400 mm. A mini 100A-current collecting electrode made by Canon Anelva is attached to the center of the flange at the other end to which the negative lead wire is connected. A sheath heater made by Sanko Electric Industry Co., Ltd. (101G, 2.3 × 3300, 100 V 600 W, heat resistant to 800°C) is wrapped about 10 times around the outer surface of the container. A collecting electrode is installed in the center of the container flange. The purpose of the collecting electrode is only to prepare the experiment. It is used to evacuate the container, apply a high voltage of 500 V or more to the electrode, and clean the inner surface of the container by ion bombardment. It is not used during the active portion of the experiment. The reaction container is evacuated, and then filled with hydrogen gas at 500 Pa. After allowing 60 minutes to saturate the metal, the container is evacuated to a pressure of about several Pa. Finally, we test that there is no air leakage and that the pressure inside the container does not change before heating the container

2.2. *Neutron Measurement System*

Fig. 3 shows an outline of the measurement system. The upper part of the figure shows the neutron measurement system, counting and energy spectrum measurement system. The lower part is the container heating system, and the left part is the DC power supply used for container heating. The temperature is measured by a thermocouple, and the power is also simultaneously input to the logger.

Here we explain the upper part of the block diagram. In order to remove the gamma-ray induced signal and the signal due to the thermal ion noise of the photomultiplier tube from the total signal, a rise time discrimination technique is adopted. The neutron detector uses a NE213 liquid scintillator (proton recoil detector, diameter 12.7 cm, thickness 12.7 cm). The neutron signal is separated from the gamma-ray signal by the rise time of the pulse in the shaping amplifier. The gate signal is supplied to the analog-to-digital converter (ADC) only when a neutron pulse signal is detected. The neutron pulse passes through a delay amplifier, reaches the ADC, and is stored in the memory.

As a high energy neutron spectrometer, the NE213 Organic liquid scintillators are used. The NE213 currently in use is φ5in × 5in. The NE213 liquid scintillator is most-often used for fast neutron energy spectrum measurement, and has good energy response to neutrons from about 0.3 MeV to 22 MeV. It can also discriminate neutrons in a mixed field of neutrons and gamma rays by waveform discrimination. It has excellent characteristics for use in neutron dose measurement using the spectral weighting function method.

As shown in Fig. 3, a 3 mm thick lead plate was placed in front of the neutron energy measurement system, and a container was placed 200 mm away from the detector NE213 to measure neutrons. Counts were accumulated for 24 hours each as BG before and after heating the container. The

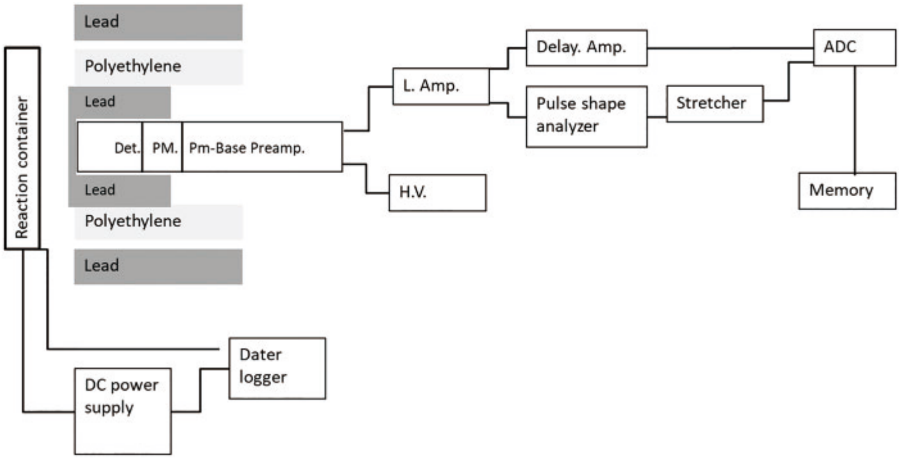

Fig. 3. Schematic diagram of the measurement system.

container was heated at 780°C for 24 hours while counting neutrons. Discrete results were obtained from the neutron spectrum accumulated as BG, but no characteristic peaks were observed.

Details of the equipment used here are shown below. The notations in the figure are as follows. The detector (denoted as Det. in the figure) is the NE213. The photomultiplier tube (P.M.) is a Hamamatsu R1250. The photomultiplier tube base (PM-Base) is an Ortec model 271. The high voltage (H.V.) power supply is an: Ortec model 458. The linear amplifier (L. Amp.) is an Ortec model 410. The delay amplifier (Delay Amp.) is a Tennelec, TC-215. The pulse shape Analyzer is an Ortec model 542. The stretcher is an Ortec model 542. The Analog-to-Digital Converter (ADC) is a Naig E-552 with a Naig E-562 memory module.

Furthermore, the number of neutrons was calibrated using 96.5 mCi, ^{252}Cf (measured on 4/15/1985). The half-life of this source is 2.65 years, and the intensity is 2.1×10^{-6}. In other words, the number of neutrons φ is $\varphi = Bq \times Ci = 96.5 \times 10^{-3} \times 3.7 \times 10^{13} \times 2.1 \times 10^{-6} = 7.5 \times 10^{5}$/s.

3. Experimental Results

Fig. 4 shows the relationship between neutrons (blue line) and container temperature (red line). This data was collected every hour. The horizontal axis is time, the left vertical axis is the neutron count per hour, and the right vertical axis is the container temperature. The container was installed and heating began at 200 ks. When the temperature reached 440°C at 220 ks, the neutron counts increased, and when the temperature exceeded 600°C, the count became 30 c/h. When the temperature was lowered to 400°C at 520 ks, the neutron count became 10 c/h. Before heating, the count was about 5 c/h, and after heating, it decreased to the same level. Therefore, the background (BG) value is 5 c/h. Then, the FG-BG value, which is obtained by subtracting the BG value, is about 24 c/h at 600°C.

Fig. 5 shows the typical changes in container temperature and neutron radiation for a container. The data was collected every 5 s. The changes in container temperature (red line) and neutron radiation (blue line) are shown over a period of 27.7 hours. The container temperature rises to 780°C on the right vertical axis. As the temperature rises, neutron radiation increases over the first few tens of ks, reaching

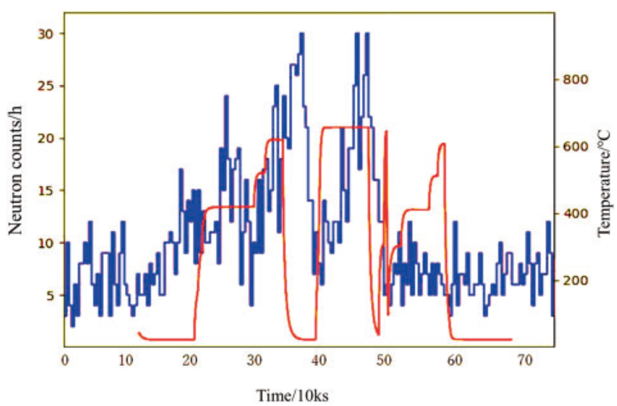

Fig. 4. Relationship between neutron count (blue line) and container temperature (red line).

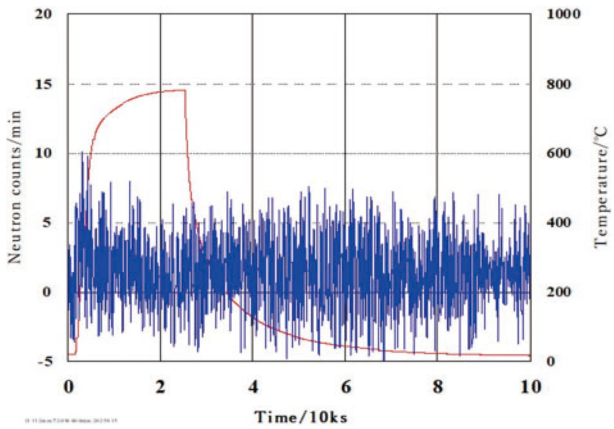

Fig. 5. Changes in container temperature (red) and neutron count (blue) at 700 W input.

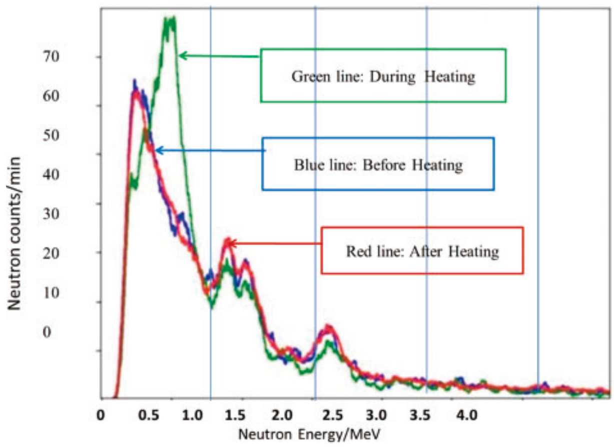

Fig. 6. Neutron spectrum obtained during heating (green line) and BG (blue and red line) of the container.

a maximum of about 5c/min. The neutron counts in Fig. 5 are about 5 counts per minute. This is in general agreement with the neutron counts in Fig. 4 which are about several tens of counts per hour.

Fig. 6 shows the neutron spectrum during heating the container and back ground that is absent of the container. This data collection is not standardized, so the actual counts are shown. A strong peak was clearly observed around 700 keV in the 200 keV to 4.5 MeV spectrum during heating of the container. The blue line is the spectrum before the test, the red line is the spectrum after the test, and the green line is the spectrum during heating of the container. The counts are integrated values. There were no radioactive materials that emit neutrons or materials that undergo spontaneous nuclear fission, such as ^{235}U, ^{239}Pu, or ^{252}Cf, in the measurement system. Neutron radiation is clearly occurring from the SUS container body. Neutrons with 2.45 MeV, characteristic of DD fusion, are not observed. Also, there are no peaks at higher energies. Fig. 4 also shows that neutrons are generated from the processed SUS304, and the higher the temperature, the greater the number of neutrons.

Fig. 7 shows the counts during heating of the container in Fig. 5 minus the BG value. The average value before and after heating was used as the background value. The energy range is 0 to 2.5 MeV, with a clear peak at an energy value of 700 keV. The reaction mechanism showing this peak is currently under analysis. The important thing is that neutrons are emitted simply by heating SUS304 material that has been subjected to a certain type of processing.

Table I shows an overview of the neutron generation tests on the SUS304 container. The columns show the test date, input wattage, container temperature, and neutron count results. Data is from November 2020 to April 2025. Input power was 478–730 W, and average container temperature was 562°C–783°C. Higher temperatures were not used as they exceeded the thermal capacity of the container. The neutron count is the foreground value minus the background value. The counts per minute are approximately 0.25–2 c/min. This is the average value over the entire vessel heating period and there is a large variability.

Fig. 8 is a graph of the temperature and neutron values shown in Table I. The neutron count in this graph is not the value when the temperature change is large in Fig. 4, but the number of neutrons during the container heating. The values are shown as counts per minute, but the count increases rapidly as

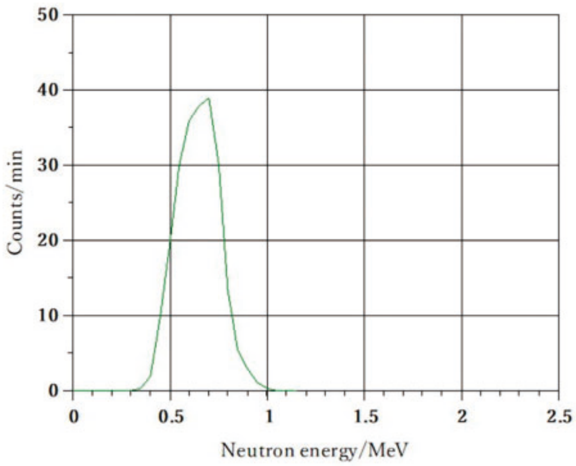

Fig. 7. The value obtained by subtracting the BG value (red and blue line) from the neutron count value during heating of the container in Fig. 6.

TABLE I: Summary of Studies

YMD	Input watt	Container Temp./°C	Neutron counts (FG-BG)/min
'20201129	*724*	*764*	*0.803*
'20240805	*478*	*589*	*0.415*
'20241021	*584*	*727*	*0.803*
'20241029	*699*	*783*	*1.972*
'20241119	*547*	*562*	*0.250*
'20241120	*720*	*622*	*1.554*
'20241125	*725*	*783*	*0.826*
'20241129	*724*	*764*	*1.064*
20250414	*720*	*760*	*1.060*
20250415	*729*	*758*	*1.198*
Back ground	*0*	*25*	*0.00*

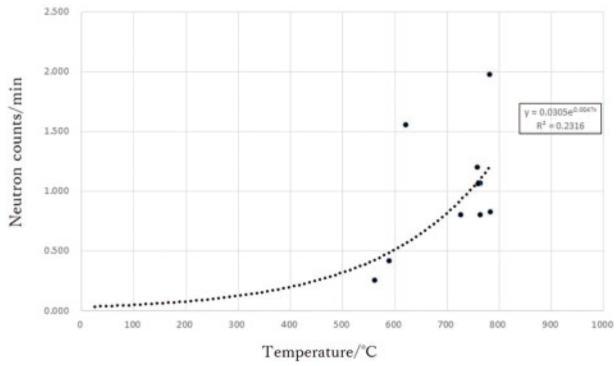

Fig. 8. Relationship between temperature and neutron counts in Table I.

the temperature increases. A detailed analysis, explained below, shows that the neutron count increases not due to the temperature but due to the amount of temperature change.

Fig. 9 shows the relationship between temperature change (°C/s) and neutron count (c/min) from Fig. 5. Here, the moving average values over 600 s are shown for both the temperature change and the number of neutrons. Since there is a large variance in the average values over 5 s, the average values over 600 s were used for ease of viewing as a graph. The two show a strong causal relationship. A large temperature change results in more neutron emissions.

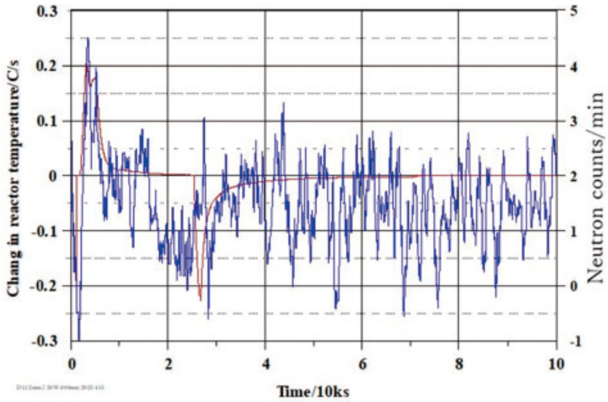

Fig. 9. Relationship between container temperature change rate (red) and neutron count (blue) in the graph in Fig. 5.

4. Discussion and Conclusions

Abnormal heat generation [7] and other radiation were observed in a system of stainless-steel metal (SUS304) and hydrogen. At the present time the underlying physical mechanism is not known. The only known reactants are hydrogen and metal. Many distortions, defects, and other structural variations exist in the processed metal. Previous studies by other researchers have shown reports of peculiar phenomena among hydrogen atoms, protons, and metal atoms at such sites [8].

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